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The Lords of Guano:

Science and the Management of Peru's Marine Environment,

1800-1973

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The Lords of Guano:

Science and the Management of Peru's Marine Environment, 1800-1973

by

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Para Mirna y Camilo

With minute and amateurish interest, I found atop a scoop in the base of a big, drifted, scorched tree trunk five little piles of fox dung, a big owl's puke ball full of hair and rat skulls, and three fresher piles of what had to be coon droppings, brown and small, shaped like a dog's or a human's.

Why intrigued ignorance asked, did wild things so often choose to stool on rocks, stumps, and other elevations?

Common sense replied: Maybe for the view. . . .

The trouble was, I *was* ignorant. Even in that country where I belonged, my ken of natural things didn't include a little bird that went *heap-heap*. . . . Or a million other matters worth the kenning. . . .

With a box gushing refrigerated air (or warmed, seasonally depending) into a sealed house and another box flashing loud bright images into our jaded heads, . . . why should we sweat ourselves where the Eskimo curlew went?

--John Graves (1960)

The Lords of Guano:

Science and the Management of Peru's Marine Environment, 1800-1973

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This is an ecological history of a development project planned and managed by technical experts: the origin, decline, spectacular revival, and tragic fate of the Peruvian guano industry. In another sense, this is a social history of an elite type--the environmental technocrat--and those they served.

During the nineteenth century, scientific travelers appropriated Andean knowledge of vast, ancient deposits of nitrogen fertilizer for use by farmers in the Northern Hemisphere. During the early twentieth century, environmental scientists reoriented the guano industry for Peruvian use. They oversaw the development of perhaps "the greatest of all industries based upon the conservation of wild animals."

This project had both global and local repercussions. The two-way exchange of personnel, ideas, and technologies between Peru and the rest of the world revolutionized scientific understanding of the Peru Current ecosystem. This knowledge led directly to international recognition of the global importance of the

El Niño phenomenon. Through the issue of human population control, Peru's experiment inspired the emergence of an environmental movement that spanned the Americas after World War II. In Peru, technical experts fundamentally influenced the political process, input-intensive agriculture, artisanal and industrial fishing, the organization of "big science" institutions, as well as the guano birds and their ecological community. Ultimately, technocrats enriched and empowered a new ruling class for Peru.

Beginning in the 1940s, the specter of an impending catastrophe in the global food supply gave impetus to the exploitation of the world's fish stocks. To serve this demand, scientists helped engineer for Peru the largest industrial fishery on Earth. Their studies legitimated the decision to let the guano birds pass into oblivion so their food, the *anchoveta*, could be processed into animal feed. As a reflection of persistent global trends of food distribution, rather than feed the world's undernourished, this fishmeal enabled affluent northerners to consume more meat. This fishery was carefully supervised by experts, but they proved unable to prevent its collapse during the El Niño of 1972-1973. This ecological disaster reveals how fleeting "sustainable growth" can be, even for the best-managed development projects.

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Abbreviations and Acronyms

In the main text, the use of acronyms has usually been avoided. In citing works in the notes, short titles have generally been used. Commonly used acronyms, as well as works and archives frequently cited have been identified by the following abbreviations:

ACAG	Archivos de la Compañía Administradora del Guano
AMFOM	Archivo del Ministerio de Fomento y Obras Publicas
APRA	Alianza Popular Revolucionaria Americana
BCAG	*Boletín de la Compañía Administradora del Guano*
BCCAG	*Boletín científico de la Compañía Administradora del Guano*
BCNPN	*Boletín del Comité Nacional de Protección a la Naturaleza*
BCONAFER	*Boletín de la Corporación Nacional de Fertilizantes*
BMFOM	*Boletín del Ministerio de Fomento*
BSGL	*Boletín de la Sociedad Geográfica de Lima*
CAG	Compañía Administradora del Guano
CHLA	*The Cambridge History of Latin America*
CONAFER	Corporación Nacional de Fertilizantes
ECAG	*Estatutos de la Compañía Administradora del Guano*
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
HAHR	*Hispanic American Historical Review*

ICAG	*Informe que sobre la Compañía Administradora del Guano eleva al Supremo Gobierno por conducto del Ministerio de Hacienda, la Comisión nombrada por Resolución Suprema de 18 de Junio de 1941*
IMARPE	Instituto del Mar del Perú
IMF	International Monetary Fund
Inf.Inst.Mar Perú	*Informe del Instituto del Mar del Perú*
IREMAR	Instituto de Recursos Marinos del Perú
JLAS	*Journal of Latin American Studies*
MCAG	*Memoria del Directorio de la Compañía Administradora del Guano*
MCONAFER	*Memoria de la Corporación Nacional de Fertilizantes*
MMFOM	*Memoria del Ministerio de Fomento*
MSY	Maximum Sustainable Yield
PROABONOS	Proyecto Especial de Promoción del Aprovechamiento de Abonos Provenientes de Aves Marinas
Schaefer papers	Milner Bailey Schaefer papers, SIO Library
SIO	Scripps Institution of Oceanography
SIO Subject Files	Scripps Institution of Oceanography, Subject Files Records, SIO Library
SNP	Sociedad Nacional de Pesquería
UC-IMR records	University of California, Institute of Marine Resources, Records, SIO Library
Vaughan papers	Scripps Institution of Oceanography, Records, Office of the Director, T. Wayland Vaughan, SIO Library

Vogt papers	William Vogt papers, Denver Public Library

Introduction

The Ecology of Expertise

> Laws . . . are eternal principles founded in the nature of things: principles that cannot be perceived with clarity except by experts accustomed to overcoming the difficulties of mental work and trained in scientific inquiry. . . . The right to decree laws pertains to the most intelligent--to the aristocracy of knowledge, created by nature.
>
> --Bartolomé Herrera (1846)

In October 1944, Enrique Ávila was in trouble. This budding young Peruvian scientist had used up the entire four-semester grant that the U.S. Institute of International Education had provided him so he could study wildlife management at the University of Wisconsin with the legendary conservationist Aldo Leopold. He had good biological training by Peruvian standards: he had completed everything but his thesis for a *bachiller* degree from the Universidad de San Agustín de Arequipa, and he had done a year of intensive fieldwork studying Peruvian marine birds with U.S. ornithologist William Vogt during the intense El Niño event of 1941. But his mediocre English-language skills slowed him down at first. Now he had neither a degree nor money to continue and faced the prospect of deportation. To make matters even more complicated, his fiancée, a former math student of his, was patiently waiting for him in Arequipa and longing for his return. His mentor Vogt had warned him this might happen; he thought Ávila (1917-1972) needed a few more years of experience and maturity before initiating studies in the United States. Likewise, Leopold thought Ávila should return to Peru and pick up his graduate work later.

But Ávila would have none of this. He was the intensely ambitious son of a successful peasant farmer and estate foreman from the high altiplano near Lake Titicaca. He identified himself as "mostly Indian," and he was acutely aware of his inferior social status as a *cholo* (a derogatory term for a Hispanicized *indio* or dark-skinned mestizo) from Puno among the white sons of the coastal elite who dominated political, economic, and scientific life in Peru. He could not bear to leave the United States without a Master of Science degree: "It would mean the opening of new opportunities . . . . In a country like mine, a degree of any kind has the magic power of a pass word." Ávila coveted "the advantage" such an accomplishment "would give to me in dealing with some petty politics of my country." To wait or fail "would have meant a direct and severe blow to my ego."[1]

Vogt used his connections as a prominent international conservationist to help get a student loan for his protégé, helped, no doubt, by the special circumstances of wartime which opened many opportunities for Latin Americans in the United States. Aldo and Estella Leopold invited Ávila into their home--and presumably to the "shack" made famous in the environmental classic *A Sand County Almanac*--to help him through his final classwork.[2] In 1945, Enrique Ávila returned triumphantly to Peru with a prestigious foreign degree and a five-year contract to work as his homeland's first native-born professional ornithologist (illus. 1). As one of the scientists entrusted with managing Peru's famed guano

1. This section is based on the following sources: Aldo Leopold to William Vogt, 11 Oct. 1944, 18 Oct. 1944, Vogt papers, box 1:2; Enrique Ávila to Vogt, 16 Oct. 1944, 26 Apr. 1948, Vogt papers, box 1:1; interview with Basilia Díaz Viuda de Ávila and Ingrid Ávila Díaz, Lima, Peru, 13 June 2001; *MCAG* 34 (1943), viii-ix; *MCAG* 35 (1944), 48.

2. Aldo Leopold, *A Sand County Almanac and Sketches Here and There* (New York: Oxford University Press, 1949).

birds, Ávila set up his homeland's first permanent marine laboratory next to the nesting colony on Isla Don Martín. Yet against his hopes, his technical expertise and accomplishments did not give him immunity from racial discrimination in Lima's scientific circles, and his work was generally discounted or ignored by those in power. "No prophet is accepted in his own country," Ávila's wife later remembered.

Ávila used his foreign links to further his scientific education at the Scripps Institution of Oceanography in California and to obtain a temporary research position at the nuclear facility in Mayagüez, Puerto Rico--two of the leading centers for environmental research in the Americas. In a brief reversal of fortune, Ávila was named Director of Investigations at the Instituto del Mar del Perú (the Peruvian Institute of the Sea, IMARPE), Peru's premier scientific research institution, in the late 1960s just before his life was cut short by cancer. If only for a moment, Ávila was in charge of research crucial to the management of Peru's vast fishing industry.

These achievements did not provide material security for his family, at least not in the short term. Several times they had to move in with their extended family back in the highlands to survive the ups and downs of Ávila's career and the Peruvian economy. After Ávila's death, his wife ended up in a poorly built hovel in Comas, a *barriada* (shantytown) on Lima's rapidly expanding northern periphery. A torrential downpour during the 1982-1983 El Niño event destroyed many of her belongings, including practically all of Ávila's carefully preserved private papers and photographs.

But Ávila's persistence finally paid off for his children. Ávila's son Yuri was able to use his own English-language skills and connections derived from his father's foreign experience to obtain an education and permanent livelihood as an engineer in the United States. Like so many immigrants, he eventually used his financial means to help support his mother and sister remaining behind in Peru and enable them to escape from the barriadas to a comfortable suburban home in Lima.

In its general features, the biography of Enrique Ávila and his family is representative of millions of aspiring professionals worldwide who have sought to use education and technical accomplishment to escape from disadvantaged backgrounds and the dilemmas of "underdevelopment." Ávila hoped his expertise would grant him some measure of the status and influence that for centuries has been the birthright of upper-class Creole and foreign-born whites in Peru.

Specialized training has long provided an avenue for social advance in Peru, at least for an already privileged few. Peru's ruling class did not start looking to the technically trained for guidance only yesterday. Despite what the black legend of Iberian obscurantism may say, we do not have to turn to France and Britain, the homelands of the Enlightenment and Industrial Revolution, to locate the deep roots of this tendency. Iberian monarchs tried to use science, technology, and expert advice to bring order to their empires at least as far back as the sixteenth century. In the best-known case, a group of expert theologians and humanists, western

Europe's first comparative ethnographers, profoundly influenced Iberian royal policy toward the indigenous peoples of the New World.[3]

Spanish colonial officials in Peru also looked to experts for help, especially during major crises. On the night of 28 October 1746, one of the most destructive earthquakes of modern times struck Peru's central coast. In Lima, then the preeminent city in South America, it toppled the king's statue over the main city bridge, collapsed the towers of the cathedral, and damaged over 99 percent of Lima's dwellings, leaving tens of thousands homeless. A tsunami virtually wiped the port city of Callao off the face of the earth, killing all but 200 of its 4,000 inhabitants and leaving Lima open to piracy or military invasion by sea (map 1). Epidemics and massive looting followed in the wake of these seismic events. For the viceroy of Peru and his subordinates, this was an unprecedented administrative challenge. For the upper class, it threatened to wipe out the prestige and power entailed by their damaged property. For everyone else, it was a dire threat to survival, long after the shaking had stopped. This cataclysm captured the attention

3. On these points, see Enrique Martínez Ruis and José María López Piñero, eds., *Felipe II, la ciencia y la técnica* (Madrid: Actas Editorial, 1999); David C. Goodman, "The Scientific Revolution in Spain and Portugal," in *The Scientific Revolution in National Context*, ed. Roy Porter and Mikuláš Teich (Cambridge, UK: Cambridge University Press, 1992), 158-177; idem, *Power and Penury: Government, Technology and Science in Philip II's Spain* (Cambridge, UK: Cambridge University Press, 1988); Antonio Lafuente and José Sala Catalá, eds., *Ciencia colonial en América* (Madrid: Alianza, 1992); Anthony Pagden, *The Fall of Natural Man: The American Indian and the Origins of Comparative Ethnography* (Cambridge, UK: Cambridge University Press, 1982); Juan J. Linz, "Intellectual Roles in Sixteenth and Seventeenth Century Spain," *Daedalus* 101:3 (Summer 1972), 59-108; R. Hooykaas, *Humanism and the Voyages of Discovery in Sixteenth-Century Portuguese Science and Letters* (Amsterdam, 1979); Edmundo O'Gorman, *La invención de América: Investigación acerca de la estructura histórica del nuevo mundo y del sentido de su devenir*, 2d ed. (Mexico City: Fondo de Cultura Económica, 1977); Lewis Hanke, *The Spanish Struggle for Justice in the Conquest of America* (Philadelphia: University of Pennsylvania Press, 1949).

of natural philosophers in Mexico, Europe, and North America and set the stage for reactions to the earthquake and tsunami that leveled Lisbon a decade later.[4]

The viceroy responded to this crisis by appointing the French mathematician Louis Godin, a former member of the geodesic expedition that measured the earth at the equator and future head of the Spanish naval academy, to chair a commission to plan the rebuilding of Lima. Over 1,100 kilometers away, at his remote missionary post in the Moxos region of the Amazon Basin, the Jesuit mathematician Juan Rehr (1691-1756) received a similar order instructing him to travel across the Andes to oversee the repair and reconstruction of Jesuit properties in the capital. After two decades in the wilderness, this Prague native was welcomed in Lima as civilization's savior. The viceroy soon appointed him to fill Godin's old positions as professor of mathematics and royal cosmographer, and more importantly, to take command of the cathedral's reconstruction.[5]

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4. Alberto Giesecke and Enrique Silgado, *Terremotos en el Perú* (Lima: Ediciones Rikchay Perú, 1981), 23-27; Charles Walker, "Shaking the Unstable Empire: The Lima, Quito, and Arequipa Earthquakes, 1746, 1783, and 1797," in *Dreadful Visitations: Confronting Natural Catastrophe in the Age of Enlightenment*, ed. Alessa Johns (New York: Routledge, 1999), 115-122, 135-138. See also T. D. Kendrick, *The Lisbon Earthquake* (Philadelphia: Lippincott, 1957); and *Histoire des tremblemens de terre arrive's a Lima, capitale du Perou, et autres lieux; avec la description du Perou, et des recherches sur les Causes physiques des Tremblemens de Terre, par M. Hales de la Société Royale de Londres, & autres Phisiciens* (Paris: La Haye, 1752), the French translation of a report to the Viceroy of Peru, also published in Mexico City, London, Lisbon, Philadelphia (by Benjamin Franklin), and Boston (in the French case with an appended translation of Stephen Hales's 1750 dissertatation on the climatic causes of earthquakes).

5. The Llanos de Mojos is a tropical savanna in what is now lowland Bolivia. *El conocimiento de los tiempos. Ephemeride del año de 1750 . . . . Por el P. Juan Rer* [sic] *de la Compañia de Jesus, Cathedratico de Prima, de Matematicas, en la Real Universidad de San Marcos de la misma Ciudad. Con Licencia* (Lima, 1749), 3, 21; Walker, "Shaking the Unstable Empire," 123-127, 142 n. 30; *Diccionario histórico y biográfico del Perú: siglos XV-XX*, ed. Carlos Milla Batres, (Lima: Editorial Milla Batres, 1986), s.v. "Rehr, Juan"; *Diccionario histórico y biográfico del Perú*, ed. Manuel de Mendiburu, 2d ed. (Lima: Librería e Imprenta Gil, 1934), s.v. "Rher, Juan" [sic]; David Block, *Native Tradition, Jesuit Enterprise, and Secular Policy in Moxos, 1660-1880* (Lincoln: University of Nebraska Press, 1994), 40, 114.

Besides changing the face of Lima's urban landscape, this Jesuit savant transformed the cosmographer's office and forever altered the course of Peruvian science. Rehr firmly believed that "everyone can see clearly in the theater of nature," and he publicly declared that Galileo had proved "our movement." Rehr continued the astronomical observations, astrological prognostications, and calendrical tasks that had long been required of kingly advisors in his position, since these were "necessary for government" and navigation in the region. But he was dissatisfied with the idea that the movements of the heavenly bodies provided a good instrument for predicting the meteorological shifts that affected local agriculture and medical practice. So he initiated empirical "rustic astrology," quantitative instrumental observations, and published the first systematic atmospheric measurements in Peru. This friar's simple act of setting up a barometer was a sure sign that the Enlightenment had arrived in Peru.[6]

What a contrast to events in Portugal, where the great earthquake of 1755 also led to the appointment of an expert commission to rebuild Lisbon, but contributed in short order to the expulsion of the Jesuits from the entire Portuguese empire by the enlightened despot, the Marquês de Pombal.[7] Despite the

6. *El conocimiento de los tiempos. Ephemeride del año de 1750*, 3, 5-6, 16, 18-22; *El conocimiento de los tiempos. Ephemeride del año de 1754* (Lima, 1753), 6; *El conocimiento de los tiempos. Ephemeride del año de 1755* (Lima, 1754), 12-13; *El conocimiento de los tiempos. Ephemeride del año de 1756* (Lima, 1755), 4-5; Jan Golinski, "Barometers of Change: Meteorological Instruments as Machines of Enlightenment," in *The Sciences in Enlightened Europe*, ed. William Clark, Jan Golinski, and Simon Schaffer (Chicago: University of Chicago Press, 1999), 69-93. Cf. Lizardo Seiner Lizárraga, "Los inicios de la meteorología en el Perú y la labor del Cosmografiato, 1753-1856," in *Science and Cultural Diversity* (in press).

7. David K. Chester, "The 1755 Lisbon Earthquake," *Progress in Physical Geography* 25:3 (2001), 363-383; J. R. Mullin, "The Reconstruction of Lisbon Following the Earthquake of 1755: A Study in Despotic Planning," *Planning Perspectives* 7 (1992), 157-179; Luis Gonzaga Jaeger, "Many Were the Pretexts," in *The Expulsion of the Jesuits from Latin America*, ed. Magnus Mörner

contributions of men like Rehr, the Spanish empire followed suit in 1767. Though designed to centralize and strengthen Iberian governance--and many say to knock down a major barrier to the modern philosophy--the Jesuits' unpopular expulsion mainly served to eliminate an entire group vital to science, education, and economic life in Latin America.[8]

Enlightened members of the urban Creole elite in Spanish America worked to fill this vacuum: by founding local economic and scientific societies, by traveling overseas for advanced education, by reforming technical training back home, by participating as correspondents and collectors in international scientific networks, and by engaging in the trans-Atlantic dispute over the supposed natural

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(New York: Alfred A. Knopf, 1965), 122-123. Cf. Kenneth R. Maxwell, *Pombal: Paradox of the Enlightenment* (Cambridge, UK: Cambridge University Press, 1995); José Augusto França, *Lisboa Pombalina e o iluminismo*, 3d ed. (Venda Nova, Portugal: Bertrand Editora, 1987).

8. Simon Schwartzman argues that Jesuit control of education set up "an impenetrable barrier" to "modern culture" in Brazil until they were expelled in 1759, *A Space for Science: The Development of a Scientific Community in Brazil*, rev. ed. (University Park: Pennsylvania State University Press, 1991), 32-46, echoing Salvador de Madariaga's evaluation of Spanish America, "The Fall of the Jesuits--The Triumph of the Philosophers," in *Expulsion of the Jesuits*, 33-40. Contrast this to Rehr's Jesuit colleague Juan de Hospital who is often credited with introducing modern natural philosophy to Quito about 1760; Juan José Saldaña, "Ilustración, ciencia y técnica en América," in *La Ilustración en América colonial: Bibliografía crítica*, ed. Diana Soto Arango, Miguel Ángel Puig-Samper, and Luis Carlos Arboleda (Madrid: Ediciones Doce Calles, 1995), 40-41; cf. Constancio Eguía Ruiz, "A Staggering Blow for Education," in *Expulsion of the Jesuits*, 175-180. Rehr's case also argues against the "cultural decadence of the Peruvian province of the order," suggested by Antonello Gerbi (who otherwise highlights Jesuit scientific contributions) in *The Dispute of the New World: The History of a Polemic, 1750-1900*, trans. Jeremy Moyle (Pittsburgh, PA: University of Pittsburgh Press, 1973), originally published as *La disputa del Nuovo Mondo: Storia di una polemica, 1750-1900* (Milan: Riccardo Ricciardi Editore, 1955), esp. 233; cf. Luis Martín, *The Intellectual Conquest of Peru: The Jesuit College of San Pablo: 1568-1767* (New York: Fordham University Press, 1968).

Some recent work has given attention to the impact of the Jesuits' expulsion; see Jorge Cañizares Esguerra, *How to Write the History of the New World: Histories, Epistemologies, and Identities in the Eighteenth-Century Atlantic World* (Stanford, CA: Stanford University Press, 2001), 165-166, 182-190, 199-204, 234-261; D. A. Brading, *The First America: The Spanish Monarchy, Creole Patriots, and the Liberal State, 1492-1867* (Cambridge, UK: Cambridge University Press, 1991), 166-183, 447-464, 467-468, 497-507.

inferiority of the Americas. Though they were mostly forbidden from holding prominent political positions and received help from foreign visitors like Alessandro Malaspina and Alexander von Humboldt, these Creoles engineered their own "cultural revolution" in the colonies.[9]

Rehr's initiatives continued to bear fruit in this context. His successors perpetuated Rehr's meteorological observations. This climate record allowed the Peruvian-born physician Hipólito Unanue (1755-1833) to recognize immediately that the hot Lima summer of 1791 was extremely anomalous. A few years later, he tied those observations to similar anomalies in 1701, 1720, and 1728. This was a major discovery for environmental science, as we now know this periodic recurrence as the El Niño phenomenon.[10]

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9. The study of this revolution and its ties to Spain has exploded in recent years. Besides ref. in previous note, see Joaquín F. Quintanilla, *Naturalistas para una corte ilustrada* (Madrid: Ediciones Doce Calles, 1999); Juan Pimentel, *La física de la Monarquía: Ciencia y política en el pensamiento colonial de Alejandro Malaspina (1754-1810)* (Madrid: Ediciones Doce Calles, 1998); Virginia González Claverán, *La expedición científica de Malaspina en Nueva España, 1789-1794* (Mexico City: Colegio de México, 1988). Older studies of note include: John Tate Lanning, *The Royal Protomedicato: The Regulation of the Medical Professions in the Spanish Empire*, ed. John Jay TePaske (Durham, NC: Duke University Press, 1985); idem, *The Eighteenth-Century Enlightenment in the University of San Carlos de Guatemala* (Ithaca, NY: Cornell University Press, 1956); Rose Marie Buechler, "The Mining Society of Potosí, 1776-1810" (Ph.D. diss., Syracuse University, 1981); idem, "Technical Aid to Upper Peru: The Nordenflicht Expedition," *JLAS* 5 (1973), 37-77; Arthur Robert Steele, *Flowers for the King: The Expedition of Ruiz and Pavon and the Flora of Peru* (Durham, NC: Duke University Press, 1964); Richard Herr, *The Eighteenth-Century Revolution in Spain* (Princeton, NJ: Princeton University Press, 1958).

10. Hipólito Unanue, [Aristio, pseud.], "Precauciones para conservar la salud en el presente Otoño," *Mercurio Peruano* 14 Apr. 1791, 275-280, in *Mercurio Peruano: Edición facsimilar*, vol. 1 (Lima: Biblioteca Nacional del Perú, 1964); idem, *Observaciones sobre el clima de Lima, y sus influencias en los seres organizados, en especial el hombre* (1806; reprint, in *Hipólito Unanue*, ed. Jorge Árias-Schreiber Pezet (Lima: Comisión Nacional del Sesquicentenario de la Independencia de Perú, 1974), 1:67; Richard Grove, "Global Impact of the 1789-93 El Niño," *Nature* 28 May 1998, 318-319. Cf. Gregory T. Cushman, "Enclave Vision: Foreign Networks in Peru and the Internationalization of El Niño Research during the 1920s," in *Science and Cultural Diversity: Proceedings of 21st International Congress of History of Science* (Mexico City: Universidad Nacional Autónoma de México, in press).

This was but one, minor example of Unanue's contributions to science, medicine, and "scientific administration" in late-colonial Peru. He was later rewarded for these accomplishments by José de San Martín and Simón Bolívar, the "liberators of South America," who appointed him to major positions in the government of independent Peru during the 1820s, including two stints as Minister of Finance. Unanue was one of several scientists to achieve prominence as founding fathers of post-colonial Latin America, before he retired with his large scientific library to the life of a patrician on a rural hacienda in the Cañete Valley.[11]

Even if, despite the best attempts of their fathers, the sons of this nascent technical elite tended to drift away to other careers or jumped directly into politics during the first decades after independence, Latin America maintained its long tradition uniting science and expertise to governance. The highly exceptional biography of a more recent Peruvian shows the immense power, wealth, and prestige that it has occasionally become possible for the underprivileged to obtain

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11. On Unanue and his Peruvian compatriots, see Jean-Pierre Clément, *El Mercurio Peruano, 1790–1795: vol. I: Estudio* (Frankfurt: Vervuert, 1997); Jorge Cañizares, "La Utopía de Hipólito Unanue: Comercio, naturaleza, y religión en el Perú," in *Saberes andinos: Ciencia y tecnología en Bolivia, Ecuador y Perú*, ed. Marcos Cueto (Lima: Instituto de Estudios Peruanos, 1995), 91-108; *Diccionario histórico y biográfico del Perú*, s.v. "Unanue, Hipólito"; John E. Woodham, "Hipólito Unanue and the Enlightenment in Peru" (Ph.D. diss., Duke University, 1964); William Pratt Dale, II, "The Cultural Revolution in Peru" (Ph.D. diss., Duke University, 1941).

On the importance of science and engineering during the era of Latin American independence, see Thomas F. Glick, "Science and Independence in Latin America, with Special Reference to New Granada," *HAHR* 71:2 (1991), 307-334; Frank Safford, *The Ideal of the Practical: Colombia's Struggle to Form a Technical Elite* (Austin: University of Texas Press, 1976), pt. 3, esp. 96-98; Emilia Viotti da Costa, "José Bonifácio de Andrada e Silva: A Brazilian Founding Father," in *The Brazilian Empire: Myths and Histories* (Chicago: University of Chicago Press, 1985), 24-52; Tristan Platt, "The Alchemy of Modernity. Alonso Barba's Copper Cauldrons and the Independence of Bolivian Metallurgy (1790-1890)," *JLAS* 32 (2000), 1-54.

in the name of meritocracy, as well as the promises and pitfalls of technocratic governance for contemporary society.

Far more than Enrique Ávila, the Peruvian-born nisei Alberto Fujimori (1938-) started life as a reviled minority. His family easily could have ended up in a U.S. concentration camp like tens of thousands of other Japanese descendants living in the Americas during World War II.[12]

Once this initial danger passed, like Ávila, Fujimori pursued a career path premised on meritocratic advancement. Like so many of his generation, Fujimori adhered to the mantra "*Quién estudia, triunfa*" (He who studies, triumphs)--the title of a popular Peruvian television show in the early 1950s. He ended up attending the Escuela Nacional de Agricultura at La Molina, Peru's national training school for agronomists. University reforms had only recently allowed the large-scale admission of students of color. "Fujimono," as he was derogatorily known, tirelessly stuck to his studies and rose to first in his class. Much like Ávila, Fujimori became a math teacher at his alma mater and eventually completed a master's degree in mathematics at the University of Wisconsin. Unlike Ávila, he was never much of a *técnico*, and he made his fortune as a land developer on Lima's suburban periphery. Fujimori gave up scientific pursuits altogether after he returned from abroad with a prestigious degree and became involved in the tumult of university politics. Posing as an outsider, he was improbably elected rector of

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12. Luis Jochamowitz, *Ciudadano Fujimori: La construcción de un político* (Lima: Peisa, 1993), ch. 2; Michi Weglyn, *Years of Infamy: The Untold Story of America's Concentration Camps* (New York: Morrow Quill, 1976), 59-66.

the renamed Universidad Nacional Agraria in 1984, and then used this as a springboard to national prominence.[13]

In 1990, Fujimori did something Enrique Ávila never dreamed of accomplishing: he jumped into the national presidential race. During his campaign, he cultivated the dual image as an anti-political técnico and agrarian populist. Building on the small, rural notoriety he had gained as the television host of a farming program, Fujimori portrayed himself as an expert on Andean cultivars. He claimed to have learned that "every problem has a scientific and rational solution" during his graduate training in the United States, and he adopted the campaign slogan "Technology, Honesty, and Work." He eschewed traditional political parties and established the habit of arriving at political rallies aboard a tractor--the "Fujimóvil." It is said that, behind the scenes, Fujimori turned to the writings of U.S. management guru W. Edwards Deming for guidance. Deming was recognized in U.S. business circles as "the American who taught the Japanese about quality," the self-proclaimed architect of Japan's postwar industrial miracle. This was a potent association, since it put a positive light on Fujimori's ethnicity and ties to "scientific management." It made him look like the right man to lead Peru down the "pathway from the periphery" blazed by the "Asian tigers," the newly industrializing countries on the other side of the Pacific Rim.[14]

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13. Jochamowitz, *Ciudadano Fujimori*, 162, 166-169, 174, 181, 183-185, 215, 221, 234-237.

14. Ibid., 185, 256-257, 264-267, 276-280; Kenneth M. Roberts, "Neoliberalism and the Transformation of Populism in Latin America: The Peruvian Case," *World Poltics* 48:1 (Oct. 1995), 92-96. On the Deming legend, see William M. Tsutsui, *Manufacturing Ideology: Scientific Management in Twentieth-Century Japan* (Princeton, NJ: Princeton University Press, 1998), 197-201. Cf. Stephan Haggard, *Pathways from the Periphery: The Politics of Growth in the Newly Industrializing Countries* (Ithaca, NY: Cornell University Press, 1990).

As it turned out, Fujimori could not have chosen a more brilliant campaign strategy. Even more than its other South American neighbors at the time, Peru was caught in a downspiral of debt, hyperinflation, unemployment, and immiseration. Leftist revolutionary movements in alliance with drug traffickers threatened to rip the Peruvian state apart, starting with its electrical infrastructure. Middle-class workers (especially those with technical training like Yuri Ávila) were leaving Peru in droves. Others survived by participating in Peru's rapidly growing "informal economy." The main presidential candidate of the political right, the international literary star Mario Vargas Llosa, promised to impose a severe "neoliberal adjustment" after his election to resolve this crisis. Coming from an exemplar of the aloof, white, cosmopolitan intellectual, such a presecription was all but impossible to sell to Peru's besieged mestizo majority.[15]

In these historical circumstances, a son of Japanese immigrants who had seemingly conquered racism and poverty through scientific training and hard work suddenly became the most powerful man in Peru. To gain further confidence at home and abroad, Fujimori placed a respected representative of the center-left with advanced degrees in agronomic engineering, agricultural economics, and public administration at the helm of his new government. Then, following the vogue set by the "Chicago Boys" in Chile during the 1970s, Harvard's *Wunderkind* economist Jeffrey Sachs in Bolivia and Poland during the 1980s, and International

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15. Roberts, "Neoliberalism and the Transformation of Populism," 92-96; Carlos Contreras and Marcos Cueto, *Historia del Perú contemporáneo: Desde las luchas por la Independencia hasta el presente*, 2d ed. (Lima: Instituto de Estudios Peruanos/Red para el Desarrollo de las Ciencias Sociales en el Perú, 2000), 331-341.

Monetary Fund officials all over the world after the fall of the Soviet bloc, Fujimori installed a a true neoliberal technocrat as his prime minister in February 1991. Oxford-educated economist Carlos Boloña (1950-) designed a radical "change of course" for the Peruvian economy that went much farther than Vargas Llosa's reviled free-market proposals. Contradicting the so-called Washington consensus of the 1990s positing a natural connection between economic and political freedom, Fujimori dissolved most of Peru's democratic institutions in order to eliminate barriers to these programs and oppose "terrorism" effectively. True to his word, the "Fujishock" and "Fujigolpe" crushed left-wing insurgency and produced a short-lived economic bonanza through a spate of privatizations. Fujimori later used his power quite successfully to mitigate damage caused by the El Niño event of 1997-1998, the strongest of the twentieth century. But this "open" authoritarian environment created enormous potential for graft. Thanks to the paranoid fascination Fujimori's ironically named spy-chief Vladimiro Lenin Montesinos had with hidden camaras, the world knows something of the extent of this corruption from thousands of "*vladivideos*." Fujimori's promise of competent, expert administration was betrayed by the very doggedness with which he sought a pathway from the periphery of power in Peru.[16]

16. Roberts, "Neoliberalism and the Transformation of Populism," 96-102; Contreras and Cueto, *Historia del Perú contemporáneo*, 342-361; *The Peru Report's Guide to Top People in Peru: ¿Quién es quién? 1992*, ed. Jonathan Cavanagh (Lima: Peru Reporting, 1992), s.v. "Hurtado Miller, Juan Carlos," "Boloña Behr, Carlos"; Antonio Zapata Velasco and Juan Carlos Sueiro, *Naturaleza y política: El gobierno y el Fenómeno del Niño en el Perú, 1997-1998* (Lima: Instituto de Estudios Peruanos/CooperAcción, 1999); *El Comercio: Anuario 2000-2001* (Lima: Apoyo Comunicaciones, 2001), 39-44, 51-56; Carmen Rosa Balbi and David Scott Palmer, "Political Earthquake: The 70 Days That Shook Peru," *LASA Forum* 31:4 (Winter 2001), 7-11.

On the connection between the Washington consensus and Peru's political economy of the 1990s, see Carlos Boloña, *Cambio de rumbo: El programa económico para los 90* (Lima: Instituto

The denoument of these events had an added twist that further illustrates a major theme of these biographical vignettes, as well as this study as a whole: *the ubiquitous rise of experts to political and economic power in Peru and around the globe*.[17]

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de Economía de Libre Mercado, 1993); Carlos E. Paredes and Jeffrey D. Sachs, eds., *Peru's Path to Recovery: A Plan for Economic Stabilization and Growth* (Washington, DC: Brookings Institution, 1991). On the role of technocrats in 1990s Peru, see Catherine M. Conaghan, "Stars of the Crisis: The Ascent of Economists in Peruvian Public Life," in *The Politics of Expertise in Latin America*, ed. Miguel A. Centeno and Patricio Silva (New York: St. Martin's Press, 1998), 142-164; Conaghan and James M. Malloy, *Unsettling Statecraft: Democracy and Neoliberalism in the Central Andes* (Pittsburgh, PA: University of Pittsburgh Press, 1994).

17. The rise of experts to power has attracted extensive attention from social scientists, especially those concerned with links between Latin America and the rest of the globe: For an introduction, see John Markoff and Verónica Montecinos, "The Ubiquitous Rise of Economists," *Journal of Public Policy* 13:1 (1993), 37-68; Miguel A. Centeno and Patricio Silva, eds., *The Politics of Expertise in Latin America* (New York: St. Martin's Press, 1998), esp. Michiel Baud, "The Quest for Modernity: Latin American Technocratic Ideas in Historical Perspective," 13-35; Benno Galjart and Silva, eds., *Designers of Development: Intellectuals and Technocrats in the Third World* (Leiden: Leiden University Centre of Non-Western Studies, 1995); Centeno, "The New Leviathan: The Dynamics and Limits of Technocracy," *Theory and Society* 22:3 (June 1993), 307-335.

Older studies that continue to influence discussion include Guillermo A. O'Donnell, *Modernization and Bureaucratic-Authoritarianism in South American Politics*, 2d ed. (Berkeley: University of California Institute of International Studies, 1979); Carlos Estevam Martins, *Tecnocracia e capitalismo: A política dos técnicos no Brasil* (São Paulo: Brasiliense, 1974); idem, "Technocratic Rule or Technocratic Counsel," *Berkeley Journal of Sociology* 27 (1972-1973), 35-58. Tsutsui's study of scientific management in Japan, *Manufacturing Ideology*, is a useful comparison. Studies narrowly focused on Europe, the United States, and Soviet Union are too numerous to mention here.

Book-length studies examining the relation between science, technology, expertise, and governance in Latin America since the late-nineteenth century include: Verónica Montecinos, *Economists, Politics, and the State: Chile 1958-1994* (Amsterdam: CEDLA, 1998); Pamela S. Murray, *Dreams of Development: Colombia's National School of Mines and Its Engineers* (Tuscaloosa: University of Alabama Press, 1997); Mauricio Tenorio-Trillo, *Mexico at the World's Fairs: Crafting a Modern Nation* (Berkeley and Los Angeles: University of California Press, 1996); Barbara Weinstein, *For Social Peace in Brazil: Industrialists and the Remaking of the Working Class in São Paulo, 1920-1964* (Chapel Hill: University of North Carolina Press, 1996); Juan Gabriel Valdés, *Pinochet's Economists: The Chicago School in Chile* (Cambridge, UK: Cambridge University Press, 1995); Simon Schwartzman, *A Space for Science: The Development of a Scientific Community in Brazil*, rev. ed. (University Park: Pennsylvania State University Press, 1991); Paul W. Drake, *The Money Doctor in the Andes: The Kemmerer Missions, 1923-1933* (Durham, NC: Duke University Press, 1989); Mario Mariscotti, *El secreto atómico de Huemul* (Buenos Aires: Sudamericana/Planeta, 1985); Peter Smith, *Labyrinths of Power: Political Recruitment in*

During the 2000 presidential election, Fujimori boldly manipulated Peru's Supreme Court and used electoral fraud to stay in power. His main opponent, economist and think-tank director Alejandro Toledo (1946-), used a tried-and-true populist tactic to oppose this action: he and his supporters took to the streets in protest. The unexpected appearance of the vladivideos eventually forced Fujimori into exile in Japan. Toledo won the election to replace Fujimori, partly because Peruvians trusted this technocrat and his proposed economic team to manage the Peruvian economy. In July 2001, he was inaugurated president of the Republic of Peru. Thus, this introduction comes full circle: the Peruvian majority voted for a man with roots in both the rural highlands and coastal shantytowns, the son of a poor sheepherder and fishing industry worker, a self-proclaimed cholo who once got by as a shoeshine boy in Chimbote. Toledo worked his way to a Ph.D. in international development from the Stanford University Department of Economics.[18] Fifty years after Enrique Ávila left his homeland to study in the United States, and for the first time since the Spaniards conquered the Inca Empire almost 500 years before, a man of indigenous descent held the highest position in the land.

At the turn of the twenty-first century, the earth's inhabitants on both sides of the North-South divide live in an age of experts. For many of us, in rich and poor countries alike, physicians mark the moment when our lives begin and when

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Twentieth-Century Mexico (Princeton, NJ: Princeton Univeristy Press, 1979); José Murilo de Carvalho, *A Escola de Minas de Ouro Preto: O peso da glória* (Rio de Janeiro: FINEP/Companhia Editora Nacional, 1978).

18. *Peru Report's Guide to Top People in Peru: 1992*, s.v. "Toledo Manrique, Alejandro"; *Current Biography Yearbook* (New York: H. W. Wilson, 2001), s.v. "Toledo, Alejandro."

they end, if only by signing a certificate. The food we eat, the water we drink, the shelters we live in--including many of the ramshackle dwellings and concrete-floored “sanitary markets” of the world’s poorest neighborhoods--are watched over by engineers and health officials (if only with a blind eye).

In perhaps the best-known case of the ascent of experts to power, the party hierarchy that ruled the Mexican state tabbed Carlos Salinas de Gotari (Ph.D., Harvard, 1978) as heir-apparent to the presidency. His fraudulent 1988 election swept a team of technocrats into key positions of power, including economist María de los Ángeles Moreno Uriegas (M.A., 1972), a rare woman technocrat, as Secretary of Fisheries.[19] This clique quickly accomplished a revolutionary transformation of the relationship between the state, civil society, and the global marketplace that has been compared to the changes that followed the Mexican Revolution of the 1910s. After the assassination of Salinas’s initial choice, he fingered his Secretary of Programming and Budget, economist Ernesto Zedillo Ponce de León (Ph.D., Yale, 1978) to succeed him as president. As in Fujimori’s case, the lofty scientific credentials of Salinas and his cronies hardly made them immune to political corruption and violence.[20]

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19. Prominent members of Salinas’s cabinet, all of the same graduate school “generation,” included Pedro Aspe Armella (Secretary of Finance--Ph.D., MIT, 1978), Jaime José Serra Puche (Secretary of Commerce--Ph.D., Yale, 1979), Jerminio Blanco Mendoza (chief NAFTA negotiator--Ph.D., Chicago, 1978). A close economic advisor, José Córdoba Montoya (who had training at the Sorbonne) scandalously lied about possessing a Ph.D. from Stanford. Other environmental technocrats included economist Patricio Chirinos Calero (Secretary of Urban Development and Ecology, Licenciatura, UNAM, 1964).

20. Miguel Ángel Centeno, *Democracy within Reason: Technocratic Revolution in Mexico* (University Park: Pennsylvannia State University Press, 1994), passim; Sarah Babb, *Managing Mexico: Economists from Nationalism to Neoliberalism* (Princeton, NJ: Princeton University Press, 2001), ch. 6-7; Stephane R. Golob, “‘Making Possible What Is Necessary’: Pedro Aspe, the Salinas Team, and the Next Mexican ‘Miracle,’” in *Technopols: Freeing Politics and Markets in Latin*

In the extreme case of one 1990s Taiwanese government, the president and 14 of 15 cabinet ministers had Ph.D.s, ten acquired from U.S. graduate schools. Beginning in 1992, a group of top economists, the "Seven Wise Men," were given charge of economic policy in the United Kingdom, despite the fact that their economic models seldom agreed and their quantitative predictions were almost always wrong. By 2002, even the President of the United States possessed a Ph.D. from the London School of Economics, had taught for years at the Ivy League's Dartmouth College, and won the Nobel Prize in Economics--at least in the fantasy world of U.S. network television. Though their actions are sometimes obscured by worshipful praise of the invisible hand of the market, experts have become the priests, even designers, of a transnational political order.[21]

A favorite explanation for this triumphal ascent of experts has been that they serve an indispensable function or role in modern society. The increasing complexity, scale, speed, specialization, and interdependence of industrialized life

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America in the 1990s, ed. Jorge I. Domínguez (University Park: Pennsylvania State University Press, 1997), 95-143; Roderic Ai Camp, *Political Recruitment across Two Centuries: Mexico, 1884-1991* (Austin: University of Texas Press, 1995), ch. 9; *Who's Who in the World, 1991-1992*, 10th ed. (Wilmette, IL: Marquis Who's Who, 1990), s.v. "Moreno Uriegas, María de los Ángeles." Cf. Nora Hamiltion, *The Limits of State Autonomy: Post-Revolutionary Mexico* (Princeton, NJ: Princeton University Press, 1982).

21. "The U.S. Poet Laureate," episode of NBC's *The West Wing*, first broadcast 27 Mar. 2002; Harry M. Collins and Trevor Pinch, *The Golem at Large: What You Should Know About Technology* (Cambridge, UK: Cambridge University Press, 1998), ch. 5; Markhoff and Montecinos, "The Ubiquitous Rise of Economists," esp. 37-41; Centeno, "The New Leviathan," esp. 307-310, 327, 331 n. 11. Two classic histories--from diametrically opposed ideological perspectives--give major credit to scientists, engineers, and business managers for the prowess of U.S. capitalism. Perhaps some such conclusions can be generalized more broadly; David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Alfred A. Knopf, 1977); Alfred D. Chandler, Jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA: Belknap Press of Harvard University Press, 1977); for an update, see Patrick J. McGrath, *Scientists, Business, and the State, 1890-1960* (Chapel Hill: University of North Carolina Press, 2002).

requires individuals with special skills. The constancy of change demands the ability to solve new problems. Modern regimes need experts to ensure their stability and smooth function, to set goals and formulate performance criteria that establish their legitimacy. Modern business needs experts to fulfill various "management needs," especially to ensure profitability (or at least maintain stock values and inflow of investment during the 1990s' market bubble). Both need experts to resolve crises of administration and production, even to define the meaning of "success." Experts are closely identified with many modern political ideals: efficiency, organization, objectivity, impartiality, rationality, practicality, probity, incorruptibility, devotion to the common good instead of private interest, the power of personal merit and competence over money and privilege, and the value of peaceful, international collaboration.[22]

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22. Such functional explanations are closely associated with Max Weber's classic sociological theory that the inexorable drive for administrative efficiency and infrastructural power demands the proliferation of "bureaucratic" systems of administration. Centeno, "The New Leviathan," 317-320, 323-324, 328; Markoff and Montecinos, "The Ubiquitous Rise of Economists," 41-43, 46; O'Donnell, *Modernization and Bureaucratic-Authoritarianism*, 30-31, 51-53, 70, 73, 77-80; Langdon Winner, *Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought* (Cambridge, MA: MIT Press, 1977), 256-263, 395; Jean Meynaud, *Technocracy*, trans. Paul Barnes (New York: Free Press, 1968), originally published as *La technocratie: Mythe ou réalité* (Paris: Payot, 1964), 19-20, 22-29, 191-193, 207-219; John G. Gunnell, "The Technocratic Image and the Theory of Technocracy," *Technology and Culture* 23:3 (July 1982), 392; Peter Burke, *History and Social Theory* (Ithaca, NY: Cornell University Press, 1992), 30-31; Anthony Giddens, *Capitalism and Modern Social Theory: An Analysis of the Writings of Marx, Durkheim and Max Weber* (Cambridge, UK: Cambridge University Press, 1971), 158-159, 178-184, 233, 235.

Following this logic, an older generation of synthetic historians posited a deep-rooted "centralist tradition" that enthroned a series of powerful bureaucratic states to rule Latin America: Raymundo Faoro, *Os donos do poder*, rev. ed. (1959; Porto Alegre, Brazil: Editora Globo, 1975); Claudio Véliz, *The Centralist Tradition of Latin America* (Princeton, NJ: Princeton University Press, 1980).

As Alejandro Toledo's team of economic experts immediately found out, however, supplying policy prescriptions to solve the complex problems of modern times is extraordinarily difficult. Once ensconced in technocratic positions, Latin American economists have often complained that the abstract theory valued by U.S. graduate schools is practically worthless for solving the everyday problems of government and management. This reality has led numerous students of expertise to suggest that the rise of technically trained professionals to positions of power has not been based on their mastery of knowledge. This includes revolutionary France, the supposed birthplace of technocracy.[23]

Critics of functional explanations often look to the structure of organizations, both government bureaucracies and corporate business, as a source of experts' influence. A "slipping sideways of power" from untrained bureaucrats and businessmen to their technical advisors can lay the foundation for the creation of "technocratic organizations" in which experts perpetuate their power through control of key resources and the selection of their successors. This can lead to the placement of technocrats in political positions that require relatively few technical skills--such as prime minister or president.

Mastery of ceremony and ritual provides another potential source of power for the technically trained. The use of jargon-laden speech ("economese"), emphasis on quantification, glorification of efficiency, specific manners of dress

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23. Aníbal Pinto and Oswaldo Sunkell, "Latin American Economists in the United States," *Economic Development and Cultural Change* 15:1 (Oct. 1966), 79-86; Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815* (Princeton, NJ: Princeton University Press, 1997), esp. 346; Markoff and Montecinos, "The Ubiquitous Rise of Economists," 48-49; Collins and Pinch, *The Golem at Large*, ch. 5.

and presentation, even the context in which experts work (the field, the laboratory, monumental modern office buildings, “think tanks”) all can confer legitimacy on a particular expert and his or her policies. At the same time, the oft-enunciated claim that there is “limited ground for action” provides a powerful blame-diverting ritual used to shield experts from blame when things go awry. The ability to create trust and reduce anxiety are two critical functions of these rituals.

Social and political conflict provides the most devious--and perhaps the most important--source of power for experts. The belief that there is a single, unified “policy reality” and that every problem has “one right answer” is fundamental to experts’ dubious claim that they are “above politics” and therefore the proper people to make decisions for the common good. The invention of “technical” problems and “objective” determinations of success may, in fact, be an implicit strategy to obscure the existence of conflict in order to serve certain vested interests.

Experts often share in such interests, usually as loyal vassals, but also as possessors of their own power. For all the rhetoric about meritocracy and the occasional ascent of figures like Ávila, Fujimori, and Toledo, it is a grim fact that becoming an expert remains a class privilege. In most societies, experts are predominantly male and share a similar social origin, values, education, and career pattern. They are often the sons of the elite that preceded them to power, even in the Soviet Union, a country in which the shoe-pounding peasant Nikita Krushchev became supreme leader. Meanwhile, patron-client relations continue to determine which experts achieve positions of influence, as was clearly the case of the technocrats that governed 1990s Mexico. Expertise exists in symbiosis with interest politics. Of course, vested interests routinely come into conflict. This goes a long way toward explaining why experts of similar background so often differ with each other and with factions of the lay public, even with the interests they ostensibly serve. The ecology of expertise is "red in tooth and claw" with few real winners in the struggle for power.[24]

Exactly how these functional, organizational, ritual, and conflictual elements come into play is unique to every historical case. To determine how experts became so important to the management of Peru's marine environment, this history will provide a collective biography of scientists and other technicians at work in Peru that traces their origins, training, career patterns, attitudes, political connections, and roles. This is the first step toward a historical sociology of the environmental expert.[25] Such a collective biography will make it possible to answer some basic questions: Where does specialized knowledge come from?

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24. On points in this section, see Markoff and Montecinos, "The Ubiquitous Rise of Economists," 43-46, 48-53, 55-57, 60; Meynaud, *Technocracy*, 29-32, 66-67, 110-112, 164-182; Centeno, "The New Leviathan," 321-323; Centeno and Silva, "The Politics of Expertise in Latin America: Introduction," in *The Politics of Expertise in Latin America*, 3-5; O'Donnell, *Modernization and Bureaucratic-Authoritarianism*, 79-82; Gunnell, "The Technocratic Image and the Theory of Technocracy," 397; Frank Fischer, *Technocracy and the Politics of Expertise* (Newbury Park, CA: Sage Publications, 1990), esp. ch. 6; Don K. Rowney, *Transition to Technocracy: The Structural Origins of the Soviet Administrative State* (Ithaca, NY: Cornell University Press, 1989); Stanley Aronowitz, *Science as Power: Discourse and Ideology in Modern Society* (Minneapolis: University of Minnesota Press, 1989), esp. ch. 1; Jürgen Habermas, *Toward a Rational Society: Student Protest, Science, and Politics*, trans. Jeremy J. Shapiro (Boston: Beacon Press, 1970), section originally published as *Technik und Wissenschaft als "Ideologie"* (Frankfurt: Suhrkampf, 1968); Howard Margolis, *Dealing with Risk: Why the Public and Experts Disagree on Environmental Issues* (Chicago: University of Chicago Press, 1996).

25. This prosopographical approach has been a venerable tradition of empirical sociology and political science, especially for Mexico. See Meynaud, *Technocracy*, 74-87, 92-95, 104, 107; Centeno, "The New Leviathan," 309-310; idem, *Democracy within Reason*; Camp, *Political Recruitment across Two Centuries* and other works; Smith, *Labyrinths of Power*.

Who posseses it? How is it used in the shaping of a decision and its execution? More importantly, what were these experts asked to accomplish? Were they successful?

Just by the main kind of sources they left behind--institutional reports and correspondence--it is obvious that the experts who came to manage Peru's marine environment were creatures of organization. Therefore, this history will also relate the history of the institutions to which they were attached. How autonomous were they from the mandates of these organizations? More importantly, who benefited from their dictates? To get at these questions, this study will often focus on the interaction and conflict *between* experts. This is where the political nature of science is most apparent.

How did Peru's marine experts imagine their environment? How did they then go about enunciating their knowledge claims? What sort of evidence constituted legitimate knowledge? In some cases, the existence of detailed private journals and correspondence, as well as published statements, makes it possible to distinguish stages of knowledge in the making. Ceremonies involved in the creation and presentation of scientific knowledge were often crucial to its impact. Photographs and other visual artifacts were a vital part of this rhetoric. They are also vital to the reader's imagination of Peru's coastal environment and the experts who managed it. Those reproduced here provide more than mere illustrations for the story that follows. Above all, this study will give precise attention to the numbers on which these management regimes were based: Tables, graphs, and quantitative data are just as vital to the argument of this study as they were to the people who compiled them in the first place. Those reproduced here should be given more than a cursory glance.

In many ways, the history that follows explains how someone like Alejandro Toledo could become president. At the end of the twentieth century, international power brokers and Peru's national electorate alike looked to a "brain trust" to help manage the Peruvian economy and government. The lords of Peru's ruling class have looked to experts to solve a long series of problems related to economic development. This study will trace how *technocrats*--scientists, engineers, economists, and other technically trained professionals exercising administrative power--influenced the course of Peruvian history over the last two centuries. This story is fundamental to understanding how *technocracy*--the ideal that technical experts should govern society and industry--achieved its uneven global ascent as a political ideology during the modern age.[26]

Overview

This is a history of a paramount example of development projects planned and managed by technical experts: the origin, decline, spectacular revival, and tragic fate of the Peruvian guano and fishing industries. It explains how the "aristocrats" who ruled the early Peruvian Republic deliberately gave birth to the modern, technocratic republic of today.

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26. Definitions based on *A Supplement to the Oxford English Dictionary*, ed. R. W. Burchfield (Oxford: Clarendon Press, 1986), s.v. "technocracy."

At its most basic level, this is an ecological history. By that, I mean an account of change over time in the basic, natural relationships between organisms and their environment--including humans. Such a history necessarily involves change in human understanding of these relationships and the various technologies used to manipulate them for human benefit. Environmental experts used science to acquire power over nature in Peru. Thus, this is a history of ecology as much as it is a history of the interactions studied by this "subversive" science.[27]

At another level, this is a social history of an elite type, the expert. Ideological justifications for the rule of an "aristocracy of knowledge" have a long history in Peru. The influential Peruvian priest Bartolomé Herrera (1808-1864) identified this intelligentsia as those with the natural right to decree the proper laws for society using knowledge acquired with special, God-given talents.[28] This account analyzes the origins, influence, success, and failure of technocrats who managed a major ecological experiment in nineteenth- and twentieth-century Peru. A few such experts, like Unanue and Fujimori, became genuine aristocrats of knowledge.

Finally, this is a political history of the changing relationship between the Peruvian state and civil society, and of Peru's ties to centers of power in the rest of the world. A technocratic elite used the institutions of the Peruvian state and

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27. See Paul B. Sears, "Ecology--A Subversive Subject," *BioScience* July 1964, 11-13.

28. Bartolomé Herrera, "Tercer respuesta," in *Escritos y discursos* (Lima, 1929), 1:131, originally in *El Comercio* 21 Oct. 1846; see epigraph to this introduction. On Herrera and the elitist ideology of the modernizing "guano republic" ruled by military strongman Ramón Castilla, see Carmen Mc Evoy, *La utopía republicana: Ideales y realidades en la formación de la cultura política peruana (1871-1919)* (Lima: Pontificia Universidad Católica del Perú, 1997), pt. 1; Contreras and Cueto, *Historia del Perú contemporáneo*, 105-108.

multinational business to mediate and manipulate these political relationships. Though they sometimes worked for their own interests, ultimately, these technocrats enriched and empowered a new ruling class for Peru. In short, this is a history of the Lords of Guano: environmental experts and those they served.

In each of these areas, this study is not subject to artificial boundaries that presume to separate Peruvian national history from the rest of the biosphere and world history. During the nineteenth century, scientists played a fundamental role in the "discovery" and exploitation of ancient Peruvian deposits of guano and nitrates, the two richest naturally occurring nitrogen fertilizers ever found. To an extent much greater than is often appreciated, Peru's "Guano Age" (1840-1879) and recovery from the national disaster that followed it were the creation of technical experts. These discoveries, in turn, strongly influenced the decline of waste-recycling farming methods in the North. This laid the foundations for modern, input-intensive agriculture and for the enormous nitrogen production and meat consumption that accompanied it.

Events in Peru during the twentieth century also turned out to have direct global significance. From 1909 to 1973, in stark contrast to the extractive economy of the preceding century, environmental scientists oversaw the implementation of a grand animal conservation experiment designed to produce a sustained yield of concentrated fertilizer and protein feed from living birds and fish. This depended on the two-way exchange of scientific personnel, ideas, and technologies between Peru, the United States, and many other countries in the Northern Hemisphere. In the process, experts helped bring modern, input-intensive farming to Peru, and they built “big science” institutions that revolutionized understanding of the Peru Current marine ecosystem. Some trends reached truly far afield. The marked impact of the El Niño-Southern Oscillation (ENSO) phenomenon on Peru’s marine environment inspired research that led directly to widespread international recognition of these events’ large-scale importance. Through U.S. ornithologist and conservationist William Vogt and the issue of human population control, Peru’s conservation experiment clearly influenced the emergence of a globalist environmental movement throughout the Americas after World War II. Such achievements--ostensibly linked to the disembodied exchange of “universal” scientific principles and techniques--were based on the rise to power of a class of experts entrusted to manage economic development, not just in Peru, but all over the world.

As a reflection of persistent trends in global food distribution, practically none of this guano or fishmeal went to feed the world’s undernourished. Peruvian guano went mainly to grow crops used as cattle feed during the nineteenth century, then to Peruvian sugar cane and cotton exported to Europe and the United States during the twentieth century. After World War II, the specter of an impending catastrophe in the global food supply due to the world’s growing population gave added impetus to the exploitation of ocean fish stocks. To serve this demand, Peru developed what was for a time the largest fishing industry on Earth, and it became the world’s poster child for rapid fishery industrialization. Peruvian fishmeal went almost entirely to industrial chicken and hog farms--and ultimately to the pocketbooks and waistlines of human omnivores in the Northern Hemisphere (and

Peru's affluent neighborhoods) who lived in the richest and fattest societies in the history of the world. This is a vivid reflection of the concentration of power that has accompanied the rise of experts.

All of these changes had major consequences for Peru's guano birds, *anchoveta* fish, and their ecological community. Misplaced faith in the capabilities of the international technocracy that managed these biological resources allowed Peru's remarkable conservation achievements to collapse: first, because of a conscious decision to allow the guano bird population to wither away under competitive pressure from the fishing industry; second, because of a major miscalculation regarding the ecological impact of the El Niño event of 1972-1973, one of history's great "unnatural disasters." Such events reveal how fleeting "sustainable growth" can be, even for the best-managed projects. On the bright side, Peru's environmental managers learned from some of their mistakes, and the fishmeal industry bounced back after a long, painful 20-year hiatus.

The organization of this work can best be understood in terms of a series of ecological relationships affecting the technology of guano and fishmeal production and consumption. Science--both as a specialized body of knowledge and as a social practice--fundamentally affected how these relationships were interpreted and manipulated over time. Expertise has its own ecology that connected nature to culture. Though this account focuses on Peru, it incorporates a systematic comparison with Latin American and global trends and makes the argument that "Peruvian" events fundamentally influenced both regional and world history. For instance, the El Niño phenomenon repeatedly intervened to determine the timing of major crises extending far beyond Peru's borders.

Chapter 1 describes the origin and fate of Peru's original guano and nitrate trade as part of the nineteenth century's global obsession with manures and their management. Thanks to the intervention of Humboldtian scientists, local knowledge of guano and nitrates among Andean peoples was converted into "universal" knowledge useful to a new breed of scientific farmers in the temperate North and a few plantation owners in the tropics. A massive trade soon developed involving the south-to-north relocation of crop nutrients, as well as the west-to-east deportation of laborers across the Pacific to work these deposits. These trends mirrored the ecological expansion of Europe into new environments all over the Earth during this Age of Empire. They underscore the vital importance of excrement to global history.

Chapter 1 also highlights the fabulous benefits that the fertilizer trade provided to the lords of Peru's "Practical Republic," especially during the 1860s and 1870s, as well as the importance of technocrats to Latin America's newly independent states. Their grand projects ended in disaster for Peru, not because of the lack of science-minded, progressive leadership, but due to systematic undercalculation of the size of Peru's fossil guano deposits, on the one hand, and a devastating war with Chile sparked by an extremely powerful El Niño-Southern Oscillation event in 1877-1878, on the other.

Chapter 2 describes the circumstances at the turn of the twentieth century that enabled conservation-minded technocrats to gain power over Peru's guano islands. From the United States, to Russia, to Latin America, “efficiency” and “scientific politics” were the watchwords of the day when it came to the management of natural resources. The rulers of Peru’s “Aristocratic Republic” (1895-1919) looked to scientists and engineers for advice on a series of issues, including the “awakening” of export agriculture. These experts engineered the ecological transformation of the Peruvian guano industry from an extractive, predatory regime to a classic example of sustained-yield conservation by protecting the guano birds from human depredations. These scientists also initated the systematic study of a recurrent climate phenomenon that affects the Peruvian coast. They named it “El Niño.”

Even if foreign-owned businesses in Peru benefited greatly from these actions, this was not a case of cultural imperialism emanating from the industrial North. Science often provided legitimation for policies already advocated by locals--sometimes against the interests of powerful foreign firms like the Peruvian Corporation of London. In fact, the reorganization of the guano industry by technicians provided a rallying point for the unification of the class that ruled Peru’s Aristocratic Republic. Nevertheless, further developments in the industrial North’s technoscience complex indirectly determined the fate of Peru’s guano industry. By inventing an efficient means to synthesize nitrogen compounds directly from the atmosphere, northern chemists changed the entire technological context in which the Peruvian guano industry operated. In fact, they liberated Peru from the pressure to export this valuable product of nature. This gave the Lords of Guano a chance to consolidate their control over Peru’s marine environment.

Chapter 3 details the new managerial regime these men built. It describes how modern, input-intensive agriculture became "conventional" agriculture in Peru. Beginning in 1909, the Compañía Administradora del Guano (CAG) organized a new *agroecological system* that supplied guano from Peru's marine environment to export agriculture on the adjacent coast. Using the latest techniques of conservation science and scientific management, CAG's managers sought to domesticate the guano birds' island environment, the Andean workers who extracted their excrement, and the coastal farmers who consumed it. Though these plans were calculated to serve Peruvian society as a whole, they mainly benefited a narrow segment of Peru's coastal elite.

The El Niño phenomenon repeatedly challenged CAG's attempts to manage this agroecosystem. In the aftermath of the powerful 1925-1926 event, scientists produced local observations that led international climate scientists to the realization that Peru's El Niño is part of one vast climate mechanism affecting the entire Indo-Pacific Basin. The Great Depression also proved difficult to handle. Technocrats stepped forward to manage this global crisis in Peru, as they did in so much of the world. Ironically, CAG's remarkable success during the 1930s at integrating cotton planters into this agroecosystem initiated a persistent fertilizer supply shortfall that eventually threatened CAG's reason for being.

Chapter 4 describes what Peru did about this problem. In 1939, CAG hired New York ornithologist William Vogt to study the the guano bird population. Vogt's background at one of the world's centers of ornithological investigation enabled him to implement a cutting-edge animal research program in Peru. The guano bird population collapsed right before his eyes under the onslaught of an exceptionally long-lasting El Niño event. This chapter follows Vogt's reaction to these experiences as a study of scientific knowledge in the making. Meanwhile, Vogt saw to the training of Peru's first native-born professional ornithologist, Enrique Ávila.

Chapter 4 also analyzes the uses to which Vogt's scientific knowledge was put in Peru. Based on his observation that food supply is the basic factor limiting the growth of the guano bird population, Vogt suggested novel approaches to bird management that were picked up by a creative new generation of CAG administrators. Their innovative policies led to a sharp increase in guano production and dramatically vindicated the ideal that experts should be in charge of Peru's marine environment.

Both Vogt and Ávila carried a number of new ideas and techniques related to scientific conservation from the Northern Hemisphere to Peru. Chapter 5 investigates Vogt's influence in the other direction and the central importance of Peru's guano experiment for the history of environmentalism in the Americas. This influence was premised on the application of ecological science to social thought regarding human population growth. In 1940, the Peruvian guano industry gave birth to the Comité Nacional de Protección a la Naturaleza, probably Peru's first independent conservation advocacy organization. Vogt's influence contributed to the establishment of similar guano industries in Mexico and Chile, as well as a series of Latin American conservation organizations like Peru's Comité Nacional. Scientists and other professionals played a critical role in this hemispheric movement; this points to widespread acceptance of the principle that experts should be in charge of environmental management.

But this was just the beginning of Vogt's influence on modern environmentalism. Vogt deserves the title of prophet of the Age of Ecology at least as much as any other figure. His intense experience with Peru's guano birds during the 1939-1941 El Niño put him on a trajectory to write *Road to Survival* (1948), the most widely read U.S. environmental book before Rachel Carson's *Silent Spring*. This jeremiad announced that humanity faced imminent catastrophe if it did not come to grips with rapid population growth. Chapter 5 carefully analyzes the argument of this important work, as well as Vogt's far-reaching influence on Aldo Leopold, Josué de Castro, and other important environmental thinkers, the birth control movement, even the United States' first generation of environmental historians. It repeatedly points to the formative influence of Vogt's technocratic experience in Latin America on these trends.

Chapter 6 focuses on the social relations that underlie the production, application, and influence of scientific knowledge. By the 1940s, CAG had come to represent a real-life version of Salomon's House, Francis Bacon's old utopian ideal of a scientific research center with the mandate to exercise power over nature. The ethnic and gender diversity of CAG's scientific staff was utterly remarkable if we take U.S. and European institutions of the time as a standard, though it was hardly free of prejudice based on social inequalities. This chapter also examines the rivalry between marine scientists in Peru and their relevance to two key debates over the nature of Peru's marine environment. One might expect such divisions to undermine the authority of experts. Instead, the fact that CAG's scientists believed in the existence of "one right answer" to every policy question acted as an encouragement to scientific investigation and the eventual development of Big Oceanographic Science in Peru.

Chapter 6 initiates a detailed investigation of the limits to technocratic governance. From CAG's foundation, its managers wanted to extend their ecological purview to many other creatures in Peru's marine environment, especially the small *anchoveta* fish that the guano birds depended on for food. This almost totalitarian vision brought the guano industry into conflict with other humans who exploited Peru's marine organisms. Their conflict set the stage for an attempt to establish a fishmeal industry under CAG's control during the early 1940s.

Chapters 7-8 describe the far-reaching outcome of this industrialization initiative--the replacement of Peru's guano producers as "the most valuable birds in the world." During the 1950s and 1960s, Peru emerged as the world's largest fish-harvesting nation and a center for oceanographic research. During the 1960s and 1970s, Peru developed its own import-substituting fertilizer manufacturing industry. This happened by design, though not without heated expert debate or popular resistance. Two scientists, a U.S. fish population biologist and one of Latin America's first neoliberal economists, played critical roles in these outcomes. The exploitation of Peru's marine environment played an important role in the development of a vast, global meat industry after World War II, as humans increased their mastery over the planet's nitrogen cycle. Meanwhile, Peru's poorest children publicly starved.

Misplaced faith in technocracy, not technology run amok, ultimately doomed both the guano and fishmeal industries in Peru. Well-informed Peruvian officials advised by the world's best scientific talent made deliberate decisions that led, first, to the demise of Peru's guano birds during the moderate El Niño of 1965, then to the collapse of Peru's vast anchoveta fishery during the strong El Niño of 1972-1973. Because of an expensive scientific miscalculation and extremely limited ground for maneuver, the dreams of generations of Peruvian developmentalists turned into a nightmare that lasted two decades.

The final chapter reviews how Peru's guano and fishing industries and the technocrats who managed them fit into the environmental history of the Earth during the twentieth century. In it, I conclude that explorations on the outer cultural boundaries of science are just as important to human creativity as is research at the world's centers of investigation. This final chapter also contemplates the persistent dilemmas that face today's environmental technocrats trying to make "sustainable development" something other than a mirage.

The epilogue briefly traces the direct ties between Peru's Lords of Guano and the publication of Rachel Carson's *Silent Spring* (1962). It ends with a melancholy description of Isla Don Martín, once home to Peru's first marine biology laboratory and well over one million raucous guano birds, where every spring will be silent now that the Peruvian fishmeal industry has recovered much of its former glory.

Chapter 1

Manure and Its Management during the Nineteenth Century: A Global Perspective

The industry and intelligence possessed by the farmer, may indeed almost be judged at a glance by the care he bestows on his dunghill.
--Jean Baptiste Boussingault (1850)

During the nineteenth century, one manure captured the fascination of capitalists, scientific farmers, even poets, like no other: *guano*, the accumulated droppings of marine birds, the most potent and complete naturally occurring fertilizer ever discovered.[1] Because of unique environmental conditions along the Pacific coast of South America since the end of the Pleistocene, the Peruvian Republic found itself in possession of fossil guano deposits that were larger and richer than the rest of the world put together. Beginning in the 1820s, Peru's ruling elite tried to use this geographical advantage to engineer a modern nation. They later turned to a second coastal resource, immense deposits of sodium nitrate, to sustain this vast undertaking. In the early 1880s, after fighting a major war over the wealth of nature, this project ended in tragedy for Peru. But the true historical

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1. Circa 1845, the German poet and novelist Joseph Victor von Scheffel (1826-1886) wrote a comic poem in praise of "Guano" to ridicule the philosopher Georg Hegel's belief in the natural inferiority of the New World. It reads in part:

> God bless you, excellent birds,
> Remote on your far guano shore,
> For despite neighbor Hegel's harsh words,
> You produce the most perfect manure!

See Gerbi, *The Dispute of the New World* , 450-451. A full Spanish translation of this poem can be found in *BCAG* 20:4 (Apr. 1944), 113-114.

significance of these “regional” events--and their meaning for the management of Peru’s marine environment after 1890, the main focus of this study--can only be gauged in global ecological perspective.

During the nineteenth century, agriculture in many parts of the globe was transformed by an ecological revolution. A central feature of this rural revolution was the exploitation of new environments, either by replacing forests and grasslands with farmland,[2] or by directly relocating crop nutrients to cultivated lands. To the latter end, millions of tons of guano and nitrates were exported from coastal Peru to North Atlantic farms and tropical plantations. In the process, guano gave birth to today’s system of *input-intensive* agriculture.

Science played an important role in this revolution. Manure helps us to understand the way science worked on a global scale during this era in several ways:

First, the “discovery” of guano and nitrates represents a classic case in which centuries-old, local know-how was validated as international scientific knowledge and translated into widespread popular practice. This was not a situation in which a scientific advance was merely applied by farmers elsewhere in the world: the theory of agricultural fertilizers developed in parallel with their use.[3] Nor was there a simple equation between this process and European imperialism, as

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2. For an overview of these changes over the long term, see John F. Richards, “Land Transformation,” in *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years*, ed. B. L. Turner II, et al. (Cambridge, UK: Cambridge University Press, 1990), 163-178.

3. This study rejects Vaclav Smil’s simplistic linear model of the relationship between nineteenth-century science and agricultural practice in *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production* (Cambridge, MA: MIT Press, 2001).

post-colonial powers in both North and South America learned to use science for their own projects.[4]

Second, this process of discovery illustrates the early workings of "Humboldtian science," an extraordinarily influential paradigm developed by Alexander von Humboldt during and after his 1799-1804 sojourn to the Americas. Humboldtian science was not aimless, Baconian fact-gathering. It was an entirely new method for doing science in the field that unified the roles of observer-collector and theorist. The search for exact, universal laws governing the geography of animal, vegetable, mineral, and human kingdoms guided these endeavors. It is also important to recognize that Humboldtian science during its earliest stages was a community activity explicitly tied to Humboldt's personality and the flowering of analytical chemistry and other sciences in post-revolutionary Paris. Moreover, the experience of young Humboldtian scientists in foreign climes and their interaction with locals directly influenced the course of science in both the South American "periphery" and European "metropolis." In the case of guano and nitrates, these endeavors produced useful knowledge of great economic value--just as the technocratic ideal promised.[5]

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4. These issues are a central preoccupation of the burgeoning study of the field sciences and the relationship between science and colonialism. For an introduction to these debates, see Roy MacLeod, ed., "Nature and Empire: Science and the Colonial Enterprise," *Osiris*, 2d ser., vol. 15 (2000); Henrika Kuklick and Robert E. Kohler, "Science in the Field," *Osiris*, 2d ser., vol. 11 (1996).

5. Susan Faye Cannon, "Humboldtian Science," in *Science in Culture: The Early Victorian Period* (New York: Science History Publications, 1978), 73-110, is the benchmark study. See also Nicolaas Rupke, "Enlightened Imperialism: The European Appreciation of Humboldt's American Journey of Exploration," in *Geography and Enlightenment*, ed. David N. Livingstone and Charles W. J. Withers (Chicago: University of Chicago Press, 1999); idem, "Humboldtian Medicine," *Medical History* 40 (1996), 293-310; Anne Marie Claire Godlewska, "Humboldt's Visual Thinking: From Enlightenment Vision to Modern Science," in *Geography and Enlightenment*; Michael

Third, this saga reveals who science served. Guano and nitrates most clearly benefited elite interests--on both sides of the emerging North-South global divide. Contrary to most scholarly opinion, guano did little during this era to increase the food supply for the burgeoning population of the industrial North Atlantic (or anywhere else). Instead, guano primarily went to increase the production of meat and dairy products for the relatively affluent.[6] Others bore the main costs of these projects. The quest for guano deposits and laborers to work them had a decidedly negative impact on many peoples and environments of the Pacific Basin. In fact, guano helped open the farthest reaches of this region to external exploitation.

Manure science enabled Peru's new rulers to build a modern state. In relation to their dealings with guano and nitrates during this era, the lords of nineteenth-century Peru have often been portrayed as irrational, backward-thinking, greedy, and corrupt, as mere pawns manipulated by foreign capitalists. This reputation is not entirely undeserved. We can say many things, in retrospect, about why their grand endeavors faltered. But we cannot say that it was for lack of faith

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Dettelbach, "Humboldtian Science," in *Cultures of Natural History*, edited by N. Jardine, James A. Secord, and E. C. Spary (Cambridge, UK: Cambridge University Press, 1996), 287-304; Roderick W. Home, "Humboldtian Science Revisited: An Australian Case Study," *History of Science* 33 (1995), 1-22; Malcolm Nicolson, "Alexander von Humboldt, Humboldtian Science and the Origins of the Study of Vegetation," *History of Science* 25 (1987), 167-194. Still influential, but largely obsolete interpretations include Brading, "Scientific Traveller," ch. 23 of *First America*; William H. Goetzmann, "Humboldt's Children," ch. 5 of *New Lands, New Men: America and the Second Great Age of Discovery* (New York: Viking, 1986).

6. Cf. Kenneth Pomeranz, *The Great Divergence: Europe, China, and the Making of the Modern World Economy* (Princeton, NJ: Princeton University Press, 2000).

in science, technology, and expertise, nor that they acted blindly, without debate or opposition.[7]

Fourth, this case vividly displays several limits to the equation of science and power. To be sure, experts must bear some of the blame for overestimating Peru's natural wealth and underestimating the costs of the projects on which Peru's original Lords of Guano were banking. But factors completely out of their control also affected the fate of their "Practical Republic": a long-lasting economic depression sparked by the world's first global debt crisis, and a horrific subsistence catastrophe unleashed by the most powerful El Niño-Southern Oscillation event of the century. Even the best scientific knowledge cannot guarantee developmental success.

Yet we should not lose sight of the things this project accomplished. It is utterly remarkable to what extent guano and nitrates were converted into both symbols and engines of progress: Peru's famous railroads, technical schools, museums, urban parks and infrastructure. New military installations repelled a bold attempt by Spain to recolonize coastal Peru. Guano also paid for the creation of a small but vibrant community of scientists and engineers based in Lima, many fleeing political unrest in Europe. From the very beginning, experts have been integral to the Peruvian Republic's ruling class. As we shall see in subsequent

7. This is the central finding of Paul Gootenberg, *Imagining Development: Economic Ideas in Peru's "Fictitious Prosperity" of Guano, 1840-1880* (Berkeley and Los Angeles: University of California Press, 1993); cf. Stuart McCook, *States of Nature: Science, Agriculture, and Environment in the Spanish Caribbean, 1760-1940* (Austin: University of Texas Press, 2002), esp. ch. 1.

chapters, they later decided to place even more trust in the abilities of experts in their quest for national development.

Merde en l'histoire

It is easy to poke fun at a history of coprology (the science of excrement)--or worse, dismiss it as trivial or uncouth for civilized discussion. City folk tend to view this foul substance with disdain or even fear, in view of its association with poverty and disease. Such attitudes have ancient roots in taboos governing religious purity. The Mosaic law commanded:

> Designate a place outside the camp where you can go to relieve yourself. As part of your equipment have something to dig with, and when you relieve yourself, dig a hole and cover up your excrement. For the LORD your God moves about in your camp to protect you and to deliver your enemies to you. Your camp must be holy, so that he will not see among you anything indecent and turn away from you.[8]

But in our secular age, these attitudes are more a reflection of how divorced urban, industrial existence (especially the urbane intellectual) has become from natural cycles and humanity's agrarian roots. Thus, the ecologically enlightened in our disposable society now have to read special books about "how to shit in the woods"

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8. Deut. 23:12-14 New International Version. Note that Victorian scientific traveler Clements Markham, the future president of the Royal Geographic Society, felt compelled to refer euphemistically to human "guano" used as fertilizer in Peru as "the kind mentioned in Deuteronomy 24:13"; Clements R. Markham, *Markham in Peru: The Travels of Clements R. Markham, 1852-1853*, ed. Peter Blanchard (Austin: University of Texas Press, 1991), 41. Cf. the Mesoamerican indigenous folklore on excrement described in Alfredo López Austin, *Una vieja historia de la mierda* (Mexico City: Ediciones Toledo, 1988).

to protect the wilderness from harm or to remind our children that "everyone poops."[9]

This separation is due, in large part, to the great success experts have had at manipulating natural processes for the rest of us. A major task experts have been asked to perform over time has been to hide, wash away, and otherwise protect us from the scourge of our own excreta. A few urban environmental historians have given admirable attention to the modern conquest of *merde* accomplished through the management of water, air, and human habits. During U.S. colonization efforts in the Caribbean and Philippines, for example, "marines and latrines" had an almost inseparable affinity, as hygienists sought to liberate locals (sometimes forcibly) from their own pollution. After World War II, the high failure rate of unregulated septic tanks in U.S. suburbia led to the intervention of experts and helped set the agenda for the U.S. environmental movement. The open sewer remains one of the most potent (and pungent) symbols of backwardness.[10]

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9. See Kathleen Meyer, *How to Shit in the Woods: An Environmentally Sound Approach to a Lost Art* (Berkeley, CA: Ten Speed Press, 1989); Taro Gomi, *Everyone Poops*, trans. Amanda Mayer Stinchecum (Brooklyn, NY: Kane/Miller Book Publishers, 1993).

10. In their quest for a "general" or "total" human history, the French *Annales* school has given the most attention to *merde en l'histoire*: see Dominique Laporte, *Historia de la mierda*, trans. Nuria Pérez de Lara (1978; Valencia, Spain: Pre-Textos, 1998); Jean-Pierre Goubert, *The Conquest of Water: The Advent of Health in the Industrial Age*, trans. Andrew Wilson (1986; Princeton, NJ: Princeton University Press, 1989); Alain Corbin, *The Foul and the Fragrant: Odor and the French Social Imagination* (1982; Cambridge, MA: Harvard University Press, 1986); André E. Guillerme, *The Age of Water: The Urban Environment in the North of France, A.D. 300-1800* (1983; College Station: Texas A & M University Press, 1988).

Histories dealing with the struggle to sanitize and "civilize" cities in the Americas include Martin V. Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present* (Baltimore, MD: Johns Hopkins University Press, 2000); Manuel Perlo Cohen, *El paradigma porfiriano: Historia del desagüe del Valle de México* (Mexico City: Miguel Ángel Porrua, 1999); Teresa A. Meade, *"Civilizing" Rio: Reform and Resistance in a Brazilian City, 1889-1930* (University Park: Pennsylvania State University Press, 1997); Sidney Chalhoub, *Cidade febril: Cortiços e epidemias na corte imperial* (São Paulo: Companhia das Letras, 1996).

Yet excretion is as fundamental to existence as eating. In fact, this history is based on the realization that many people have embraced excrement as useful stuff and concerned themselves with where it comes from--with its ecology--in order to obtain *more* of it for humankind.

All organisms need a variety of nutrients to grow. Nitrogen is one of the most important of these nutrients: It is vital to building chlorophyll for photosynthesis; it forms the chemical bonds between amino acids used to construct enzymes and all other proteins; and it constitutes part of the nucleic acid chains (DNA and RNA) that code for protein synthesis and genetic reproduction. Humans must directly consume nine essential amino acids that our body chemistry cannot synthesize independently. (Thus, the need to eat "complete proteins.") To get these nutrients, experts recommend that adult men and women consume 0.75 grams of protein per kilogram of weight per day for good health. Fast-growing infants need more than twice as much, and protein deficiency or kwashiorkor is one of the major nutritional problems facing the world's poorest children. In settled agricultural societies, the vast majority of these proteins (and the amino acids and

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A half-century ago, two U.S. historians noted the special link between sanitation and U.S. imperialism in the Caribbean, Merle Curti and Kendall Birr, *Prelude to Point Four: American Technical Missions Overseas, 1838-1938* (Madison: University of Wisconsin Press, 1954), esp. ch. 6; on the obsession of U.S. scientists and physicians with fecal pollution in the Philippines, see Warwick Anderson, "Excremental Colonialism: Public Health and the Poetics of Pollution," *Cultural Inquiry* 21 (Spring 1995), 640-669. On "septic-tank suburbia," see Adam Rome, *The Bulldozer in the Countryside: Suburban Sprawl and the Rise of American Environmentalism* (Cambridge, UK: Cambridge University Press, 2001), ch. 3

nitrogen they contain) have to come either directly from plant horticulture or from animals fed on these crops.[11]

In most environments, *usable* nitrogen is the nutrient persistently in shortest supply. Practically all nitrogen in the biosphere is tied up in its unreactive, molecular form (N_2). Even though it makes up 78 percent of the earth's atmosphere, nitrogen gas is extremely difficult to incorporate into other chemical compounds. It must first be converted to nitrogen oxides (NO_x), nitrate (NO_3^-), or ammonia (NH_3) to be used in biological systems. In intensively cultivated agro-ecosystems, crop plants will quickly run out of nitrogen in these forms unless it is returned to the soil somehow. Yellowing leaves and stunted growth are tell-tale signs that a plant is not getting the nitrogen it needs to form chlorophyll, much less protein-rich tissues. Meanwhile, a class of bacteria are constantly converting enormous quantities of usable nitrogen back to unreactive, molecular form in a process known as denitrification. Thus, ecologists speak of a "nitrogen cycle."

Humans still have no way to control lightning, the only inorganic phenomenon in nature that transforms significant amounts of nitrogen into an organically useful form. But for a long time, we have known how to manipulate two ecological processes for this purpose: 1) by planting leguminous plants (green manures) or wet paddies that take advantage of the ability of some symbiotic bacteria to "fix" atmospheric nitrogen; 2) by recycling organic waste to return nutrients to a system. More recently, scientists have figured out how to synthesize

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11. See National Research Council (U.S.), Subcommittee on the Tenth Edition of the RDAs, Food and Nutrition Board, Commission on Life Sciences, *Recommended Dietary Allowances*, 10th ed. (Washington, DC: National Academy Press, 1989), ch. 6.

nitrogen compounds directly using industrial processes. Phosphate (PO_4^{3-}), potassium (K^+)--and water (H_2O), of course--are other vital nutrients typically in short supply for agriculture.[12]

The recycling of animal manures was crucial to the maintainance of soil fertility in many traditional forms of intensive agriculture. After harvest, many Old World peasant societies typically set out their livestock to convert crop waste into nutrient-rich animal waste; their animal enclosures provided much greater dung concentrations whose trade could even be commercialized. West Indian planters, notorious for their supposed propensity toward "soil mining," not infrequently engaged in "dung farming" and other forms of manuring to maintain sugar cane production. But animal manure had its disadvantages: it degraded easily, required heavy labor to move, and demand routinely overshot supply. In early-modern Switzerland, a persistent manure shortage served to limit the development of grain agriculture, a struggle made even more challenging by the rapidly changing climatic conditions of the Little Ice Age.[13]

Because humans tend to eat a diet much richer in proteins than livestock, the use of human night soil and other household waste recycled nitrogen and other

12. Vaclav Smil, "Nitrogen and Phosphorus," in *The Earth as Transformed by Human Action*, 423-425; idem, *Enriching the Earth*, xiii-xiv.

13. Smil, *Enriching the Earth*, ch. 2, app. B; Fernand Braudel, *The Structures of Everyday Life: The Limits of the Possible*, vol. 1 of *Civilization and Capitalism, 15th-18th Century*, trans. Siân Reynolds (1979; New York: Harper & Row, 1981), 116-117; Christian Pfister, *Das Klima der Schweiz von 1525-1860 und seine Bedeutung in der Geschichte von Belvölkerung und Landwirtschaft*, vol. 1 of *Bevölkerung, Klima und Agrarmodernisierung 1525-1860* (Bern: Haupt, 1984); idem and Paul Messerli, "Switzerland," in *The Earth as Transformed by Human Action*, 644-645; David Watts, *The West Indies: Patterns of Development, Culture and Environmental Change since 1492* (Cambridge, UK: Cambridge University Press, 1987), 399-405, 425-428, 435, 444-446; idem, "Dung-Farming: A Seventeenth-Century Experiment in Agricultural Improvisation," *Barbados Museum and Historical Society Journal* 34 (1972), 58-63.

nutrients even more efficiently. In the Valley of Mexico, indigenous farmers of *chinampas* used human excrement to augment the fertility of these irrigated, raised fields. This practice helped maintain some of the highest population densities in the ancient world. After the Spanish conquest, Mexican *chinamperos* came to depend more on excrement from livestock newly introduced from the Old World. Remnants of such ancient customs are still visible in "dump heap" gardening among Mesoamerican peasants today. Crop plants grow so well in these disturbed environments that the great student of Mesoamerican economic botany Edgar Anderson, among others, came to believe that settled agriculture was born in the dump.[14]

In recent centuries, no one surpassed South Chinese farmers in recycling efficiency. In the Zhujiang (Pearl River) delta, the combined use of aquaculture, crop and excrement recycling supported an estimated 17 to 25 people per hectare, creating a large agricultural surplus for export. Early-modern European travelers in the region marveled at Chinese capabilities. Later, hygienically minded observers were horrified by the number of parasites typically acquired by night-soil users, not to mention their stench. It should also be noted that the very existence of this rich agricultural region was due in large part, not to local nutrient recycling, but to far-away highland clearance for swidden agriculture, massive erosion, and the build-up of silt in the delta from the eleventh to sixteenth centuries. As is so often the case,

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14. Ross Hassig, *Trade, Tribute, and Transportation: The Sixteenth-Century Political Economy of the Valley of Mexico* (Norman: University of Oklahoma Press, 1985), esp. 47-53; Edgar Anderson, *Plants, Man, and Life* (Boston: Little, Brown, 1952), ch. 9. Anderson was a disciple of the cultural geographer Carl Sauer, the father, in so many ways, of environmental history in the United States; see ch. 5.

one region's bounty was based on another region's poverty. This highlights the fact that unintentional relocation of nutrients by rivers, volcanos, and other processes has always been a factor in intensive agriculture, at least in some regions. Moreover, no *closed* recycling system without external inputs, no matter how efficient, can come close to conserving its nitrogen while maintaining maximum, short-term crop yields.[15]

Along with muck from riparian zones, forest leaves, and a few minerals, fish and marine algae were among the first agricultural nutrient additives extracted on a significant scale from another environment altogether. Fish fertilizer figures into stories of the first American Thanksgiving. William Bradford records that the Indian Squanto taught the New England Pilgrims how to plant maize. Squanto also "told them except they got fish" to fertilize it, their maize "would come to nothing, and he showed them that in the middle of April they should have store enough come up the brook; . . . all of which they found true by trial & experience." When Robert Cushman (my direct ancestor) and a group of additional colonists arrived "unexpected or looked for" in November 1621 after that first growing season, they fortunately found "plenty of victuals in every house," which Cushman took as evidence that Providence had prepared the land for European conquest. In fact, the recycling of fish scrap and market excess as fertilizer has age-old roots in Europe. This leads scholars to think Squanto taught the Plymouth colonists a practice he

15. Smil, *Enriching the Earth*, ch. 2, esp. p. 34; Robert B. Marks, *Tigers, Rice, Silk, and Silt: Environment and Economy in Late Imperial South China* (Cambridge, UK: Cambridge University Press, 1988), 66-83, 282-288.

learned while he was in enslaved by Europeans, not an indigenous practice born in the New World.[16]

By the end of the seventeenth century, areas of Japan already had a significant trade supplying dried fish as fertilizer. This practice was widespread in commercial agriculture by the time of the Meiji Restoration in 1868. In fact, one environmental historian believes "marine nutrients"--both as food and fertilizer--"may have been the key factor limiting demographic shrinkage after the 1720s, despite . . . persistent soil erosion and the shift of arable land to nonfood production." The conquest of the sea was vital to the eventual modernization of Japan, though night soil, plant waste, and other recycled nutrients remained important until the widespread adoption of chemical fertilizers in the 1920s.[17]

Such traditional techniques could support millions, but not billions of people. Since the late eighteenth century, a continuing revolution in agricultural practice has completely transformed the food-producing capacity of land and labor all over the world. Changes in land tenure and scientific knowledge, new crops and new machines tend to get most of the credit for this epochal shift. But this

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16. William Bradford, *Of Plimoth Plantation*, quoted in *Major Problems in American Environmental History: Documents and Essays*, ed. Carolyn Merchant (Lexington, MA: D. C. Heath, 1993), 69-70; Robert Cushman, "Reasons and Considerations Touching the Lawfullness of Removing Out of England into the Parts of America," in *American Environmental History*, ed. Louis S. Warren (Oxford: Blackwell, 2003); Lynn Ceci, "Squanto and the Pilgrims," *Society* 27:4 (1990), 40-44; idem, "Fish Fertilizer: A Native North American Practice?" *Science*, n.s., 4 Apr. 1975, 26-30; William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York: Hill and Wang, 1983), 45; Wines, *Fertilizer in America*, 8-9; Braudel, *The Structures of Everyday Life*, 157.

17. Conrad Totman, *Early Modern Japan* (Berkeley and Los Angeles: University of California Press, 1993), 150, 260-261, 272-274 [quote p. 274]; Penelope Francks, *Technology and Agricultural Development in Pre-War Japan* (New Haven, CT: Yale University Press, 1984), 30-31, 51, 59, 110, 123, 163-164, 251.

emphasis has less to do with the real forces driving change and more to do with our deification of entrepreneurs and "advanced" technologies as the cultivators of progress, a faith tied to our persistent belief that the Rise of the West was technologically driven, *autochtonous*, and inevitable.[18]

With the aid of a new class of agricultural scientists, humble animal dung and other fertilizers played a role no less significant in the transition from traditional, waste-recycling to modern, input-intensive forms of agriculture. More than one historian believes the crucial phase of this technological revolution "began with manures."[19]

The rapidly urbanizing and industrializing societies of nineteenth-century Europe and North America initiated this shift, or at least the part relevant to this particular history. Their development was hardly self-contained, however, as they had to look farther and farther afield for resources to fuel their growth. An

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18. Such bias has long pervaded the history of science and technology, as noted by Winner, *Autonomous Technology*, 225; and John M. Staudenmaier, "Comment: Recent Trends in the History of Technology," *American Historical Review* 95 (1990), 715-725. G. E. Fussell's survey, "The Agricultural Revolution, 1600-1850," in *Technology in Western Civiliztion: The Emergence of Modern Industrial Society, Earliest Times to 1900*, ed. Melvin Kranzberg and Carroll W. Pursell, Jr. (New York: Oxford University Press, 1967), 1:128-142, typifies this tendency derived from a narrow focus on regions bordering the North Atlantic, as does Peter D. McClelland, *Sowing Modernity: America's First Agricultural Revolution* (Ithaca, NY: Cornell Univ. Press, 1997). Contrast these to interpretations in global context: Daniel R. Headrick, "Technological Change," in *The Earth as Transformed by Human Action*, 61-63; J. M. Blaut, *The Colonizer's Model of the World: Geographical Diffusionism and Eurocentric History* (New York: Guilford Press, 1993).

19. F. M. L. Thompson, referring to various animal manures and oilseed cakes in "The Second Agricultural Revolution, 1815-1880," *Economic History Review*, n.s., 21:1 (Apr. 1968), 66; see also G. P. H. Chorley, "The Agricultural Revolution in Northern Europe, 1750-1880: Nitrogen, Legumes, and Crop Productivity," *Economic History Review*, n.s., 34:1 (Feb. 1981), 71-93, esp. 92. Contrast this to ecologically minded Ernest L. Shusky who utterly ignores the earlier inputs required to accomplish intensification in "Modern Agriculture: The Neocaloric," pt. 2 of *Culture and Agriculture: An Ecological Introduction to Traditional and Modern Farming Systems* (New York: Bergin & Garvey, 1989).

ecologist would call this tendency to exploit new resources, organisms, and environments *niche expansion*, an adaptive strategy typical of ecological generalists (rather than specialists), the category of species most capable of rapid, sustained population growth. This expansive capacity, particularly as it related to the vast ecological windfall that came with frontier conquest and overseas colonialism, was one of the secrets to the "great divergence" between the economies of Europe and China and between North and South during the modern era. Europe, the United States--and Japan, for that matter--could not have industrialized even close to the extent that they did without resources taken from less-developed regions.[20]

On both sides of the North Atlantic, this transition first involved the increasingly efficient transfer of animal wastes from the city back to the rural environment. In nineteenth-century Paris, suburban *marais* farms used the ready supply of urban horse dung to produce vast quantities of vegetables for Parisian consumers. Farmers in the Low Countries became so adept at recycling urban (especially human) waste that these techniques became widely known as the "Flemish system." U.S. cities provided horse manure and human night soil to nearby farms on a more limited scale, though they supplied vast quantities of dried blood, ground-up bone, and rendered slaughterhouse refuse as fertilizer. These systems still involved recycling, of course, as urban-dwelling humans and animals continued to depend significantly on food and fodder grown in the nearby

20. Pomeranz, *The Great Divergence*. As this viewpoint applies to the growth of a major U.S. city exploiting so-called internal frontiers, see William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York: W. W. Norton, 1991). On the niche concept, see Ernest Callenbach, *Ecology: A Pocket Guide* (Berkeley and Los Angeles: University of California Press, 1998), 80-81; Robert E. Ricklefs, *Ecology*, 3d ed. (New York: W. H. Freeman, 1990), ch. 35.

countryside. In recent years, rendered animal waste has instead been used directly as animal feed; the incorporation of nervous tissue in this waste allowed the fatal spread of bovine spongiform encephalopathy or “mad cow disease.”[21]

On the Atlantic seaboard of the United States, a full-fledged fish fertilizer industry based on menhaden (*Brevoortia tyrannus*) emerged in the 1850s, thanks in part to rising demand for fish oil (and petroleum) created by the failing supply of whale oil. After pressing out the oil, fish remains were ground up, dried, and sold as “fish guano,” a nod to the importance of Peruvian guano discussed below. Town folk objected to the vile fumes emitted by these factories and frequently forced them to close. This led a few crafty entrepreneurs to build floating plants that could be easily moved beyond the reach of authorities. Resource depletion became a serious problem by 1880, and a few menhaden fishermen returned to whaling--and marketed rendered whale remains as fertilizer. After the turn of the century, farmers diverted the supply of fishmeal to livestock when they discovered its great value as protein-rich feed. This pattern of recycling fishery waste as agricultural nutrients, then converting the fishery into a direct source of animal feed, then moving on to a new marine resource once the fish were depleted has been repeated many, many times. It turned California’s sardine canneries into industrial ghost towns, and it almost did the same to Peru’s gigantic fishmeal plants, as we shall see.[22]

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21. Smil, *Enriching the Earth*, 34; Richard A. Wines, *Fertilizer in America: From Waste Recycling to Resource Exploitation* (Philadelphia: Temple University Press, 1985), 22-33.

22. Wines, *Fertilizer in America*, 15, 88-95; Robert Lloyd Webb, “Menhaden Whalemen: Nineteenth-Century Origins of American Steam Whaling,” *American Neptune* 60:3 (2000), 277-288; Arthur F. McEvoy, *The Fisherman’s Problem: Ecology and Law in the California Fisheries, 1850-1980* (Cambridge, UK: Cambridge University Press, 1986), esp. 132.

Scientists played a fundamental role in the exploitation of a phosphate-rich source of animal waste that contributed to the breakdown of the old waste-recycling system. Early in the nineteenth century, British farmers (like U.S. farmers) started making extensive use of ground-up bone recycled from slaughterhouses, dead draught animals--and sometimes human cemeteries. By developing a means to liberate the insoluble phosphorus in bones and produce superphosphates, British agricultural chemists spawned modern fertilizer manufacture. This process made this vital nutrient much more available to plants. Scientists like John Bennet Lawes and Joseph Henry Gilbert helped turn this discovery into a profitable business by spending a great deal of effort promoting their agricultural value using experimental plots. But bones came nowhere near meeting phosphate demand, even with the importation of vast quantities all the way from the Argentine pampas. British producers turned to rich local deposits of coprolites, the fossilized feces of extinct, Tertiary-period animals, as their first major, non-recycled phosphate source. Entrepreneurs in the United States and other countries eventually followed the British lead. As the last step in the commercial exploitation of the Great Plains bison, North American companies paid disenfranchised Indians to gather up the bones of their one-time prey and ship them to the city for processing. In Canada, the Métis (a group sharing both European and indigenous ancestry) set large prairie fires to help them locate the bones.[23]

23. Wines, *Fertilizer in America*, ch. 7-9; Smil, "Nitrogen and Phosphorus," 431; idem, *Enriching the Earth*, 11-13, 56-57; Thompson, "The Second Agricultural Revolution," 69-70; Andrew C. Isenberg, *The Destruction of the Bison: An Environmental History, 1750-1920* (Cambridge, UK: Cambridge University Press, 2000), 159-162; LeRoy Barnett, "Buffalo Bone Industry in Canada," *Alberta History* 27:1 (1979), 10-16, 27:2 (1979), 6-13. See also Richard Grove, *The Cambridgeshire Coprolite Mining Rush* (Cambridge, UK: Oleander Press, 1976).

Humboldt's Current

None of these new inputs compared in fertilizing value to two new sources developed during the mid-nineteenth century along the extremely arid Pacific coast of South America: guano and nitrates. Scientists again played an important role in publicizing and creating a market for these valuable commodities.

Since ancient times, Peruvian farmers have recognized the fertilizing value of various animal manures--*huanu* to Quechua speakers. This valuable knowledge has never been totally forgotten by locals. In a well-known passage, the indigenous chronicler Garcilaso de la Vega (1539-1616) reported that the Inca and other indigenous Peruvians,

> fertilized the soil by manuring it, and in the valley of Cuzco and almost all the highland area they treated their maize fields with human manure [*huanu runap*], which they regarded as the best. They go to great trouble to obtain it, and dry it and pulverize it in time for the sowing season. In the [higher Sierra], . . . the climate is too cold for growing maize, and they sow potatoes and other vegetables: for this they use the manure of the Peruvian sheep [llamas and alpacas, *huanu huanacup*], which they regard as more beneficial than any other.
>
> On the seacoast, from below Arequipa to Tarapacá, . . . they use no other manure but the dung of sea birds [*huanu piscup*], of which large and small varieties occur . . . in such enormous flocks that they seem incredible to anyone who has not seen them. They breed on some uninhabited islands off the coast, where they deposit such an amount of dung that is no less incredible. From a distance the heaps of it look like the snowy crests of a range of mountains. . . . The dung of the sea birds produces great fertility. In other parts of the same coast, . . . they manure with the heads of sardines [*huanu challuap*] and use nothing else.

Twentieth-century conservationists loved to repeat de la Vega's account of the management of these bird colonies:

> In the times of the Inca kings these birds were so carefully watched that no one was allowed to land on the islands during the breeding season under pain of death, so that they should not be disturbed or driven from their nests. It was also illegal to kill them at any season either on the islands or elsewhere, under pain of the same penalty.
>
> Each island was assigned, on the Inca's instructions, to a certain province, . . . in which each village had its piece and each householder in the village his part, according to the quantity of manure he was reckoned to need . . . based on the requirements of his land.[24]

Eighteenth-century European scientific travelers routinely reported that "prodigious quantities" of "huano" were used for agriculture in many places along the Peruvian coast, and sometimes transported long distances. Local informants agreed that guano was the feces of marine birds, especially "Huanàes," and that the best-quality guano came from recently occupied bird colonies. In 1763, Juan Rehr's successor as viceregal cosmographer, Cosme Bueno, calculated the annual guano consumption of just one coastal province, Chancay, at approximately 90,000 fanegas (5,000 tons). Peru had a significant local guano industry, even a local guano science, long before its discovery by northerners.[25]

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24. Garcilaso de la Vega, El Inca, *Royal Commentaries of the Incas and General History of Peru: Part One*, trans. Harold V. Livermore (1609; Austin: University of Texas Press, 1966), 246-247. For Quechua terms, confirmed using modern dictionaries, see Markham, *Markham in Peru*, 41, 143. Cf. Robert E. Coker, "Peru's Wealth-Producing Birds," *National Geographic Magazine* June 1920, 541; William Vogt, "Informe sobre las aves guaneras por el ornitólogo americano Señor William Vogt," *BCAG* 18:3 (Mar. 1942), 38.

25. Commentators included Louis Feuillée, Amédée François Frézier, Jorge Juan and Antonio de Ulloa. For a summary of this early knowledge, see George Evelyn Hutchinson, "Survey of Existing Knowledge of Biogeochemistry: 3. The Biogeochemistry of Vertebrate Excretion," *Bulletin of the American Museum of Natural History* 96 (1950), 43-49; Antonio Raimondi, *Historia de la geografía del Perú: Libro primero*, vol. 2 of *El Perú* (Lima: Imprenta del Estado, 1876), 237, 312; Cosme Bueno, "Descripcion de las Provincias pertenecientes al Arzobispado de Lima," in *Conocimientos de los tiempos, Ephemeride del año de 1764* (Lima, 1763), 58-60.

Nineteenth-century Humboldtian scientists preferred to trust their own observations over the opinion of locals. It is unclear whether Alexander von Humboldt (1769-1859) actually landed on any of the guano islands during his famous five-year expedition to the "equinoctial regions of the New Continent." His encounter with the Grupo Huaura late in 1802 (if only from a distance) led him to believe that birds were somehow responsible for these deposits. Nevertheless, he could not imagine how the vast numbers of "cormorants, flamingos, and cranes [!]" he observed along the Peruvian coast could sustain Peruvian agriculture, since he estimated that they deposited only about one centimeter of excrement on the islands every 300 years. (Twentieth-century studies have shown that active colonies deposited more than this amount each breeding season.) He speculated that a geological catastrophe might have formed these organic deposits in a manner like the coal and lignite deposits of Europe.[26]

Humboldt's young Peruvian disciple, Mariano Eduardo de Rivero, did some experiments to test his mentor's conclusions. After comparing the chemical composition of ancient "red" and "brownish" guanos from the Islas Chincha with freshly produced "white" guano, Rivero concluded that all types of Peruvian guano came originally from birds. Moreover, he confirmed that locals harvested large amounts of manure from existing bird colonies year after year knowing that Peruvian farmers preferred fresh excrement and were willing to pay extra for it. He also recognized that this fresh guano supply tended to vary from year to year due to

26. Martin Heinrich Klaproth, "Chemische Untersuchung des Guano aus den Inseln der Peruanischen Küste," in *Beitrage zur chemischen Kenntnis der Mineralkörper* (Berlin: Heinrich August Rottmann, 1807), 4:303-306.

the presence or absence of birds. Following up Bueno's observations, Rivero calculated the annual consumption of just 18 haciendas in the Chancay valley at 33,600 fanegas (1,900 metric tons).[27] A later Swiss scientific traveler, Johann Jakob von Tschudi (1818-1889), reported Rivero's findings to an international audience. Tschudi was much more adept at ornithology than either Humboldt or Rivero. He concluded, based on field observations and a captive experiment, that individual birds were capable of producing at least 100 to 150 grams of guano per day. Nevertheless, the vast guano industry that developed after 1840 almost exclusively mined ancient accumulations of excrement. Thanks in large part to Humboldt, foreigners ignored the possibility of exploiting Peru's living population of guano birds until after 1890.[28]

From subsequent marine research, we know that the Peru Current provisioned this biological abundance. This "eastern boundary current" proceeds northwest along the Pacific coast of South America for nearly 4,000 kilometers from Valparaiso, Chile, past Punta Pariñas near the Peru/Ecuador border toward the

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27. By comparison, at the beginning of the 1910s, Chancay valley farmers consumed nearly the same amount of guano reported by Rivero in 1827; by 1950 they were purchasing seven times as much. During the 1910s, the larger region bought roughly twice the amount each year reported by Bueno in 1763; in 1956, the peak year for the twentieth-century Peruvian guano industry, this region consumed nine times the amount of 1763. See app. 7.

28. Mariano Eduardo de Rivero y Ustáriz, "Razón de las haciendas del valle de Chancay y las cantidades de fanegas de guano que él en el beneficio de sus tierras por año, sacado de las islas de Chincha y de Ancón," in *Colección de memorias científicas, agrícolas é industriales publicadas en distintas épocas* (Brussels: Imprenta de H. Goemaere, 1857), 1:171, originally published in *Memorial de ciencias naturales y de industria nacional y estranjera* (Lima) 1:2 (1828), 70; idem, "Memoria sobre el guano de pájaros del Perú," in *Colección de memorias*, 164-169, originally published as *Memoria sobre el guano de pájaros, y su uso en el Perú* (Lima: J. Ross, 1827); Johann Jakob von Tschudi, *Travels in Peru, on the Coast, in the Sierra, across the Cordilleras and the Andes, into the Primeval Forests*, trans. Thomasina Ross (New York: A. S. Barnes, 1854), 167-170; see also idem, *Ornithologie*, pt. 2 of *Untersuchungen über die Fauna peruana* (St. Gallen: Druck und Verlag von Schellen und Zollikofer, 1845-1846).

Islas Galapagos where it interacts with the equatorial current system. It is a consequence of the inertial motion of the South Pacific caused by the eastward rotation of the earth. This "Coriolis force" causes Pacific waters to slosh away from the equatorial coast of South America and back again far to the south along the southern coast of Chile in an immense counterclockwise gyre. Even more important for biological production is the prevailing southeast trade wind caused by upward atmospheric convection near the equator that pushes the surface water toward the northwest away from the South American coast. This produces a region of intense subsurface upwelling along most of the Peruvian littoral. These cool waters (which originate in the dark at mid-level depths below the photic zone where active photosynthesis takes place) pack heavy concentrations of chemical nutrients that have trickled down from above. Generations of ocean scientists have commented on the extraordinary coolness of these waters (15° to 22° Celsius on average) in comparison to the rest of the tropics. This is up to 8° below the global average for Peru's latitude (4°S to 17°S).[29]

Alexander von Humboldt is often unjustly credited with discovering the Peru Current because he was the first scientist recognized for taking direct sea-surface temperature measurements along the Peruvian coast. Humboldt incorrectly speculated that this cold water flowed in from the south all the way from the Antarctic. Circa 1840, against Humboldt's wishes, Heinrich Berghaus insisted on labeling this phenomenon the "Humboldt Current" in the Royal Prussian Maritime

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29. Warren S. Wooster, "Yearly Changes in the Peru Current," *Limnology and Oceanography* 6:2 (Apr. 1961), 222-226; Gerhard Schott, *Geographie des Indischen und Stillen Ozeans* (Hamburg: C. Boysen, 1935), charts 25, 26.

Atlas to glorify the scientific accomplishments of the German nation. The name stuck, partly because Peruvians welcomed this association between their country and one of history's great scientists. Of course, Humboldt's "discovery" had been common knowledge among sailors in the region for centuries.[30]

Unimaginably large numbers of phytoplankton feast on nutrients brought to the surface by upwelling, the real cause of this coolness. They serve as food for predatory zooplankton. These microscopic creatures, in turn, support enormous shoals of *anchoveta* (*Engraulis ringens*), a small, schooling species closely related to economically important fish known commonly as the anchovy, sardine, or pilchard. Before the advent of Peru's massive fishing industry after World War II, anchoveta and other plankton-grazing creatures fed a dazzling array of large predatory animals, including the tuna-like bonito (*Sarda chilensis*), Peruvian sea lions or *lobos del mar* (*Otaria flavescens*), and various cetaceans, such as the porpoise. New England whalers once frequented the port of Paita to hunt sperm whales (*Physeter catodon*) that lived in abundance in the upwelling regions of the eastern and central equatorial Pacific. Anchoveta also once fed a vast population of marine birds. The most important producers of guano, respectively, have all been species of the order Pelicaniformes: the *guanay* or Peruvian cormorant

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30. Schott, "Der Peru oder Humboldtstrom," *Forshungen und Fortschritte* 7 (1931), 373-377, translated as "Corriente Peruana o Corriente de Humboldt," *Revista de Marina* (Lima) 22 (1937), 322-328; idem, "Zur Frage: Peru-Strom oder Humboldt-Strom?" *Annalen der Hydrographie und Maritimen Meteorologie* 65 (1937), 73-75; Georg Wüst, "Humboldt-Strom, nicht Peru Strom," *Petermanns Geographische Mitteilungen* (1935), 439-441; Manuel Vegas Vélez, "La investigación oceanográfica en el Perú desde Humboldt a nuestros días," *Revista del Instituto de Estudios Histórico-Marítimos del Perú* (Lima) 6-7 (1983-1986), 139-140. Note that the Spanish-sponsored Malaspina expedition to the Pacific carried sea-surface thermometers when it visited Peru twice in the early 1790s; Virginia González Claverán, "La expedición Malaspina y su instrumental científico," *Quipu* 5 (1988) 143-160.

(*Phalacrocorax bougainvillii*), the *piquero* or Peruvian booby (*Sula variegata*), the *alcatraz* or Peruvian pelican (*Pelecanus thagus*) and, to a much lesser extent, the *camanay* or blue-footed booby (*Sula nebouxii*) (illus. 2-5). Except for the camanay, they tend to nest in large, concentrated colonies on islands and points along the coast of Peru and northern Chile.[31]

The combination of cool ocean water, prevailing onshore winds, and an extremely stable atmosphere gives these coasts one of the most arid climates in the world. During most years, the coast gets little more than a sprinkling of mist (*garua*). Nevertheless, this "arid" coast is extremely humid during the winter months and often overcast or foggy for weeks at a time, as generations of foreign visitors including Charles Darwin have lamented. This almost complete lack of precipitation prevents the breakdown of uric acid ($C_5H_4N_4O_3$) and the volatilization and leaching of water-soluble ammonia (NH_3) from guano deposits. Even strata hundreds of years old retained high concentrations of nitrogen.

31. On the natural history of the guano birds and their ecosystem, see D. Pauly and I. Tsukayama, eds., *The Peruvian Anchoveta and Its Upwelling Ecosystem: Three Decades of Change* (Callao, Peru: IMARPE, 1987); David Cameron Duffy, Coppelia Hays, and Manuel A. Plenge, "The Conservation Status of Peruvian Seabirds," in *Status and Conservation of the World's Seabirds*, ed. J. P. Croxall, P. G. H. Evans, and R. W. Schreiber (Cambridge, UK: International Council for Bird Preservation, 1984), 245-259; Robert Cushman Murphy, *Oceanic Birds of South America* (New York: MacMillan, 1936), esp. 1:94-108, 2:819-846, 899-909; idem, *Bird Islands of Peru: The Record of a Sojourn on the West Coast* (New York: G.P. Putnam's Sons, 1925), esp. ch. 3-4. In his recent study of three families of the Pelicaniformes, Paul A. Johnsgard classifies the guanay as a shag (*Leucocarbo bougainvillii*) and the Peruvian pelican as a subspecies of the brown pelican (*Pelicanus occidentalis*) common in North America; *Cormorants, Darters, and Pelicans of the World* (Washington, DC: Smithsonian Institution Press, 1993), 249-252, 387-397. Lobos del mar have also been classified alternatively as *O. byronia* and sperm whale as *P. macrocephalus*.

The Guano Age

A small sample of guano numbered among the thousands of specimens in Alexander von Humboldt's possession after he returned to Europe. He passed it on to French chemists whose published analyses revealed its high nitrogen and phosphate content. As a consequence, Humboldt usually gets credit for "discovering" guano. For many years, a handful of export promoters in Peru and abroad tried to drum up interest in this new manure source, occasionally by sending small consignments to set up crop experiments in the North. According to an 1824 article in *The American Farmer*, the leading voice for agricultural improvement in the United States, "From the composition of the guano, it is easy to conclude its fertilizing properties, and it must be judged to be a powerful manure." It added, "The naturally sterile coasts of Peru, owe their fertility" to this substance.[32]

Then, the German chemist Justus von Liebig published *Organic Chemistry in Its Application to Agriculture and Physiology* (1st ed., 1840). It found a ready international audience and became, almost overnight, one of the most influential scientific texts ever written. Liebig strongly emphasized the importance of nitrogen for agriculture and the necessity of fertilizer inputs, though ironically in

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32. Antoine François Fourcroy and Louis Nicolas Vauquelin, "Guano, ou sur l'engrais naturel del îlots de la mer du Sud, près des côtes du Pérou," *Memoires de l'Institut des Sciences, Lettres et Arts: Sciences Mathématiques et Physiques* 1:6 (1806), 369-385; "Guano--A Celebrated Manure Used in South America," *The American Farmer* (Baltimore) 24 Dec. 1824, 316-317; Raimondi, *Historia de la geografía del Perú: Libro Segundo*, vol. 3 of *El Perú* (Lima: Imprenta del Estado, 1879), 15, 20; Wines, *Fertilizer in America*, 34-35; Klaproth, "Chemische Untersuchung des Guano," 4:299-313; Jimmy M. Skaggs, *The Great Guano Rush: Entrepreneurs and American Overseas Expansion* (New York: St. Martin's Press, 1994), 5. For an example of Peruvian promotion, see Rivero, "Memoria sobre el guano de pájaros del Perú."

light of what happened next, he discounted the need to apply nitrogen-rich manures.[33]

Though the excitement over Liebig's book surely helped, clever marketing initiated the guano boom. In the late 1830s, Francisco Quirós y Ampurdia (1798-1862), a long-time promoter of European entrepreneurial ventures to restore the mines of his hometown Cerro de Pasco, Peru's principal highland mining center, began to turn his attention toward lowland development. In 1840, he orchestrated a deal between a group of French traders in Lima, a Liverpool merchant house, and the Peruvian government to commercialize the export of guano. In 1841, this partnership exported over 8,000 metric tons of guano to Great Britain (fig. 1). Other groups quickly jumped into the trade. The international propaganda campaign that followed touting guano's value as a fertilizer completely blurred the boundary between science and salesmanship. By December 1844, guano was being shipped in commercial quantities via England to the United States, and soon as far as the sugar cane plantations of Barbados and Mauritius.[34]

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33. Justus Freiherr von Liebig, *Organic Chemistry in Its Application to Agriculture and Physiology*, trans. Lyon Playfair (London: Taylor & Walton, 1840), originally published as *Die organische Chemie in ihrer Anwendung auf Agricultur und Physiologie* (Braunschweig: F. Vieweg und Sohn, 1840); Margaret W. Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880* (New Haven, CT: Yale University Press, 1975), 12-13, 25, 49-50, 172-177; Smil, *Enriching the Earth*, 6-10, 41-42, 255 n. 26. See also William H. Brock, *Justus von Liebig: The Chemical Gatekeeper* (Cambridge, UK: Cambridge University Press, 1997).

34. *Diccionario histórico y biográfico del Perú*, s.v. "Quirós y Ampurdia, Francisco"; W. M. Mathew, "Foreign Contractors and the Peruvian Government at the Outset of the Guano Trade," *HAHR* 52:4 (Nov. 1972), 598-620; idem, "Peru and the British Guano Market, 1840-1870," *Economic History Review*, n.s., 23:1 (Apr. 1970), 113-114; Wines, *Fertilizer in America*, 34-36; Jonathan V. Levin, *The Export Economies: Their Pattern of Development in Historical Perspective* (Cambridge, MA: Harvard University Press, 1960), 48-59; William Kelleher Storey, *Science and Power in Colonial Mauritius* (Rochester, NY: University of Rochester Press, 1997), 35. David Watts estimates Barbados's guano consumption at 4,000 to 7,000 metric tons per year during the

All told, from 1840-1880, Peru exported an estimated 12.7 million metric tons of guano from its islands with a sale value in the range of £150 million. This amount of guano contained approximately 1.6 million metric tons of nitrogen, similar quantities of phosphate and lime (CaO), 300,000 metric tons of potash (K_2O), and smaller amounts of manganese, iron, and other trace elements necessary for plant growth. Even though its nutrients were not balanced to true agricultural needs, Peruvian guano was the most complete, most concentrated fertilizer available on the world market for decades. British farmers purchased the lion's share, followed by German, U.S., and other European agriculturists. During the 1870s, plantations in Cuba, Puerto Rico, and other Caribbean colonies, Mauritius, and China together bought 134,000 metric tons. Thus, the Peruvian guano trade became truly global, though it strongly favored northwestern Europe.[35]

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mid-1850s when world sugar prices experienced a temporary spike, *The West Indies*, 495, 497, 551 n. 44.

35. See app. 1. My estimates of total nutrient exports are based on Shane J. Hunt's export estimates, Hutchinson's digest of nineteenth-century nutrient content analyses, and Antonio Raimondi's contention that practically all guano before 1869 (around nine million metric tons by the time deposits ran out in 1870) came from the Islas Chincha. Note that Hunt's estimates fit well with Raimondi's and take losses during loading into consideration: Hunt, "Price and Quantum Estimates of Peruvian Exports, 1830-1862" (Discussion paper no. 33, Research Program in Economic Development, Woodrow Wilson School of Public and International Affairs, Princeton University, 1973), 42-49, table 21; Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 82-86; Raimondi, "Islas, islotes y rocas del Perú: (De los manuscritos del Naturalista Italiano Antonio Raimondi," *BSGL* 63:1-2 (1946), 12-21, esp. p. 17.

Value estimates are based on British wholesale prices reported by Mathew, "Peru and the British Guano Market," 117, 120; Robert G. Greenhill and Rory M. Miller, "The Peruvian Government and the Nitrate Trade, 1873-1879," *JLAS* 5:1 (May 1973), 110-111, tables 1-2. They ranged from £10-14 per English ton. Retail dealers in England charged up to 20 percent more. Lower prices may have reigned in other countries. In the United States, wholesale prices varied from as low as US$45 in the mid-1840s to as high as US$90 per long ton in 1872, but tended to hover in the US$55-60 range; Wines, *Fertilizer in America*, 49-51.

Smil's statistics on Peruvian guano are wildly inaccurate for both the nineteenth and twentieth centuries, *Enriching the Earth*, 40-43, app. F; note also that Mathew's estimates of British imports seem much too low when compared to Peruvian export estimates. Cf. Heraclio Bonilla, "La

Scientific theory and promotional claims aside, the adoption of this new manure source was only a small step from applying urban waste, bone meal, and other recycled inputs to increase crop output. Farmers who experimented with guano could see obvious results long before harvest, especially with young plants, and it worked wonders with a variety of crops, soil types, and moisture conditions. Nevertheless, its adoption was concentrated among certain crops and regions. In the United States, most guano went to farms close to big cities, like those on western Long Island, that were already integrated into an urban-rural waste recycling system. These farms were profitable enough to afford such an expensive input. Around the Chesapeake Bay, guano allowed grain farmers to go back to "forcing" worn-out lands with manure, as tobacco planters had done during the early colonial period before adopting a system of long-fallow shifting cultivation dependent on slavery. During the Guano Age, Chesapeake farmers converted large swaths of regrown pine scrub to plowed agriculture. Antebellum farmers in the Deep South showed great interest in Peruvian guano; some plantation owners close to major ports used it on a large scale. Most cotton planters, however, continued to prefer a three-field rotation system integrating maize, green manures, and swine. Though Peruvian guano prepared the way, the South's true "guano craze" happened after the Civil War and primarily involved phosphatic guanos extracted elsewhere in the world.[36]

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coyuntura commercial del siglo XIX en el Perú," *Revista del Museo Nacional* (Lima) 35 (1967-1968), 159-187; J. M. Rodríguez, "Historia de los contratos del guano y sus efectos en las finanzas del Perú," *La economista peruano* 6:145 (1921), 85-129.

36. Wines, *Fertilizer in America*, 36-42, 47-53; Carville Earle, "The Myth of the Southern Soil Miner: Macrohistory, Agricultural Innovation, and Environmental Change," in *The Ends of the Earth: Perspectives on Modern Environmental History*, ed. Donald Worster (Cambridge, UK:

The majority of British purchases (and, therefore, the biggest share of all Peruvian guano) went to turnips, swedes, and grass--that is, for cattle forage. Instead of increasing the production of agricultural staples for Britain's exploding population, much less to help reduce Ireland's population hemorrhage after the potato famine of the mid-1840s, guano primarily benefited meat and dairy consumers. (Contrary to the advice of agronomists at the time, cereal farmers disliked the surplus straw they got when using guano and feared that guano depleted the soil in other ways--which it did, indirectly, because of its unbalanced nutrients. Cereal growers did benefit from the increased supply of cattle manure, however.) Peruvian guano thus helped initiate a trend away from cereal cultivation in Britain that only intensified toward the end of the nineteenth century with massive importation of wheat from the disappearing temperate grasslands of North and South America. As early as 1872, the *Agricultural Economist* was asking English farmers, "why grow corn at all?" Guano made it possible for the world's relatively affluent to eat higher on the food chain during the nineteenth century, a preview of events described in chapters 7-8.[37]

To the later chagrin of Peru's ruling class, guano also smoothed the way for the adoption of other new fertilizers. More than any other substance, guano

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Cambridge University Press, 1988), 175-210; Weymouth T. Jordan, "The Peruvian Guano Gospel in the Old South," *Agricultural History* 24 (Oct. 1950), 211-221. Cf. Avery O. Craven, *Soil Exhaustion as a Factor in the Agricultural History of Virginia and Maryland, 1606-1860*. Urbana: University of Illinois Press, 1925).

37. Mathew, "Peru and the British Guano Market," 112-116, 122, 125; T. W. Fletcher, "The Great Depression of English Agriculture 1873-1896," *Economic History Review*, n.s., 13:3 (1961), 418-419, 422, 424; Chorley, "The Agricultural Revolution in Northern Europe," passim; cf. Peter Gray, *Famine, Land and Politics: British Government and Irish Society, 1843-50* (Dublin: Irish Academic Press, 1999).

displaced the old system of waste recycling, and it accelerated the trend whereby farmers on both sides of the North Atlantic, even tropical plantations, became dependent on external inputs. By encouraging what economists and ecologists call *throughput*--one-way patterns of production, consumption, and waste--rather than recycling, it made farm operations much more like those of the factory. Though it took many decades to accomplish, expert agronomists slowly gained influence over these operations in the name of agricultural efficiency. Together, these factors gradually created an entirely new technological--and ecological--system surrounding intensive agriculture. By itself, guano did not represent a radical departure from the fertilizers that preceded it. Nevertheless, its use reinforced a series of new practices, the sum of which was revolutionary in scope. In so many ways, modern industrial life, especially that of Britain's new class of privileged "beefeaters," flourished on the concentrated nutrients provided by guano.[38]

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38. On the adoption of guano and its impact on agricultural systems in Britain and the United States, see Wines, *Fertilizer in America*, 162-174; Thompson, "The Second Agricultural Revolution," esp. 64. On guano's influence in the decline of older manuring practices on Caribbean plantations, their relation to slave emancipation, and the general relation between environmental and economic pressures, see Watts, *The West Indies*, 499, 512-513, 538. On throughput, see Callenbach, *Ecology: A Pocket Guide*, 63-64, 114.

This systems approach to technological innovation has had a major impact on the historiography of industrialization; see Staudenmaier, "Recent Trends in the History of Technology," 717-719; Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore, MD: Johns Hopkins University, 1983); David Hounshell, *From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States* (Baltimore, MD: Johns Hopkins University Press, 1985). Unfortunately, such studies may be in danger of reinforcing the false, nationalistic belief that the industrialization of the United States was largely autochtonous; see idem, "Rethinking the History of 'American Technology,'" in *In Context: History and the History of Technology: Essays in Honor of Melvin Kranzberg*, ed. Stephen H. Cutcliffe and Robert C. Post (Bethlehem, PA: Lehigh University Press, 1989), 216-229.

Likewise, guano had a broad impact on coastal Peru. The Peruvian government lost little time in nationalizing ownership of this valuable resource so it could charge royalties on its extraction and control its export. Guano export duties soon became Peru's largest source of external income. The guano trade created a huge financial windfall, the largest share of which went to service a growing internal and international debt and enrich the financiers of the nascent Peruvian Republic. A significant chunk went to fund the military during this age of instability, and to build railroads, great wonders of modern engineering designed to connect the mining, agricultural, and population centers of the Andes to the Pacific coast--including the two highest railways ever built anywhere in the world. These changes fostered a confident, progressive, even utopian mentality among Peru's emerging coastal plutocracy. For all these reasons, the period 1840-1879 has come to be known as Peru's "Guano Age."[39]

39. The Peruvian nationalist historian Jorge Basadre originally coined this descriptor. A huge historical literature exists for Peru's *Edad del Guano*, much of it concerned with Peru's insertion into the global economy. For a historiographic introduction, see Gootenberg, *Imagining Development*, ch. 1; on Peru's political economy, see idem, *Between Silver and Guano: Commercial Policy and the State in Postindependence Peru* (Princeton, NJ: Princeton University Press, 1989); on guano's economic impact, see Shane Hunt, "Growth and Guano in Nineteenth-Century Peru," in R. Cortés Conde and Shane J. Hunt, eds., *The Latin American Economies: Growth and the Export Sector, 1830-1930* (New York: Holmes and Meier, 1985), 255-319; on the role of the guano trade in the (failed) formation of a national bourgeoisie to rule Peru, see Heraclio Bonilla, *Guano y burguesía en el Perú* (Lima: Instituto de Estudios Peruanos, 1974); for an opposing view on the formation of elite ideology, see Mc Evoy, *La utopía republicana*, ch. 1-3. Jonathan Levin, in *The Export Economies: Their Pattern of Development in Historical Perspective* (Cambridge, MA: Harvard University Press, 1960), presented the Peruvian guano trade as a classic historical case of an enclave "export economy" in the "unindustrialized portion of the globe." His interpretation attained great influence during the 1960s in the context of the "modern revolt" against narrow dependence on raw material exports and "frustrated economic development." His work has since been revised almost beyond recognition by the above writers.

Guano Imperialism

Shock waves from this seismic shift in the global economy impacted many other parts of the biosphere as the world's imperial nations searched for new sources of guano, laborers to work them, and ways to control its supply. This search was intimately tied with forms of "ecological imperialism," including the "world hunt" for valuable wild organisms and ecological invasions species accompanying humans on their travels.[40] Scientists (sometimes unwittingly) played a significant supporting role in this conquest.

Based on reports of large marine bird colonies from hunters involved in annihilating the southern fur seal (*Artocephalus australis*), ships rushed from the North Atlantic to the arid, southwestern coast of Africa in search of guano islands like those in Peru. From 1843-1845, as many as 300,000 metric tons of nitrogenous guano were rapidly exhausted from Ichaboe and other islands in this region for sale in Great Britain. This flood depressed prices in the short term and inspired merchants of Peruvian guano to divert part of their supply to the United States. Lower prices and broader distribution convinced many additional consumers to give guano a try, and this rapidly expanded its market.[41]

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40. Classic discussions of these issues include Alfred W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (Cambridge, UK: Cambridge University Press, 1986); Charles S. Elton, *The Ecology of Invasions by Animals and Plants* (London: Methuen, 1958). On the world hunt, see John F. Richards, *The Unending Frontier: An Environmental History of the Early Modern World* (Berkeley and Los Angeles: University of California Press, forthcoming); John M. MacKenzie, *The Empire of Nature: Hunting, Conservation, and British Imperialism* (Manchester, UK: Manchester University Press, 1988); Farley Mowatt, *Sea of Slaughter* (Toronto: McClelland and Stewart, 1984).

41. Wines, *Fertilizer in America*, 54-55; Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 134-157; Arthur C. Watson, "The Guano Islands of Southwestern Africa," *The Geographical Review* 20:4 (1930), 631-641; Mathew, "Peru and the British Guano Market," 114.

Unsatisfied with Peruvian state control of the guano supply, in the early 1850s, speculators tried to convince the British and U.S. governments to send gunboats to the northern coast of Peru so they could extract guano from the Islas Lobos without paying export taxes. In an expansive mood after the spectacular triumph over Mexico in 1848, U.S. Secretary of State Daniel Webster offered his support, but the Peruvian navy preempted this by stationing several warships to protect these islands from "Yankee pirates."[42] North American entrepreneurs then targeted the Galápagos (until it was discovered they had no guano deposits) and tiny bird islands in the Caribbean. Information gathered by sperm whalers and the "Wilkes" Exploring Expedition of 1838-1842--the United States' first major foray "to extend the empire of commerce and science" by sea--proved vital to the search for bird colonies in remote sections of the central equatorial Pacific.[43] The U.S. Congress passed the Guano Island Act of 1856 to legitimate their territorial claims. U.S. companies eventually extracted around 500,000 metric tons of phosphate-rich guano from Baker and Jarvis atolls, the first of several Pacific islands annexed by the United States under the act. (We now know that periodic torrential rains caused

42. Markham, *Markham in Peru*, 6; Skaggs, *The Great Guano Rush*, ch. 2; Wines, *Fertilizer in America*, 56-58; Dan O'Donnell, "The Lobos Islands: American Imperialism in Peruvian Waters in 1852," *Australian Journal of Politics and History* 39:1 (1993), 37-55.

43. U.S. Secretary of the Navy to Lt. Charles Wilkes, 1838, quoted in John P. Harrison, "Science and Politics: Origins and Objectives of Mid-Nineteenth Century Government Expeditions to Latin America," *HAHR* 35:2 (May 1955), 180; Skaggs, *The Great Guano Rush*, 68-69. Such expeditions played a major role in U.S. territorial expansion into Mexico and overseas, as well as the "launching" of U.S. science; see Paula Rebert, *La Gran Línea: Mapping the United States-Mexico Boundary, 1849-1857* (Austin: University of Texas Press, 2001); Robert V. Bruce, *The Launching of American Science, 1846-1876* (New York: Alfred A. Knopf, 1987), ch. 15; William Stanton, *The Great United States Exploring Expedition of 1838-1842* (Berkeley and Los Angeles: University of California Press, 1975); William H. Goetzmann, *Exploration and Empire: The Explorer and Scientist in the Winning of the American West* (New York: Alfred A. Knopf, 1966).

by the El Niño phenomenon leached the nitrogen from the marine-bird deposits in this normally arid equatorial region.) This initiated an international race to claim even the remotest specks of land in the Pacific, and led eventually to the discovery of vast mineral phosphate deposits on populated Nauru, Banaba (Ocean), and Makatea islands.[44]

The United States started its formal colonization of the Caribbean and Pacific by seizing several islands under the Guano Island Act. In 1858, for example, it used a gunboat to forcibly take possession of Navassa (La Navase) Island from the black Republic of Haiti. U.S. companies removed well over 700,000 metric tons of mineral phosphate (not organic bird guano as is commonly believed) from this island for processing into superphosphate in Philadelphia and Baltimore. In all, the United States officially laid claim to 66 territories under the Guano Island Act, nine of which are still official possessions. U.S. companies only mined about twenty of these islands, since after the Civil War they increasingly came to rely for phosphate on rich mineral deposits in South Carolina and Florida.[45]

In the mid-1860s, Spain tried to exercise this same sort of gunboat diplomacy against Peru itself. Soon after Spain reconquered Santo Domingo and briefly helped the French install an Austrian noble as ruler of Mexico, three Spanish frigates abruptly abandoned the Spain's Scientific Commission to the

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44. Wines, *Fertilizer in America*, 61-66; Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 160-195, 208-222; Skaggs, *The Great Guano Rush*, ch. 3-5.

45. Skaggs, *The Great Guano Rush*, 99-104, 150-152, 199-200, 230-236; Wines, *Fertilizer in America*, 58-61, 66-70; Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 323-325; Smil, "Nitrogen and Phosphorus," 431; Dan O'Donnell, "The Pacific Guano Islands: The Stirring of American Empire in the Pacific Ocean," *Pacific Studies* 16:1 (1993), 43-66.

Pacific and seized the Islas Chincha by force. These "scientific" craft were quickly joined by a Spanish naval blockade.[46] Peru responded by transferring its foremost resident technician, the Polish engineer Ernest Malinowski, from building railroads to organizing a defense. He was joined in this endeavor by a Peruvian engineer and a Colombian who, like Malinowski, had been trained at France's École Polytechnique. Their artillery placements and Peru's new steam-powered gunboats repelled Spain's bombardment of Callao, disabled its most modern warship, and sank Spain's pretensions of recolonizing South America. No northern power ever

46. The Spanish Comisión Científica del Pacífico, much like the French Comission Cientifique du Mexique and official U.S. forays into the region, vividly illustrates the reemergence of an association between science and colonialism in the Americas during the mid-nineteenth century--a movement which gave birth to the idea that a place called "Latin" or "Hispanic America" even exists as a natural geographical entity or "continent." On these points, see Robert Ryal Miller, *For Science and National Glory: The Spanish Scientific Expedition to America, 1862-1866* (Norman: University of Oklahoma Press, 1968), esp. 10, 106-110; Leoncio López-Ocón Cabrera, "La Comisión Científica del Pacífico (1862-1866) y la Commission Scientifique du Mexique (1864-1867): Paralelismos y divergencias de dos proyecciones latinoamericanas de la ciencia europea," *De la ciencia ilustrada a la ciencia romántica: Actas de las I Jornadas sobre «España y las expediciones científicas en América y Filipinas»*, comp. Ateneo de Madrid (Madrid: Ediciones Doce Calles, 1995), 459-469; Marcos Cueto, "La ciencia peruana y la Comisión Científica del Pacífico," in *De la ciencia ilustrada a la ciencia romántica*, 451-457; Miguel Ángel Puig-Samper, "Románticos y nacionalistas: La Comisión Científica del Pacífico (1862-1866)," in *La ciencia española en ultramar: Actas de las I Jornadas sobre «España y las expediciones científicas en América y Filipinas»*, comp. Ateneo de Madrid (Madrid: Ediciones Doce Calles, 1991), 335-345; idem, *Crónica de una expedición romántica al Nuevo Mundo: La Comisión Científica del Pacífico* (Madrid: Consejo Superior de Investigaciones Científicas, 1988); López-Ocón and Puig-Samper, "Los condicionantes políticos de la Comisión Científica del Pacífico: Nacionalismo e Hispanoamericanismo en la España Bajoisabelina (1854-1868)," *Revista de Indias* 47 (1987), 667-684; John Leddy Phelan, "Pan-Latinism, French Intervention in Mexico (1861-1867) and the Genesis of the Idea of Latin America," in *Conciencia y autenticidad históricas: Escritos en homenaje a Edmundo O'Gorman, emerito, aetatis anno LX dicata*, ed. Juan A. Ortega y Medina (Mexico City: Universidad Nacional Autónoma de México, 1968), 123-177. Cf. Martin E. Lewis and Kärin E. Wigen, *The Myth of Continents: A Critique of Metageography* (Berkeley and Los Angeles: Univeristy of California Press, 1997).

again tried to control the Peruvian guano trade by military force, though such independence came at great monetary expense for Peru.[47]

Meanwhile, in its quest for laborers to man the guano mines and its booming coastal agricultural sector, Peruvians engaged in an imperialist enterprise of its own that reached all the way to the other side of the Pacific. In 1854-1855, the Peruvian state used receipts from the guano trade to end the payment of tribute by indigenous peoples and to compensate owners for the abolition of black slavery, thus eliminating major sources of coerced labor and government tax income. Francisco Quirós, the founder of the guano trade, supervised the slaves' emancipation for the Peruvian state. Like their counterparts in the Caribbean, California, Mauritius, Australia, and South Africa, Peruvian entrepreneurs looked to China to augment their coastal labor supply. From 1847-1874, Peruvians contracted over 92,000 "coolies," primarily from South China via Portuguese Macao, who had been displaced by progressive environmental degradation, imperialist intrusion, and political unrest. About ten percent died on the long voyage across the Pacific and never even made it to Peru. Most ended up on coastal plantations, but thousands died as virtual slaves working alongside convicts in the harsh conditions of the guano islands. Floggings were routine. Dozens committed suicide. The guano industry became synonymous with brutality. British humanitarians voiced their outrage against this new form of "yellow slavery." Their campaign put a stop to the Hong Kong coolie trade, but their

47. Danuta Bartkowiak, *Ernesto Malinowski: Constructor del ferrocarril transandino, 1818-1899* (Lima: Fondo Editorial del Banco Central de Reserva del Perú, 1998), ch. 9.

homeland kept benefiting from the opium trade and importing guano--as well as gold, sugar, coffee, and other products produced by slaves. In the early 1870s when Chinese immigration reached its peak, labor unrest became commonplace on the guano islands. As late as the 1920s, visitors still could not help but notice a grisly relic of the Age of Guano: "the dismal spot . . . at every island--the Chinese graveyard--where garments, detached bones, and twisted corpses of poor coolies have for many years been exposed to the merciless sun."[48]

Similar horrors were visited on other Pacific islanders by labor contractors. In a racist attempt to substitute "noble savages" for Asian immigrants and provide Peruvian coastal planters with enough workers to supply the international demand for cotton during the U.S. Civil War, in 1862-1863 over 30 South American ships embarked for the south-central Pacific in search of human cargoes. They cajoled, tricked, or kidnapped at least 3,600 "colonists" who were brought to Peru for sale. Contrary to popular belief, only a tiny handful could have ended up on the guano islands, despite the best attempts of the contractors. International humanitarian pressure (in the context of the Spanish blockade) put an end to this practice, but few islanders ever returned home, despite their mandated repatriation. Those who did transferred smallpox, dysentery, and other crowd diseases to these once isolated

48. Murphy, *Bird Islands of Peru*, 314 [quote]; Mathew, "A Primitive Export Sector: Guano Production in Mid-Nineteenth-Century Peru." *JLAS* 9:1 (May 1977), 40-48; Contreras and Cueto, *Historia del Perú contemporáneo*, 127-136; Levin, *The Export Economies*, 85-90, 130-132; Michael J. Gonzales, *Plantation Agriculture and Social Control in Northern Peru, 1875-1933* (Austin: University of Texas Press, 1985), ch. 5; Watt Stewart, *Chinese Bondage in Peru: A History of the Chinese Coolie, 1849-1874* (Durham, NC: Duke University Press, 1951), passim; Cecilia Méndez G., *Los trabajadores guaneros del Perú, 1840-1879* (Lima: Universidad de San Marcos, 1987). On environmental factors that contributed to South Chinese unrest and emigration, see Marks, *Tigers, Rice, Silk, and Silt*, 333-345.

habitats. On Easter Island (Rapa Nui) approximately 58 percent of its 4,100 inhabitants died or disappeared during the 1860s, another in a long series of ecological tragedies that have hit this remote island. The forces of "European biological expansion" thus arrived at the hands of South Americans, paving the way for formal Chilean colonization and the invasion of sheep herds. Conditions among "free" African-Americans and Hawaiians working on guano islands elsewhere in the world were little better.[49]

In the meantime, the Peruvian state made a valiant attempt to estimate how long the guano bonanza would last, so it could negotiate loans based on future receipts and make some plans for how to spend this windfall. Early guesses ranged as high as 117 million tons for the Chincha Islands alone. In 1845, the more reasonable Mariano de Rivero lowered this outrageous figure by 100 million. In 1853, the European-educated plantation owner who initiated the coolie trade, Domingo Elías (1805-1867), caused an enormous stir when he reported that only 6 million tons of guano remained on the Islas Chincha. He did this in part to manipulate his lucrative guano-loading contract. But this move was part of Elías's long campaign to undermine the existing conservative government and its policy to use guano receipts to consolidate Peru's massive internal debt. Within a week, the

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49. H. E. Maude, *Slavers in Paradise: The Peruvian Slave Trade in Polynesia, 1862-1864* (Stanford, CA: Stanford University Press, 1981), esp. 183-194; Skaggs, *The Great Guano Rush*, 163-169, ch. 10; J. R. Flenley, et al., "The Late Quaternary Vegetational and Climatic History of Easter Island," *Journal of Quaternary Science* 6 (1991), 85-115; Clive Ponting, "The Lessons of Easter Island," ch. 1 of *A Green History of the World: The Environment and the Collapse of Great Civilizations* (New York: Penguin Books, 1993); Levin, *The Export Economies*, 132-133. On the impact of "virgin soil epidemics" and other ecological invasions in the South Pacific, see J. N. Hays, *The Burdens of Disease: Epidemics and Human Response in Western History* (New Brunswick, NJ: Rutgers University Press, 1998), 184-190; Crosby, *Ecological Imperialism*.

Peruvian executive--a follower of Bartolomé Herrera and his vision of an "aristocracy of knowledge"--hired an expert commission to study the deposits and working conditions on the Islas Chincha. Its members included the aging co-founder of the Peruvian Republic's first scientific journal and natural history museum, Nicolás Fernández de Piérola (1788-1857), the newly arrived French engineer Charles Fraguett, and a recent immigrant from war-torn Milan, the young naturalist-revolutionary Antonio Raimondi. Using relatively quick stratigraphic surveys instead of impractical core samples, they estimated a remainder of 11.399 million metric tons and considered "this precious fertilizer to be inexhaustible for many years to come." This was an overestimate by more than 50 percent. Elías's guess was off by much less, as it later turned out. But Piérola's report had more immediate consequences: Elías had his guano contract revoked; he then organized an armed revolt that contributed within a few months to the overthrow of his foes as rulers of the Peruvian state. An 1863 survey of the northern islands calculated 6.767 million metric tons of extant phosphatic guano on Isla Lobos de Tierra alone, an even wilder overcount. British observers such as the scientist Clements Markham, for their part, also routinely overestimated Peru's guano deposits.[50]

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50. José Castañón, et al., "Informes de las comisiones encargadas de medir el guano de las islas de Chincha," *BCAG* 4:3 (Mar. 1928), 178-187 [quote p. 178]; C. Faraguet [sic Charles Fraguett], "Memoria sobre la cubicación del guano en la isla Norte de Chincha," *BCAG* 4:3 (Mar. 1928), 189-194; Nicolás de Piérola, "Informe sobre el estado del carguío de guano en las islas de Chincha y sobre el cumplimiento del contrato celebrado con D. Domingo Elías," *BCAG* 4:3 (Mar. 1928), 155-177; all three reports were originally submitted to the Peruvian government in Oct.-Nov. 1853 and published in *El Peruano* in 1854. See also Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 40-42; Mathew, "A Primitive Export Sector," 37-41; Bartkowiak, *Ernesto Malinowski*, 107; Raimondi, "Islas, islotes y rocas del Perú," 12-21; Frederick B. Pike, *The Modern History of Peru* (New York: Frederick A. Praeger, 1967), 99-103; *Enciclopedia ilustrada del Perú*, ed. Alberto Tauro (Lima: PEISA, 1987), s.v. "Elías, Domingo," "Piérola y Flores, Nicolás Fernández de." Cf. Alfonso W. Quiroz, *La deuda defraudada: Consolidación de 1850 y dominio*

These numbers had enormous political and economic importance for this statistical age. The involvement of highly trained foreigners such as Fraguett and Markham and their seeming exactitide made them trustworthy. This made it possible for the Peruvian national government to acquire a series of loans with a nominal value totaling £51.84 million, the largest debt burden, by far, acquired by any Latin American country between 1850 and "the first world debt crisis" of 1873. Needless to say, like so many products of nature, these deposits ran out years before they were expected to--by the end of 1870 in the case of the Islas Chincha. Raimondi was hardly the first or the last to lament that these vast quantities "disappeared, unfortunately, without leaving any great benefit to the country." He was less aware of the radical environmental effects these changes had on the guano island landscape (illus. 6).[51]

The Origins of the Nitrate Industry

The depletion of Peru's richest guano deposits was no cause for dire concern--at least in the long term--because of the development of a new, nitrogen-rich product from the coastal deserts of Tarapacá, the driest in the world. Vast deposits of *salitre*, also known as saltpeter or sodium nitrate ($NaNO_3$), lay close

económico en el Perú (Lima: Instituto Nacional de Cultura/Editorial y Productora Gráfica "Nuevo Mundo," 1987).

51. Raimondi, "Islas, islotes y rocas del Perú," 17; Carlos Marichal, *A Century of Debt Crises in Latin America: From Independence to the Great Depression, 1820-1930* (Princeton, NJ: Princeton University Press, 1989), esp. 80, 85-90, app. A. On the rising importance of statistics and the interpenetration of science, engineering, and administrative expertise during this era, see Theodore Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton, NJ: Princeton University Press, 1995), esp. ch. 3, 6; idem, *The Rise of Statistical Thinking, 1820-1900* (Princeton, NJ: Princeton University Press, 1986).

beneath the surface crust of Peru's southernmost province. "Nitrate of soda," said one booster, "is one day going to be called to replace guano in the markets of Europe when these become exhausted; salitre is going to last for centuries and Europe is going to be obligated to buy it to feed its impoverished soils."[52] The history of its local, then "universal" discovery and subsequent adoption as an agricultural manure is closely tied to that of Peruvian guano.

There are no firm indications that pre-Hispanic or colonial-era farmers in Peru used salitre as fertilizer. It found its first major use as an explosive. In the late eighteenth century, a few local miners used sodium nitrate to make blasting powder, ignoring the official monopoly held by the viceregal powder works in Lima. The Napoleonic wars changed all that. In 1808, the Peruvian viceroy sent an expedition to Tarapacá to see if these deposits could be used to bolster colonial defenses. For several years, regional chemists had been trying to develop an economic technique to convert "cubic niter" (sodium nitrate) to "prismatic niter" or potassium nitrate (KNO_3)--the explosive ingredient in gunpowder.[53]

Enter the scientific expert. An entrepreneur intent on developing the Tarapacá deposits traveled all the way from Lima to the far reaches of Upper Peru--almost as far as Juan Rehr after the 1746 earthquake--to consult Rehr's compatriot, naturalist Thaddaeus Haenke (1761-1817). Haenke was a native of Trébič with a doctorate from the University of Prague, both in the present-day Czech Republic. In the early 1790s, he had served on the Spanish-organized Malaspina expedition to

52. A. G. Leubel (1861), quoted in Oscar Bermúdez, *Historia del salitre desde sus orígenes hasta la Guerra del Pacífico* (Santiago de Chile: Ediciones de la Universidad de Chile, 1963), 154.

53. Bermúdez, *Historia del salitre*, 22-25, 20-33, 44-56.

the Pacific and stayed behind in South America after becoming extremely ill with scurvy. Haenke immediately revealed to his visitor the European chemical process for synthesizing potassium nitrate from sodium nitrate. It was then adapted to the existing Peruvian technique for deriving salitre from its conglomerate ore. Stevedores were drafted from the small, local guano industry to load this valuable mineral salt for shipment from the southern port of Iquique to Lima for processing. Peruvian gunpowder contributed to the high death toll of the independence wars in South America (1808-1826). Some of this gunpowder even made it all the way to Spain, but the existence of these deposits--a valuable state secret--was not widely publicized, and the Tarapacá nitrate industry fell into decline with the end of hostilities in the 1820s.[54]

The official scientific discovery of Peru's nitrate deposits happened as the result of the kind of chance meeting so common among expatriate communities. In 1821 in Madrid, the industrialist Pedro Fuentes, a Tarapacá native whose family was in the nitrate business, happened to run into Mariano Eduardo de Rivero y Ustáriz (1798-1857, illus. 7), a native of Arequipa. Rivero was winding up a decade-long tour of Europe's scientific capitals far removed from his homeland's independence struggle. He had dedicated most of his efforts to mineralogy and metallurgy and acquired the highest certification possible for a foreigner from the French École de Mines. Fuentes proudly reported the wonders of Peruvian salitre to his compatriot and provided Rivero with a sample. When Rivero returned to

54. Ibid., 56-61, 65-67, 87; *Diccionario histórico y biográfico del Perú*, s.v. "Haenke, Tadeo." On the Malaspina expedition (1789-1794), see Pimentel, *La física de la Monarquía*; González Claverán, *La expedición científica de Malaspina en Nueva España*.

Paris, he passed it on for expert chemical analysis to the crystallographer René-Just Haüy and published an article in *Annales de Mines* pointing to the existence of large processed quantities already sitting in sacks in Iquique waiting for a buyer. Rivero, thus, is usually credited with "discovering" Peruvian salitre.[55]

This chance meeting affected the history of manure and its management in other ways. In 1822 in Paris, Ecuadorian-born naturalist Leopoldo Zea (the former director of Madrid's botanical garden), now in the service of independent Gran Colombia, contracted Rivero to head a mission to staff a school of mines and a natural history museum in Bogotá. They hoped to replace the many scientists who had been gunned down or exiled during the wars for independence and put the region back on the road to progress. With the help of Rivero's life-long friend in science Alexander von Humboldt, they organized and equipped a small team of technicians from the Parisian scientific community to travel to Colombia. It included the mining engineer Jean Baptiste Boussingault (1802-1887), a young Frenchman who wanted desparately to follow in the footsteps of his friend Humboldt, especially to see active Andean volcanoes.[56]

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55. Bermúdez, *Historia del salitre*, 98-99; *Diccionario histórico y biográfico del Perú*, s.v. "Rivero y Ustáriz, Mariano Eduardo de"; Rivero, "Nota sobre el nitrato de sosa. Descubierto en el Distrito de Tarapacá (Peru)," in *Colección de memorias*, 1:5-6, originally published in *Annales de Mines* (1821); idem, "Noticia sobre el salitre y el borato de cal de Iquique por Mariano E. de Rivero," in *Colección de memorias*, 2:231-239, esp. p. 232, originally published in *Memoirs de agriculture et economie rurale* (1854).

56. Safford, *The Ideal of the Practical*, 101-103; Bermúdez, *Historia del salitre*, 100-101; *Diccionario histórico y biográfico del Perú*, s.v. "Rivero y Ustáriz, Mariano Eduardo de." On Rivero's life and connection to Humboldt, see *Mariano Eduardo de Rivero en algunas de sus cartas al Barón Alexander von Humboldt*, ed. Monique Alaperrine-Bouyer (Arequipa, Peru: Centro de Estudios Arequipeños, Universidad Nacional de San Agustín, 1999), esp. 17-18, 23-24.

In most areas this mission did not fulfill the lofty goals set by the Gran Colombian Congress, though Boussingault and Rivero did reestablish a meteorological observatory in Bogotá, and they assisted Antioquian gold miners with their amalgamation techniques. As with so many nineteenth-century voyages to the tropics in the mold of Humboldtian science, this expedition's most important contribution involved bridging the chasm separating local understanding of the South American environment and the "universal" knowledge of European science. In the process, it opened entire new realms for learned research on both shores. Rivero and Boussingault continued Humboldt's "practical astronomy" in the region and collaborated on a number of studies published in Colombia and Europe.[57] Rivero must have passed on his knowledge of Peruvian salitre and guano to Boussingault before Bolívar reappointed Rivero--on Humboldt's recommendation--as the Director General of Mines and Public Instruction in Peru. There, he served alongside Hipólito Unanue and Nicolás Fernández de Piérola among the Peruvian Republic's first technocrats.[58]

57. E.g., Boussingault and Rivero, *Memoire sur le lait de l'arbre de la vache (palo de vaca* (Paris: Feugueray, 1823); idem, *Sur les eaux chaudes de la Corddillère de Venezuela* (Paris: Feugueray, 1823); Rivero and Boussingault, *Memoir on Several Masses of Iron Found in the Eastern Cordillera of the Andes* (Edinburgh: A. Constable, 1824); Boussingault, Rivero, and François Désiré Roulin, *Résultats d'observations astronomiques et de measures barométriques faites dans un voyage de Caracas à Bogota* (Paris: Imprimerie de Fain, 1825)--a classic example of quantitative Humboldtian science. These and other articles were translated and republished in *Colección de memorias*, vol. 1.

58. Rivero to Humboldt, Lima, 1826, in *Mariano Eduardo de Rivero en algunas de sus cartas al Barón Alexander von Humboldt*, 68. Interestingly, this letter also reported some of Unanue's ongoing meteorological observations and Rivero's marine fish research to Humboldt.

Boussingault, was utterly fascinated by the extent of the coastal guano trade after he visited the northern port of Paita in 1832. These first-hand observations ultimately had an immense effect on his life. He later recalled:

> Along a great extent of the coast of Peru, the soil, which . . . is perfectly barren of itself is rendered fertile, and is made to yield abundant crops, by the application of guano; and this manure, which effects a change so prompt and so remarkable, consists almost exclusively of ammoniacal salts. *It was with this fact before me that in 1832, when I was on the coasts of the Southern Ocean, I adopted the opinion which . . . well-established facts [now] prove beyond doubt that salts, having ammonia [NH_3] for their base, must be ranked among the most powerful of all agents in promoting vegetation*.[59]

After his return home to France, Boussingault devoted the rest of his scientific career to laboratory and field research on the role of nitrogen in plant nutrition. After two decades of experimentation and "contradictory" results, he finally came to the "definite judgment" in the mid-1850s (several years after agricultural empirics) that mineral nitrates had fertilizing capabilities similar to the "most active" organic manures. Thanks to the inspiration provided by Peruvian agricultural practices, Boussingault went on to reveal more of the chemical workings of the nitrogen cycle than any other individual. He also became an outspoken proponent of nitrogen fertilizers of all sorts--to the great benefit of Peruvian exporters.[60]

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59. Emphasis added; J. B. Boussingault, *Rural Economy, in Its Relation with Chemistry, Physics, and Meteorology; or Chemistry Applied to Agriculture*, trans. George Law (New York: D. Appleton, 1850), 255 [quote], 289-290, 342, originally published as *Économie rurale considérée dans ses rapport avec la chimie, la physique et la meteorologie*, 2 vols. (Paris: Béchet, 1843-1844); cf. idem, *Memorias* (Bogotá: Banco de la República, 1985), 5:148-149.

60. Boussingault, *Rural Economy*, 249, 256, 316-317; idem, "De l'action du salpêtre sur le développement des plantes," *Journal de pharmacie et de chimie*, 3d ser., 29 (Apr. 1856), 271-274, originally published in *Annales de Chimie et de Physique*; *Dictionary of Scientific Biography*, ed.

In the meantime, European warfare, not agricultural science, revived the Tarapacá nitrate industry. The revolutions of 1830 motivated several countries to import Peruvian salitre for the first time, a total of 2,718 metric tons in 1830-1831. When the most famous Humboldtian traveler of them all, the budding geologist Charles Darwin, arrived on the central Pacific coast of South America in 1835, he went to some effort to visit Peru's booming saltpeter works. According to Darwin, some of this production was already beginning to be used by enterprising Europeans as an agricultural manure, though it cost far too much in these early years to be used on a large scale for this purpose.[61]

Peruvian salitre exports multiplied from 50,000 metric tons during the 1830s, to over 400,000 metric tons during the 1850s. As with guano, Great Britain imported the majority, followed by France, Germany, and the United States. Chile, northern Peru, and the Antilles took a small share; some even made it to Australia.[62]

As the nitrate industry grew, it attracted more and more people, especially technically minded foreigners. Late in 1853, right after he finished his tasks on the Islas Chincha, the Peruvian government sent the naturalist Antonio Raimondi (1826-1890) to investigate Tarapacá, the first of many exploratory expeditions he

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Charles Coulston Gillispie (New York: Charles Scribner's Sons, 1970), s.v. "Boussingault, Jean Baptiste Joseph Dieudonné"; Smil, *Enriching the Earth*, 5-6, 12-13; Bermúdez, *Historia del salitre*, 154-158.

61. Charles Darwin, *The Voyage of the Beagle*, Harvard Classics (1839; New York: P. F. Collier & Son, 1937), 365-368; Bermúdez, *Historia del salitre*, 103, 109-111. Cf. James A. Secord, "The Discovery of a Vocation: Darwin's Early Geology," *British Journal for the History of Science* 24 (1991), 133-157; Cannon, "Humboldtian Science," 86-92.

62. See fig. 1 and app. 1; Rivero, "Noticia sobre el salitre y el borato de cal de Iquique," 2:238-239.

performed for the Peruvian state. These trips took him all the way to the distant Peruvian Amazon and allowed him to more than fulfill his romantic dream, directly inspired by Humboldt, to leave behind the tragic events of 1848-1849 in Italy for the sublime nature of the American tropics.[63] The Peruvian state also sent Ernest Malinowski (1818-1899) to Tarapacá in 1853. Like Raimondi, Malinowski was a European refugee: the Russian invasion of Poland in 1830 had forced him to leave his homeland for France, then Algeria and Peru. He traveled to Tarapacá explicitly to investage an application for a patent to use steam heat to purify salitre registered by Pedro Gamboni Vera, a mechanically adept Chilean who came north to seek his fortune in the nitrate fields after abandoning his original plan to study industry in the United States. Twenty years later, the Peruvian state again called on Raimondi to adjudicate a patent dispute between Gamboni and three other firms over a process to extract iodine on a massive scale from the nitrate industry's waste water. By this time, an international cohort of industrial engineers from Europe and the Americas were involved in a race to develop new technological systems to maximize the efficiency and profitability of nitrate manufacture in Tarapacá, as well as newly discovered deposits in the Atacama desert of Bolivia and northernmost Chile. The fact that immigrant entrepreneurs like Gamboni had few Peruvian loyalties proved to be important in the eventual War of the Pacific.[64]

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63. Bermúdez, *Historia del salitre*, 131 n. 1, 133 n. 1; José Balta, "La labor de Raimondi," *BSGL* 43:4, pt. 2 (1926), 401, 408, 443.

64. Bermúdez, *Historia del salitre*, 139-142, 147-148, 253-258, 266-268, 272-277; Bartkowiak, *Ernesto Malinowski*, 106-111.

These new technological systems did little to reduce the nitrate factories' voracious demand for resources. As late as the mid-nineteenth century, this driest of deserts still had riparian forests of *algarrobo* or carob trees (*Prosopis* spp.) that had formed layer upon layer of ancient wood. All this wood, living and dead, was soon consumed for charcoal and building materials. This forced nitrate manufactueres to import coal and lumber from as far away as England and Oregon. Meanwhile, the underground aquifers that nourished these trees were practically sucked dry by the nitrate factories' thirst for water. The entirely barren wastes of today in this region are a human creation.[65]

These remote oases of industry in the midst of the desert also had to import laborers. Thousands of Gamboni's countrymen came north for work, though they were always outnumbered by highland Peruvian and Bolivian laborers. Most were hired by *enganche*, a regional system of contracting laborers first developed in central Chile in the 1850s by the North American railway builder Henry Meiggs. He brought it with him in the 1860s when he became Peru's main railway builder. This form of debt peonage quickly spread to other construction and mining companies in Peru. With the decline of the coolie trade, it became the dominant system for importing workers along much of the Pacific coast of Latin America.[66]

Despite these import costs, new, faster, more-efficient steam technologies like Gamboni's patented system and economies of scale gradually reduced the cost

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65. Rivero, "Noticia sobre el salitre y el borato de cal de Iquique," 2:233-235; cf. Isaiah Bowman, *Desert Trails of Atacama* (New York: American Geographical Society, 1924).

66. Bermúdez, *Historia del salitre*, 243; Michael Monteón, "The *Enganche* in the Chilean Nitrate Sector, 1880-1930," *Latin American Perspectives* 6:3 (Summer 1979), 66-79; see also Watt Stewart, *Henry Meiggs, Yankee Pizarro* (Durham, NC: Duke University Press, 1946). On the later use of the *enganche* system in the Peruvian guano industry, see ch. 3.

of production for large companies with connections to foreign capital. This pushed Peruvian-born producers still using older methods to the margins of the industry. In 1866, the price of nitrates on the British market fell to the level of guano for the first time.[67]

European farmers took a little while to switch, however. This was partly out of agrarian conservatism. (Latin American farmers were not the only group guilty of "routinism" during this or any era).[68] But sodium nitrate had a major disadvantage: it did not *smell* like a good fertilizer. In stark contrast to growing urban prejudice against the stench of excrement and decay, which was thought to cause disease, farmers used foul odors to help detect the best fertilizers. This came from long experience with animal manures, but it also worked with guano and fishmeal. Unscrupulous salesmen often adulterated or faked fertilizers. Farmers quickly learned that genuine Peruvian product had a tell-tale ammoniacal stench. Like city dwellers, farmers, too, may have become more sensitive to smell in the course of the nineteenth century.[69] From the point of view of the agricultural chemist, the last remnants of guano from the Islas Chincha still had a higher nitrogen content than impure sodium nitrate, as well as other valuable nutrients. Thus, North Atlantic farmers, at least for the moment, were willing to pay the

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67. Mathew, "Peru and the British Guano Market," 120; Greenhill and Miller, "The Peruvian Government and the Nitrate Trade," 110-111.

68. Notorious examples of studies that blame the agricultural underdevelopment of South America's two largest export economies, ultimately, on the failure to adopt "rational" new agricultural science and technology include James R. Scobie, *Revolution on the Pampas: A Social History of Argentine Wheat, 1860-1910* (Austin: University of Texas Press, 1964), esp. ch. 8; and Stanley J. Stein, *Vassouras: A Brazilian Coffee County, 1850-1900: The Roles of Planter and Slave in a Plantation Society* (Cambridge, MA: Harvard University Press, 1958), esp. ch. 9. Contrast this to the recent study by McCook, *States of Nature*.

69. Corbin, *The Foul and the Fragrant*, passim.

premium charged by the Peruvian government as it tried to milk the last shilling before its most valuable natural resource dried up forever. In response, farmers took greater care to avoid wasting this precious substance, often by consulting experts.[70]

Miasmas and the "Practical Republic"

Meanwhile, fear of miasmas, the foul-smelling vapors thought to emanate from human excrement and other putrifying waste, inhibited the development of sewer farming and directed Peru's wealth based on manures toward new goals. In the days before the "Pasteurization" of health science and the obsession with insect vectors in "tropical" medicine, any campaign against an epidemic required an attack against excrement. Many experts believed the safest thing to do was to wash this filth away as fast and as efficiently as possible. This process diluted its nitrogen content. It also removed a potential competitor for nitrates, guano, and other forms of fertilizer.[71]

The massive urban epidemics of the mid-nineteenth century provided real cause for alarm. More than a few *porteños* blamed the yellow fever epidemic of 1871, the worst that ever hit Buenos Aires, on heavy (El Niño related?) early-summer rains that flooded the Argentine capital's cesspools and turned its streets

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70. Mathew, "Peru and the British Guano Market," 122-125; Wines, *Fertilizer in America*, passim; Greenhill and Miller, "The Peruvian Government and the Nitrate Trade," 110-112.

71. Corbin, *The Foul and the Fragrant*, esp. 117-122; Hays, *The Burdens of Disease*, ch. 7; Sheldon Watts, *Epidemics and History: Disease, Power and Imperialism* (New Haven, CT: Yale University Press, 1997), ch. 6. See also François Delaporte, *The History of Yellow Fever: An Essay in the Birth of Tropical Medicine* (Cambridge, MA: MIT Press, 1991); Bruno Latour, *The Pasteurization of France*, trans. Alan Sheridan and John Law (Cambridge, MA: Harvard University Press, 1988).

into giant sewers.[72] Buenos Aires authorities used the presence of open latrines as one excuse among many to evacuate Buenos Aires' teeming tenements. Many, rich and poor alike, never moved back to the city center. This initiated the suburbanization and sanitization of Argentina's capital and its transformation into the "Paris of South America." Far to the north, a yellow-fever epidemic in 1878 (thought to have come from Havana) killed 20,000 people in the Mississippi Valley. The city fathers of Memphis, Tennessee, the worst-hit urban area, decided that a new sewer system was the best way to fight back. Their celebrated "sanitary" network rigorously segregated sewage from storm runoff (potentially making it more valuable as a fertilizer) before dumping it in a bayou of the Mississippi River, out-of-sight of the city and out-of-reach of farmers. Excrement unified the ecological history of the rural, urban, tropical, and temperate worlds in many ways during the Guano Age.[73]

Peru's capital city was also beset by epidemics. During the austral summer of 1868, yellow fever descended on Lima. Both rich and poor died in such

72. Anomalous floods on the northern pampas are often associated with strong ENSO events, so these storms were likely related via atmospheric teleconnection to torrential downpours in arid northern Peru that year. See Vera Markgraf and Henry F. Diaz, "The Past ENSO Record: A Synthesis," in *El Niño and the Southern Oscillation: Multiscale Variability and Global and Regional Impacts*, ed. Diaz and Markgraf (Cambridge, UK: Cambridge University Press, 2000), 475-476. For an overview of the relation between ENSO and epidemic outbreaks, see Michael H. Glantz, *Currents of Change: Impacts of El Niño and La Niña on Climate and Society*, 2d ed. (Cambridge, UK: Cambridge University Press, 2001), ch. 12.

73. Scobie, *Buenos Aires: Plaza to Suburb, 1870-1910* (New York: Oxford University Press, 1974), 122-126, 153-154, 193; Antonio Elio Brailovsky and Dina Foguelman, *Memoria verde: Historia ecológica de la Argentina* (Buenos Aires: Editorial Sudamericana, 1991), 222-248; Melosi, *The Sanitary City*, ch. 8, esp. 153-160. Similar concerns transformed Rio de Janeiro at the end of the nineteenth century: see Nancy Leys Stepan, *Beginnings of Brazilian Science: Oswaldo Cruz, Medical Research and Policy, 1890-1920* (New York: Science History Publications, 1976); Meade, *"Civilizing" Rio*, esp. ch. 3; Chalhoub, *Cidade febril*, ch. 1-2.

numbers that the cemetery outside the city wall originally built by hygienists to prevent this sort of outbreak could not hold all the corpses, 4,222 in all. Manuel Pardo y Lavalle (1834-1878), a practical-minded businessman educated in political economy at the College de France, took control of relief efforts during the Lima epidemic. His work was so highly regarded that a junta of city notables elected him mayor of Lima, a major step toward the presidency of the country. Meanwhile, Peruvian guano exports reached an all-time high in 1870--over 700,000 metric tons--and sold at record prices under a controversial contract with the French firm Dreyfus Bros. & Co. In 1870 and 1872, with the Islas Chincha at or near exhaustion, Peru floated two loans intended to raise £34.1 million, the largest ever for a Latin American government.[74]

Thanks to Peru's massive guano income, the city had plenty of cash for rapid urban reconstruction, years before other Latin American capitals experiencing similar plagues. Guano paid for street paving, waste disposal, and potable water infrastructure, all to protect against disease. Other projects were meant to be more spectacular: In July 1872, just before Pardo took office as Peru's first civilian president, Lima witnessed the inauguration of the Exposition Palace, a permanent museum to art and industry modeled after the grand exhibition halls of the world's fairs. It was surrounded by a large, formal, healthful French garden and stood across a wide boulevard from the new Palace of Vaccination. This open avenue, reminiscent of Vienna's Ringstrasse, replaced the old, defensive wall that enclosed

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74. See app. 1 and fig. 1; Mc Evoy, *La utopía republicana*, 79-83; *Enciclopedia ilustrada del Perú*, s.v. "Pardo y Lavalle, Manuel"; Marichal, *A Century of Debt Crises in Latin America*, ch. 3; Bonilla, *Guano y burguesía*, ch. 2.

the tightly spaced center of Lima. Its post-1746 colonial landscape started to disappear rapidly after the tragedy of 1868.[75]

These new temples to Science, Reason, and Progress--"the myths of the nineteenth century" according to José Carlos Mariátegui--did not work as talismans against further disaster. Only days after the inauguration of Exposition Park, violence related to Pardo's impending inauguration left the out-going president murdered. A mob hung the mutilated bodies of the instigators of this plot from Juan Rehr's cathedral towers, then decapitated and burned them. Public order in Lima has always hung by a thread.[76] Events like this go a long way toward explaining why the lords of Peru's ruling class began to become so obsessed with the equation between "Order and Progress" during this era. Yet despite their best efforts, a world debt crisis, a global environmental cataclysm, and a disastrous regional war brought the whole country to the brink of chaos by the end of the 1870s.

Manuel Pardo's new administration recognized the danger and tried to engineer a long-term solution. During his first major public address as president, Pardo announced that service on Peru's huge outstanding debt was consuming

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75. Mc Evoy, *La utopía republicana*, 79-83; Emilio Romero, *Historia económica del Perú* (Buenos Aires: Editorial Sudamericana, 1949), 402-403. On the design and construction of the Ringstrasse, see Robert Rotenberg, *Landscape and Power in Vienna* (Baltimore, MD: Johns Hopkins University Press, 1995), 40-42, 131-141. On the monumentalism of world's fairs and urban renewal during this era in Latin America, see Tenorio, *Mexico at the World's Fairs*; Patricia Fumero, *Teatro público y estado en San José, 1880-1914: Una aproximación desde la historia social* (San José: Editorial de la Universidad de Costa Rica, 1996).

76. José Carlos Mariátegui, *Siete ensayos de interpretación de la realidad* peruana (1928; Lima: Biblioteca Amauta, 1994), 260; Mc Evoy, *La utopia repúblicana*, 103-104; Pike, *The Modern History of Peru*, 130-132.

almost all of its eroding guano income--practically the sole basis of the national budget. Not for the first time, the Peruvian state was bankrupt.[77]

Many Peruvians blamed sodium nitrate for these problems. Reality was a bit more complicated: Little by little, brand-name guarantees, official chemical assays by government inspectors, consumer protection laws, and scientific advocacy convinced farmers on both sides of the North Atlantic to trust new kinds of stenchless fertilizer. Seed cakes--a new, concentrated organic fertilizer made from what was once considered agricultural waste--had acquired an enthusiastic market. Europe's state-subsidized sugar-beet growers, veritable fanatics for agricultural science compared to other farmers, led the switch to nitrates and other chemical fertilizers, especially in Germany. The explosion of beet-sugar production, tied to an obsession with increasing yields, helped make sugar an article of mass consumption and convenient source of calories for working-class Europeans about this time. Thus, Peruvian nitrates helped keep Europe's poor alive, if not healthy. Germany's new-found obsession for artificially fertilized root crops also dramatically increased the availability of cattle fodder. As in England, this enabled Germany's relatively affluent to increase dramatically their consumption of meat. Since this entailed an increase in the manure supply, this new system did not eliminate farming based on waste recycling. It did, however, bring an abrupt end to the traditional, three-field system of crop rotation and its replacement by a quasi-industrial "free economy" (*freie Wirtschaft*) that concerned

77. Greenhill and Miller, "The Peruvian Government and the Nitrate Trade," 108-109; Bermúdez, *Historia del salitre*, 321-323.

itself little with the ecological constraints of the individual farm. Meanwhile, small, competitively priced quantities of sulphate of ammonia [$(NH_4)_2SO_4$] had begun to appear on the fertilizer market, as Europe's coal-steel complex installed recovery ovens that captured this by-product from the airless heating of coal, a process used to make coke (to replace wood charcoal for pig-iron smelting) and coal gas (to replace whale oil for city lighting)--all important ecological shifts in their own right that reinforced the process of northern industrialization.[78]

More importantly, Peruvian guano was falling in quality and reputation as contractors exploited partially leached deposits along the north Peruvian coast. Imposing an export duty on nitrates to fill the Peruvian government's coffers and to manipulate international demand was not an attractive option. On the one hand, a high, uniform nitrate tax would tend to drive small, inefficient producers--the only part of the industry still owned by Peruvian nationals--out of business. On the other hand, a tax that protected small producers would discourage technological innovation and foreign investment, the lifeblood of the industry. Peru's governing officials were prisoners of circumstance on this count, not unbending devotees of the free market. They certainly were not impotent pawns of foreign capitalists.[79]

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78. J. A. Perkins, "The Agricultural Revolution in Germany, 1850-1914," *Journal of European Economic History* 10:1 (Spring 1981), 71-118, esp. pp. 88-89; Wines, *Fertilizer in America*, passim; Skaggs, *The Great Guano Rush*, 10; Mathew, "Peru and the British Guano Market," 120,124; Smil, *Enriching the Earth*, 47-51; Sidney Mintz, *Sweetness and Power: The Place of Sugar in Modern History* (New York: Penguin Books, 1986), 126-150; Noel Deerr, *The History of Sugar* (London: Chapman and Hall, 1950), ch. 29. On beet sugar science, see François Mélard, "The Conditions of Felicity of a Blind Instrument," unpublished paper presented at the Society for Social Studies of Science Annual Meeting, Cambridge, MA, 2 Nov. 2001.

79. Greenhill and Miller, "The Peruvian Government and the Nitrate Trade," 112; Gootenberg, *Imagining Development*, passim. In his detailed study of these events, Thomas F. O'Brien explains Peru's response as "a desparate effort by an impecunious and unstable government to preserve [a] contradictory and now faltering system built upon a foreign export enclave," in *The*

The steps taken by Pardo's government to establish an international cartel to control the nitrate trade make this clear. In 1873, his government first proposed the establishment of a quasi-state company, the Compañía Administradora del Estanco del Salitre, that would have monopoly control over salitre exports and work on a quota system. In 1875, the Peruvian Congress and president finally agreed to nationalize the Tarapacá nitrate industry--at high levels of compensation to ensure owner support. Pardo placed expropriation under the control of two expert commissions: a team of engineers to evaluate the resources and capacity of each nitrate factory, and a team of lawyers to confirm legal title to all these properties.[80]

This policy was in line with ongoing administrative reforms designed to create a "Practical Republic" managed by a new class of highly trained public servants. These included the reoganization of Peru's national corps of civil engineers and architects, the creation of a new Faculty of Political and Administrative Sciences (now the economics faculty) at the Universidad de San Marcos, and the establishment of a permanent national school of engineering and mining in Lima. This last event finally brought to fulfillment Mariano de Rivero's life-long dream to establish a school of mines in Andean South America. (During the 1840s, Rivero had worked to establish an "escuela central de minas" at Huánuco, a remote inland city that eventually became the gateway to Peru's main coca growing region.) Engineers trained at this national school played an important

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Nitrate Industry and Chile's Crucial Transition, 1870-1891 (New York: New York University Press, 1982), ch. 1-2, esp. pp. 27-28.

80. Greenhill and Miller, "The Peruvian Government and the Nitrate Trade," 113-115; O'Brien, *The Nitrate Industry and Chile's Crucial Transition*, ch. 2; Wines, *Fertilizer in America*, 126-135; Bermúdez, *Historia del salitre*, 330-333.

role in the future of the Peruvian guano industry.[81] At least during this phase of its history, Peru was keeping pace with most of the Americas (including California) when it came to building viable institutions for training a technocratic elite.[82]

These institutions were established too late, however, to influence Peru's nitrate expropriation. The two expert commissions appointed by Pardo did not function as well as planned. They could not agree over who had jurisdiction to set property values. The two Peruvian engineers charged with evaluating the nitrate deposits were given neither the resources nor the time to do direct testing on a large scale. They had to rely on estimates provided by the owners, a policy designed to win their support for nationalization. To avoid graft, the engineers averaged the claims made by different owners with similar capacities to ensure a fair, if inflated, distribution of payments.[83]

Other events made their work largely irrelevant. Pardo's government blindly tried to negotiate a new, £7 million loan against future nitrate proceeds to

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81. Mc Evoy, *La utopía republicana*, ch. 3, esp. 161-163; José Ignacio López Soria, *Habich el fundador* (Lima: Universidad Nacional de Ingeniería, Proyecto Historia UNI, 1998), esp. 9-12, 20-24; Rivero, "Apuntes histórico-estadísticos sobre el Departamento peruano de Junín en los años que lo administró como prefecto M. E. de Rivero (Año de 1855)," in *Colección de memorias*, 2:188-189;. See also Mc Evoy, *Un proyecto nacional en el siglo XIX: Manuel Pardo y su visión del Perú* (Lima: Pontificia Universidad Católica del Perú, 1994); A. Reynaldo Susano, "La escuela monetarista de San Marcos. Reflexiones sobre el pensamiento monetario peruano desde el Segundo cuarto del siglo XIX hasta mediados de los años 60 de presente," in *Estudios de historia de la ciencia en el Perú*, ed. Ernesto Yepes del Castillo (Lima: CONCYTEC/SOPHYICYT, 1986), 2:213-226; Jorge Manco, "La revista de la Facultad de Ciencias Económicas y la formación del economista en la Universidad Nacional Mayor de San Marcos (1928-1958)," in *Estudios de historia de la ciencia en el Perú*, 2:227-250; José Carlos Martín, *Historia de la Facultad de Ciencias Políticas y Administrativas* (Lima, 1949).

82. On technical schools elsewhere in the Americas, see Michael L. Smith, *Pacific Visions: California Scientists and the Environment, 1850-1915* (New Haven, CT: Yale University Press, 1987), 123-129; Murray, *Dreams of Development: Colombia's National School of Mines and Its Engineers*; de Carvalho, *A Escola de Minas de Ouro Preto*; Safford, *Ideal of the Practical*.

83. Bermúdez, *Historia del salitre*, 333-337, 348-349.

pay for the expropriation and to finish Peru's Andean railways--still far from completion. But this was made utterly impossible by the financial panic of 1873 and ensuing global debt crisis. Things deteriorated further after the two Ottoman caliphates stopped servicing £100 million owed to European creditors. Peru brought in the new year 1876 by defaulting on £33 million in loans, by which time Peru's neighbor Bolivia was in similar financial straits. Peru proceeded with the nationalization anyway, according to its Minister of Finance, to provide "fresh income which can fulfill, when the guano is exhausted, the republic's obligations to its overseas creditors." It did this partly from a position of strength: this sharp economic downturn forced even the largest nitrate manufacturers to the verge of bankruptcy. Two-thirds of the nitrate manufacturers eagerly accepted sale certificates promising future remuneration. These were attractive, because the Peruvian government paid interest in the meantime (with loans supplied by Peruvian banks), while many companies kept producing nitrates as before for a commission. The old British guano contractor Antony Gibbs & Sons, now a big player in the nitrate business, acted as Peru's sole agent for European nitrate sales. With this cartel in place, nitrate prices jumped by 30 percent, while guano exports recovered a bit.[84]

Then nature intervened.

84. Greenhill and Miller, "The Peruvian Government and the Nitrate Trade," 116-119, 129 [quote]; O'Brien, *The Nitrate Industry and Chile's Crucial Transition*, ch. 2; Bermúdez, *Historia del salitre*, 342-346; Marichal, *A Century of Debt Crises in Latin America*, ch. 3.

El Niño and the War of the Pacific

In 1877 and 1878, intense rains pummeled the dry northern coast of Peru. This created a "year of abundance" for peasants who knew to plant rainfed crops and take advantage of such periodic events. But the rains utterly destroyed the steam pumps and irrigation canals that fed Piura's troubled cotton industry--giving a respite to its *algarrobo* savannas, which were being cut down systematically to feed these engines. Worse, from the point of view of progress-minded Peruvians, floods washed out the Salaverry-Trujillo sugar railroad, the only major "guano" route nearing completion. The total impact of this climate disaster for Peru still needs to be evaluated.[85]

Peru's neighbors were hit much worse. The austral summer rains of 1877-1878 never arrived in central Bolivia. Cochabamba, Bolivia's breadbasket, exported starving peasants instead of grain. A malaria epidemic spread up from the lowlands, leading to a crackdown on migration by health authorities. The mines at Potosí, Bolivia's biggest source of external income, had to shut down because of lack of water. Grain prices increased by a factor of ten, and a famine ensued that lasted into 1879. Oruro, Bolivia's other major mining center, was paralyzed when, despite official efforts, incoming migrants came close to exhausting its food. This conjuncture of drought, disease, famine, and economic breakdown was remarkably similar to the events of 1804-1805 in Upper Peru, another year of disastrous floods

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85. Anne Marie Hocquenghem, *Para vencer la muerte: Piura y Tumbes: Raíces en el bosque seco y en la selva alta, horizontes en el Pacífico y en la Amazonia* (Lima: Instituto Frances de Estudios Andinos/Instituto de la Naturaleza y el Conocimiento Ambiental Humano, 1998), 303-309; William Vernon Bishel, "Business Ideology and U.S. Foreign Policy: Michael P. Grace and the Grace Contract in Peru, 1880-1890," (Ph.D. diss., Indiana University, 1991), 51-52.

along the northern Peruvian coast. Chile and Peru sent some relief supplies, but this classic subsistence crisis perilously weakened Bolivia.[86]

Chile had little grain to sell to its neighbor because it, too, experienced "a truly phenomenal year" in 1877--so anomalous that it inspired Benjamín Vicuña MacKenna, the dean of Chilean historians, to write that year what may be Latin America's first national environmental history. The year started with the capital's earliest summer rainstorm of the century (9 February) followed by a wet autumn with consistently low barometer readings. The skies opened up in July. Santiago was spared major damage (unlike a similar event in 1783), but the southern half of the central valley was devastated, including the year's wheat crop, a vital economic sector already in rapid decline. It even rained in the nitrate fields of the Atacama Desert--an extremely rare event. Chilean agricultural production and exports declined across the board and remained depressed through 1878. Local food shortages and high prices made these hungry years for many of Chile's poor. Vicuña MacKenna noted the correspondence between this Chilean disaster and strange weather in Australia, New Zealand, Hawaii, Tahiti, and the Marquesas. This coincidence made perfect sense to him since a tsunami associated with a powerful May earthquake in southern Peru had affected the entire Pacific Basin.

86. Roberto Querejazu Calvo, "Los jinetes del apocalipsis," ch. 12 of *Guano, salitre, sangre: Historia de la Guerra del Pacífico* (La Paz, Bolivia: Editorial Los Amigos del Libro, 1979); Michela Pentimalli de Navarro and Gustavo Rodríguez Ostria, "Las razones de la multitud (Hambruna, motines y subsistencia: 1878-79," *Estado y sociedad: Revista boliviana de ciencias sociales*, no. 5 (1988), 15-33; Enrique Tandeter, "Crisis in Upper Peru, 1800-1805,." *HAHR* 71:1 (1991), 35-71; B. Francou and L. Pizarro, "El Niño y la sequía en los altos Andes centrales (Perú y Bolivia)," *Bulletin de l'Institut Français d'Etudes Andines* 14:1-2 (1985), 1-18.

He concluded that these events proved the need for an improved meteorological service in the Pacific Basin.[87]

That is exactly what Chile, Mexico, and many other countries got from this environmental crisis. The new government of Porfirio Díaz decided to organize a modern meteorological network after it, too, experienced widespread droughts--and a few food riots--during 1877. In California, after a major drought the previous winter had given the coup de grace to California's herding economy, its new meteorological stations received heavy precipitation in January and February 1878, sometimes in quantities that stood as records until 1998. The Central Valley's mechanized farms produced a bumper wheat crop that confirmed their dominance over the trans-Pacific grain trade, a position held not long before by Chile. This dampened the spirits of progress-minded Chileans even further, since California's rising fortunes seemed to erect an enormous barrier to the recovery of Chilean wheat exports.[88]

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87. Benjamín Vicuña MacKenna, *El clima de Chile: Ensayo histórico* (Buenos Aires: Editorial Francisco de Aguirre, 1970), ch. 16-17, esp. pp. 335, 344, originally published as *Ensayo histórico sobre el clima de Chile (desde los tiempos prehistóricos hasta el gran temporal de julio de 1877)* (Valparaiso, Chile: Imprenta del Mercurio, 1877); William F. Slater, "Chile and the World Depression of the 1870s," *JLAS* 11:1 (1979), 72-79; Arnold J. Bauer, *Chilean Rural Society from the Spanish Conquest to 1930* (Cambridge, UK: Cambridge University Press, 1975), 62-73. Cf. Luc Ortlieb, "Eventos El Niño y episodios lluviosos en el Desierto de Atacama: El registro de los úlitmos dos siglos," *Bulletin de l'Institut Français d'Etudes Andines* 24:3 (1995), 519-537; idem, "Las mayores precipitaciones históricas en Chile central y la cronología de eventos 'ENSO' en los siglos XVI-XIX," *Revista Chilena de Historia Natural* 67:3 (1994), 117-139.

88. Enrique Florescano and Susan Swan, *Breve historia de la sequía en México* (Xalapa, Mexico: Universidad Veracruzana, Dirección Editorial, 1995), 21-24, 56-57, 199; Mariano Bárcena and Miguel Pérez, *Estudios de meteorología comparada*, vol. 1 (Mexico City: Oficina Tipográfica de la Secretaría de Fomento, 1885); Donald J. Pisani, *From Family Farm to Agribusiness: The Irrigation Crusade in California and the West, 1850-1931* (Berkeley and Los Angeles: University of California Press, 1984), 3-11, 286-289; Luis Ortega, "Nitrates, Chilean Entrepreneurs and the Origins of the War of the Pacific," *JLAS* 16:2 (Nov. 1984), 339-346; on Chile's new telegraphic meteorological service, see *Nature* 3 Oct. 1878, 600.

The Pacific rim of the Americas got off easy during these years compared to the rest of the world. A persistent climate anomaly linked, in part, to one of the most powerful El Niño-Southern Oscillation events in history affected practically the entire globe during the late 1870s. Floods like those preceding the 1871 yellow fever epidemic returned in force on the Argentine pampas, another of Chile's competitors as a wheat exporter. Argentine governing officials turned this seeming disaster to its advantage. Following on the heels of a prolonged drought, a smallpox epidemic, a "grand invasion" of cattle, and now, a flood, General Julio Roca marched his army across the grassland frontier to complete the genocidal murder of Argentina's last unconquered indigenous nomads. The final "Conquest of the Desert" in 1879-1880 further strengthened Argentina's position as Chile's most powerful rival, opened vast new regions to agricultural production, and provided Roca with a springboard to the presidency.[89] Besides the areas listed by Vicuña MacKenna, New Guinea, New Caledonia, Samoa, the Philippines, Korea, southern Africa, Morocco, Algeria, and much of the Caribbean Basin experienced anomalous droughts. The Scottish scientific traveler Henry Forbes, a future Lord of Guano, personally witnessed the harvest failures and forest fires that beset much of Indonesia during these years. The failure of the monsoon over the East African highlands led to the weakest Nile River flood in a century. But these paled before the apocalypse experienced by British-ruled India, northern China, and northeastern Brazil. No one knows for sure how many died of starvation or disease in these

89. Brailovsky and Foguelman, *Memoria verde*, 167-171; Scobie, *Revolution on the Pampas*, 39, 117-118.

regions--many because of Malthusian attitudes among those who could have done something to ameliorate these disasters. Twenty to 30 million is a reasonable guess of the total number who died from what scientists writing in *Nature* referred to as "the southern drought." [90]

Other regions experienced problems during these years tangentially linked to ENSO but closely related to manure and its management. As we have already seen, Cuba and the Mississippi Valley experienced a tragic yellow fever epidemic. In the British Isles, the 1877 and 1878 planting--and prime manuring--seasons were exceptionally cool and wet. This reduced demand for Peruvian guano and nitrates. Things only got worse in 1879, when western and central Europe experienced their coldest, wettest growing season since 1816, the "year without a summer." By this time, after a series of poor harvests, England's "age of high farming" was over and its long agricultural depression well-advanced. Britain relied increasingly on food purchased abroad--even from regions like India facing famines. English rural life never recovered. In contrast, farmers on the Continent soon rebounded and entered a new phase of intensification, Europe's "first green revolution," in which nutrient-rich seed cakes, urban waste recycling, new chemical fertilizers, and imported nitrates all played an important role.[91]

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90. *Nature* 28 Mar. 1878, 436; S. J. Whitmee, "The Southern Drought," *Nature* 4 Apr. 1878, 447; Hyde Clarke, "The Drought," *Nature* 21 Nov. 1878, 53; Mike Davis, *Late Victorian Holocausts: El Niño Famines and the Making of the Third World* (London: Verso, 2001), passim; George N. Kiladis and Henry F. Diaz, "An Analysis of the 1877-78 ENSO Episode and Comparison with 1982-83," *Monthly Weather Review* 114:6 (June 1986), 1035-1047; I. Klein, "When the Rains Failed: Famine Relief and Mortality in British India," *Indian Economic and Social History Review* 21 (1984), 186-214; Roger L. Cunniff, "The Great Drought: Northeast Brazil, 1877-1880" (Ph.D. diss., University of Texas at Austin, 1970).

91. Fletcher, "The Great Depression of English Agriculture," passim; J. L. van Zanden, "The First Green Revolution: The Growth of Production and Productivity in European Agriculture,

This did not help Peru or Bolivia in the short term. From 1878 onward, Peruvian guano sold at its lowest prices since the early 1850s because of declining quality and demand. Nitrate purchasers held back their orders, expecting the inflated price to crash in these circumstances. But Peruvian officials were looking ahead to the end of the crisis and tried to solidify their cartel. Even though the government of Pardo's successor was having trouble paying off the debt to its own nitrate manufacturers, it looked to take advantage of the ongoing crisis and buy up nitrate companies in Bolivia's sector of the Atacama Desert. Many sold out, but by far the largest concern, the British- and Chilean-owned Antofagasta Nitrate and Railway Co. would not, nor would it join in a cartel, even when promised a guaranteed share of world nitrate sales. In February 1878, in desparate need of funds, the Bolivian government imposed a moderate export tax on this company as a requirement for renewing its contract to extract nitrates from Bolivian soil.[92]

Chile's ruling class, with British acquiescence, decided to take advantage of Bolivia's weak situation. Much like Peru, Chile had been in dire economic straits for three years before the floods of 1877, its government was deeply in debt, and things looked bad for the foreseeable future. Months before Bolivia seized the Antofagasta Nitrate and Railway Co. for its refusal to pay this new tax, a political faction led by Chilean capitalists who owned a major interest in this company and

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1870-1914," *Economic History Review*, n.s., 44:2 (May 1991), 215-239, esp. pp. 230-231. Cf. H. H. Lamb, *Climate: Present, Past, and Future* (London: Metheun, 1977); J. D. Chambers and G. E. Mingay, *The Agricultural Revolution, 1750-1880* (London: B.T. Batsford, 1966). On European events following the 1815 eruption of Tambora in Indonesia, see John O. Post, *The Last Great Subsistence Crisis in the Western World* (Baltimore, MD: Johns Hopkins University Press, 1977).

92. Greenhill and Miller, "The Peruvian Government and the Nitrate Trade," 123-124; Bermúdez, *Historia del salitre*, ch. 8.

the trade that supplied this region presented war as Chile's only "salvation." Even though most Chilean-owned nitrate firms had gone bankrupt by this date, they argued that Chileans had a natural right to salitre because men like Pedro Gamboni had invested Chilean ingenuity, capital, and labor to build the industry. Historians have buried the events that followed beneath a pile of nationalist posturing and legalist rhetoric. No matter how one looks at it, Chilean jingoists carried the day: like any self-respecting power during this Age of Empire, Chile invaded its weaker neighbor for its natural resources.

Peru and Bolivia had signed a mutual defense pact in 1873 for just this sort of situation. Chileans knew this and were well-prepared when Peru jumped into the War of the Pacific (1879-1884) to defend Bolivia. The Chilean military quickly occupied the nitrate fields of Antofagasta and Tarapacá, Peru's guano islands, and Lima itself, though Peru and Bolivia fought on in a long, bloody war of attrition. Chile's superior weapons and organization eventually crushed its politically unstable opposition. By force of arms, Chile took over Bolivia's outlet to the sea and Peru's southernmost coastal provinces. Chile acquired the monopoly over nitrate production that Peru had long coveted, and eventually established its own cartel. Within a decade, just as its jingoists had foreseen, Chile was exporting over one million metric tons a year, and its Nitrate Age was in full swing, though this bonanza went on to spark yet another global debt crisis and Chilean civil war before the nineteenth century was over. By treaty, Peru was allowed to retain only 50 percent of the paltry income that came from its remaining guano deposits--all of which went to foreign creditors. Chile carried away Peru's national library, the brand-new rolling stock of the Salaverry-Trujillo railway, and many other "engines of progress." Under these circumstances, several internal factions in Peru revolted against centralized rule, and Peru remained in turmoil for over a decade. This was a huge blow against the Peruvian coastal elite's long quest for national hegemony. Contrast this to the outcome in Bolivia, where General Narcisco Campero Leyes, an enlightened conservative trained in engineering at the École Spéciale Militaire de Saint-Cyr in France, rose to power during the war and laid the foundations for years of stable oligarchic rule.[93]

Thus, Peru suffered a disastrous national defeat in its quest to supply the world's ever-increasing demand for concentrated fertilizer and explosives. The point here is not to blame El Niño for the outcomes of the 1870s. The economic bust of the mid-1870s, other climate mechanisms, and plenty of human volition were involved in this global crisis. In some ways, these were *unnatural* disasters indivisible from the rapid emergence of a new industrial economy hungry for resources from all over the world.[94]

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93. Far too much has been written about the War of the Pacific. My argument follows closely the balanced, minutely-researched study of the Chilean side by Luis Ortega, "Nitrates, Chilean Entrepreneurs and the Origins of the War of the Pacific," *JLAS* 16:2 (Nov. 1984), 337-380; and Slater, "Chile and the World Depression of the 1870s," 67-99; Bermúdez's Chilean perspective in *Historia del salitre* is also quite even-handed; on the outcome of the war, see O'Brien, *The Nitrate Industry and Chile's Crucial Transition*. For the Bolivian side, see Querejazu, *Guano, salitre, sangre*; for the Peruvian side, see Bonilla, *Un siglo a la deriva: Ensayos sobre el Perú, Bolivia y la guerra* (Lima: Instituto de Estudios Peruanos, 1980). On political divisions within Peru before and after the War of the Pacific, see Mark Thurner, *From Two Republics to One Divided: Contradictions of Postcolonial Nationmaking in Andean Peru* (Durham, NC: Duke University Press, 1997); Florencia Mallon, *Peasant and Nation: The Making of Postcolonial Mexico and Peru* (Berkeley and Los Angeles: University of California Press, 1995), esp. ch. 6; idem, *The Defense of Community in Peru's Central Highlands: Peasant Struggle and Capitalist Transition, 1860-1940* (Princeton, NJ: Princeton University Press, 1983), ch. 3.

94. This is Davis's central point in *Late Victorian Holocausts* and much of the literature on climate, disasters, and human history. See also William B. Meyer, et al., "Reasoning by Analogy:

The War of the Pacific underscores the importance of manure and its management to nineteenth-century global history. Beginning with Alexander von Humboldt's "discovery" of Peruvian guano circa 1802, science and expertise proved crucial to the reorientation of agricultural manures from waste-recycling to input-intensive farming. Partly because hygienists feared the spread of epidemics and tried to wash away urban sources of human excrement, "scientific" farmers became increasingly dependent on concentrated manures shipped from as far away as Peru and remote atolls in the central Pacific. This new, industrial form of agriculture proved unable to prevent the famines of the late 1870s, largely because it was oriented toward the luxury production of meat, on the one hand, and working-class consumption of cheap sugar, on the other. Britain, at least, became much more dependent on grain imports as it fell into its great agricultural depression. This drove the conquest of the world's temperate grasslands for grain agriculture. It also siphoned foodstuffs and laborers away from populations on the margins of existence toward the world's centers of capitalist production. As we shall see, these forces made the world ever more dependent on input-intensive agriculture.

Climate, Human Affairs, and the Human Sciences," in *Human Choice and Climate Change*, ed. Steve Rayner and Elizabeth L. Malone (Columbus, OH: Batelle Press, 1998), 3:218-289; Louis A. Pérez, Jr. *Winds of Change: Hurricanes and the Transformation of Nineteenth-Century Cuba* (Chapel Hill: University of North Carolina Press, 2001); Theodore Steinberg, *Acts of God: The Unnatural History of Natural Disasters in America* (New York: Oxford University Press, 2000); Virginia García Acosta, ed., *Historia y desastres en América Latina*, 2 vols. (Bogotá and Lima: La Red/CIESAS/Tercer Mundo/ITDG, 1996-1997); Eric Wolf, *Europe and the People without History* (Berkeley and Los Angeles: University of California Press, 1982); Wilhelm Abel, *Agricultural Fluctuations in Europe: From the 13th to the 20th Centuries*, rev. ed., trans. Olive Ordish (New York: St. Martin's Press, 1980).

The Guano Age ended in utter tragedy for those Peruvians who tried to make the nineteenth century an Age of Progress. Ever since, the old Lords of Guano have been dismissed as little more than architects of a "fictitious prosperity" and national collapse. Yet the timing and extent of these disasters during the 1870s helps us to understand why intelligent men made the decisions that brought about Peru's nitrate debacle. This liberates us, somewhat, from the vicious blame-game that has always surrounded the outcome of the War of the Pacific. People today are still unconscious of the powerful role El Niño played in bringing an end to the Guano Age, but science-minded Peruvians never again let themselves be ignorant of its impact on their country's fortunes. As in Roca's Argentina, Porfirio Díaz's Mexico, and Campero's Bolivia, ruling-class Peruvians looked to the conquest of new ecological frontiers, to exports, to environmental science--to an aristocracy of knowledge--to rebuild their nation. Above all, they looked to the conservation of the guano birds, the original source of the fossil deposits that fueled the Guano Age, for a way out of the problems left by the War of the Pacific.

Chapter 2

The Birth of the Conservation Technocrat in Peru

The guano problem is eminently a national problem.
--José Antonio de Lavalle y García (1912)

At the end of the nineteenth century, the Peruvian guano industry lay in ruins. Nevertheless, some guano remained on Peru's coastal islands, and Peru's rulers recognized the potential value of this natural resource for the pursuit of national development. Peruvian government officials first looked to foreign lenders in this pursuit, as they had for decades. But in other matters they increasingly turned to experts for developmental advice, both Peruvians and foreigners. Between 1890 and 1915, a handful of scientists and engineers definitively solved Peru's "guano problem" when they formulated a viable plan to redirect guano-based development. They established a company to provide fertilizer on a sustained-yield basis for Peruvian export agriculture based on the careful conservation of Peru's *existing* colonies of marine birds. Such reforms provided a rallying point for the unification of the class that ruled Peru's "Aristocratic Republic" (1895-1919). These actions gave birth to the conservation technocrat in Peru. These new Lords of Guano, in turn, built Peru's modern, technocratic republic.

The Global Conservation Movement

By placing environmental experts in charge of its affairs, Peru joined a movement that was transforming the management of nature the world over at the turn of the twentieth century. During this era, governments increasingly resorted to conservation experts to guarantee efficient use of resources and rationalize production. John Wesley Powell, the Humboldtian explorer of the "arid regions of the West" and eventual director of the U.S. Geological Survey, and Gifford Pinchot, the French-trained professional forester who established the U.S. Forest Service and later served as governor of Pennsylvania, are probably the best-known representatives of this technocratic movement, at least in North America. Both men shared the utilitarian belief that equitable distribution of natural resources via public ownership and expert management would provide for the "greatest good of the greatest number for the longest time." Nevertheless, private "trusts" tended to benefit most from these conservation projects, particularly hydraulic development in the arid U.S. West.[1]

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1. Samuel P. Hays founded this technocratic interpretation in *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920* (Cambridge, MA: Harvard University Press, 1959), see esp. pp. 2-4. Stephen Fox, in contrast, argues in *The American Conservation Movement: John Muir and His Legacy* (Madison: University of Wisconsin Press, 1981) that amateurs like John Muir formed the base of American conservationism. Clayton R. Koppes emphasizes the conflicts and contradictions between different visions of conservation in "Efficiency, Equity, Esthetics: Shifting Themes in American Conservationism," in *The Ends of the Earth*, 230-251. An avalanche of more recent studies point to the diverse origins of U.S. conservationism, perhaps a secret to its power and persistence as a movement; see esp. Robert Gottlieb, *Forcing the Spring: The Transformation of the American Environmental Movement* (Washington, DC: Island Press, 1993), ch. 1; Vera Norwood, *Made from This Earth: American Women and Nature* (Chapel Hill: University of North Carolina Press, 1993).

On Powell and Pinchot, see also Char Miller, *Gifford Pinchot and the Making of Modern Environmentalism* (Washington, DC: Island Press/Shearwater Books, 2001); Donald Worster, *A River Running West: The Life of John Wesley Powell* (New York: Oxford University Press, 2001); Douglas H. Strong, *Dreamers & Defenders: American Conservationists* (Lincoln: University of Nebraska Press, 1988), ch. 2-3; Goetzmann, *Exploration and Empire*, ch. 15.

On the beneficiaries of these hydraulic projects, see Pisani, *Family Farm to Agribusiness*; Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water*, rev. ed. (New York: Penguin, 1993); Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985).

But this movement was much, much larger than the United States. Late czarist Russia and the early Soviet Union also nurtured a distinctive conservation movement dominated by professional scientists. It somehow managed to survive the Stalinist purges and emphasis on production at all costs of the 1930s.[2] Both movements were preceded and paralleled by conservation efforts--often led by physicians or engineers--in British, French, and Dutch colonies. The great droughts of the late 1870s had given many of these efforts new impetus. Decades later, these conservation regimes often lived on after decolonization under the control of native-born technocrats. This global conservation movement clearly transcended ideological and national affinities.[3]

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2. Douglas R. Weiner, *Models of Nature: Ecology, Conservation,and Cultural Revolution in Soviet Russia* (Bloomington: Indiana University Press, 1988); idem, *A Little Corner of Freedom: Russian Nature Protection from Stalin to Gorbachev* (Berkeley and Los Angeles: University of California Press, 1999). On technocratic governance and economic production in the Soviet Union more generally, see Rowney, *Transition to Technocracy: The Structural Origins of the Soviet Administrative State*; Lewis H. Siegelbaum, *Stakhovanism and the Politics of Productivity in the USSR, 1935-1941* (Cambridge, UK: Cambridge University Press, 1988); Nicholas Lampert, *The Technical Intelligentsia and the Soviet State: A Study of Soviet Managers and Technicians, 1928-1935* (London: Macmillan, 1979).

3. Richard H. Grove's opus is a benchmark for all studies of the relation between science, conservation, and European colonialism: *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600-1860* (Cambridge, UK: Cambridge University Press, 1995); idem, *Ecology, Climate and Empire: Colonialism and Global Environmental History, 1400-1940* (Cambridge, UK: White Horse Press, 1997). See also Peder Anker, *Imperial Ecology: Environmental Order in the British Empire, 1895-1945* (Cambridge, MA: Harvard University Press, 2001); Richard Drayton, *Nature's Government: Science, British Imperialism, and the "Improvement of the World"* (New Haven, CT: Yale University Press, 2000); Peter Boomgaard, "Oriental Nature, Its Friends and Its Enemies: Conservation of Nature in Late-Colonial Indonesia, 1889-1949," *Environment and History* 5:3 (Oct. 1999), 257-292; David Gilmartin, "Scientific Empire and Imperial Science: Colonialism and Irrigation Technology in the Indus Basin," *Journal of Asian Studies* 53 (1994), 1127-1149; Michael Osborne, *Nature, the Exotic, and the Science of French Colonialism* (Bloomington: Indiana University Press, 1994); William Beinhart, "Introduction: The Politics of Colonial Conservation," *Journal of Southern African Studies* 15:2 (Jan. 1989), 143-162; Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940* (New York: Oxford University Press, 1988), esp. ch. 6-7, 9-10; John McCracken, "Experts and Expertise in Colonial Malawi," *African Affairs* 81:132 (Jan. 1982), 101-116. On

This trend had its analogue in Latin America. Beginning in 1861, the self-taught Brazilian forester Manuel Gomes Archer and a team of black slaves replanted what is now Tijuca National Park above Rio de Janeiro with native trees to guard its urban water supply. After 1911, the reorganized Brazilian Forest Service took a decidedly different tack: Portuguese-trained agronomist Edmundo Navarro de Andrade devoted it to planting Australian eucalyptus in place of the Atlantic rainforest. After returning to the private sector as manager of forestry for a railroad company, he almost single-handedly set up Brazil to become the world's largest producer of eucalyptus wood.[4]

Well before the Great Drought of 1877-1878 had taken its full course, a group of engineers and scientists met for a series of debates at the Instituto Polytechnico in the capital of the Brazilian Empire. This led to the creation of a commission of engineers to tour the devastated Northeast. With an eye to the British drought response in India, they recommended an elaborate system of reservoir construction and tree planting to permanently alter the climate of the dry *sertão*. The Brazilian state hired an English hydraulic engineer to plan three

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conservation thought and policy in explicit connection to the events of the 1870s, see Grove, "The East India Company, the Australians and the El Niño: Colonial Scientists and Ideas about Global Climatic Change and Teleconnections between 1770 and 1930," in *Ecology, Climate and Empire*, 125-141; R. J. Henry, "Technology Transfer and Its Constraints: Early Warnings from Agricultural Development in Colonial India," in *Technology and the Raj: Western Technology and Technical Transfers to India, 1700-1947* ed. Roy MacLeod and Deepak Kumar (New Delhi: Sage Publications, 1995), 51-77; Davis, *Late Victorian Holocausts*.

4. José Drummond, "The Garden in the Machine: An Environmental History of Brazil's Tijuca Forest," *Environmental History* 1:1 (Jan. 1996), 83-104; Robin W. Doughty, *The Eucalyptus: A Natural and Commercial History of the Gum Tree* (Baltimore, MD: Johns Hopkins University Press, 2000), ch. 5; Warren Dean, *With Broadax and Firebrand: The Destruction of the Brazilian Atlantic Forest* (Berkeley and Los Angeles: University of California Press, 1995), 223-225, 232-238.

enormous dam projects. Northeastern politicians, who wanted railroads not dams, organized their own team of Brazilian engineers to rebut this foreigner's plan. They eventually derailed construction, but after subsequent droughts, the Brazilian Republic revived and completed these projects. Beginning in 1909--the same year Peru embarked on its guano conservation experiment by founding the Compañía Administradora del Guano--the Brazilian state systematically built an enormous technocratic apparatus to manage these hydraulic systems against drought. Much like the vast hydraulic empire in the United States, to which it was closely tied, this Brazilian leviathan grew into one of the largest reservoir systems in the world.[5]

Similarly, Miguel Ángel de Quevedo, Mexico's "apostle of the tree," became interested in watershed conservation while completing his degree in hydraulic engineering at France's École Polytechnique, and then supervising the massive project to drain the Valley of Mexico during the 1890s. With the vital assistance of economist José Yves Limantour, the most powerful of the *científicos* who advised the government of Porfirio Díaz (1876-1911), Quevedo laid the foundations for the Mexico City park system, Mexico's expansive forest reserve system, and after the Mexican Revolution, its national parks system. In fact, middle-class *ingenieros* and *licenciados* disgruntled with the authoritarian científicos helped carry an outspoken water conservationist all the way to the

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5. Cunniff, "The Great Drought," ch. 4, 6. See also Gerald Michael Greenfield, *The Realities of Images: Imperial Brazil and the Great Drought*, Transactions of the American Philosophical Society, v. 91, pt. 1 (Philadelphia, 2001); Marco Antonio Villa, *Vida e morte no sertão: Histórias das secas no Nordeste nos séculos XIX e XX* (São Paulo: Atica, 2000); Anthony L. Hall, *Drought and Irrigation in North-east Brazil* (Cambridge, UK: Cambridge University Press, 1978). On related trends for a later period in Argentina, see Gustavo Lins Ribeiro, *Transnational Capitalism and Hydropolitics in Argentina: The Yacyretá High Dam* (Gainesville: University Press of Florida, 1994).

presidency during the first phase of the Revolution: Francisco Madero, a former student at the Technical Agricultural School of the University of California, had played an important role in planning hydraulic projects in the region where his family owned an irrigated cotton-growing empire--one of the centers, it should be added, of subsequent revolutionary violence.[6]

It is important to underscore that the new generation of conservation technocrats who rose to power in the Americas during this era hardly imposed views of the world that were totally foreign. In Brazil, Mexico, and Peru, technocrats validated positions already promoted by a class of local partisans. These conservation movements were not a clear-cut case of foreign cultural imperialism like that exercised by Europe and the United States over their formal overseas colonies. Nor did conservation science serve some autochtonous "national interest" for Latin Americans. But these movements were eminently about domination. Peru's twentieth-century experiment in marine conservation is best understood as a form of *internal colonialism* akin to that practiced by Brazil, Mexico, the United States, Russia, and so many other countries so both "nationals"

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6. Lane Simonian, *Defending the Land of the Jaguar: A History of Conservation in Mexico* (Austin: University of Texas Press, 1995), ch. 4; Clifton B. Kroeber, *Man, Land, and Water: Mexico's Farmlands Irrigation Policies, 1885-1911* (Berkeley and Los Angeles: University of California Press, 1983), esp. 46-47, 70-73; Alan Knight, *The Mexican Revolution* (Cambridge, UK: Cambridge University Press, 1986), 1:21-24, 55-57, 62, 71; Ramón Eduardo Ruíz, *The Great Rebellion: Mexico, 1905-1924* (New York: Norton, 1980), 139-141. On "scientific politics" and the ubiquity of technocrats in Porfirian Mexico, see Tenorio, *Mexico at the World's Fairs*, esp. 23-24, 48-54, 125-127, app. 1; Perlo, *El paradigma porfiriano*; Charles Hale, "Political and Social Ideas in Latin America, 1870-1930," in *CHLA* (1986), 4:387-389, 392; idem, *The Transformation of Liberalism in Late Nineteenth-Century Mexico* (Princeton, NJ: Princeton University Press, 1989); Camp, *Political Recruitment across Two Centuries*, ch. 4, esp. table 1.

and “foreigners” could benefit from the exploitation of humans and nature located within their national frontiers.[7]

Order and “Progress”

The devastating War of the Pacific broke down commercial organization and seemingly demolished much of the “ficitious prosperity” built up in Peru during the Guano Age. Nevertheless, fossil guano deposits remained on a few islands, although of lower quality, and various state officials and businessmen began to look for ways to make guano a part of Peru’s economic reconstruction. As in Mexico and Brazil, science, technology, and expertise held great prestige as instruments of progress among a class of Peruvian modernizers. Even more so than during the Guano Age, they provided the grounds for agreement between competing factions and the restoration of political order in Peru.

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7. The debate on “science and the colonial enterprise” has come a long way since the three-stage, diffusionist model of George Basalla, “The Spread of Western Science,” *Science* 5 May 1967, 611-622, and the nationalist preoccupation of science studies in Latin America reflected in Hebe M. C. Vessuri “The Social Study of Science in Latin America,” *Social Studies of Science* 17 (1987), 519-554. But this discussion still has trouble making sense of postcolonial situations, partly because of the persistence of nationalist concerns fed by the growing “North-South” divide, more so because of the relative lack of attention paid by postcolonial theorists toward Latin America’s two centuries of “neocolonial” independence. A globalist focus on the more narrow question of *who benefits* from science, technology, and expertise seems to offer one way to achieve a new understanding. Landmarks in this discussion include Roy MacLeod, “On Visiting the ‘Moving Metropolis’: Reflections on the Architecture of Imperial Science,” *Historical Records of Australian Science* 5:3 (Nov. 1982), 1-16; idem, ed., “Nature and Empire: Science and the Colonial Enterprise”; Juan José Saldaña, “Teatro científico americano: Geografía y cultura en la historiografía latinoamericana de la ciencia,” in *Historia social de las ciencias en América Latina* (Mexico City: Porrúa, 1996), 7-41; Paolo Palladino and Michael Worboys, “Science and Imperialism,” *Isis* 84:1 (Mar. 1993), 91-102; Lewis Pyenson, “Cultural Imperialism and Exact Sciences Revisited,” *Isis* 84:1 (Mar. 1993), 103-108.

In January 1890, after years of discussion, Peru signed the so-called Grace Contract. This international agreement got its name from Michael P. Grace, an Irish-born businessman who had immigrated to Peru in the late 1850s to assist his brother William--the future mayor of New York City and founder of W. R. Grace & Co.--with the family business supplying ships anchored at the Islas Chincha. During the long unrest of the 1880s, Michael sold arms to the Peruvian government and bought up choice highland mines and coastal plantations for the family company. Of course, he wanted to protect these investments, and perhaps get a hold on the central Andean railway itself. Playing a role much like Francisco Quirós 50 years before, Michael Grace orchestrated an agreement between British bondholders and the government of General Andrés Cáceres that retired the huge, £51 million (US$250 million) foreign debt that had accrued since the default of 1876. In return for canceling the debt, bondholders received shares in the Peruvian Corporation of London which received control of Peru's railways for 66 years and the right to extract and export two to three million long tons of guano. The Peruvian Corporation promised to complete, modernize, and extend these rail lines and to allow local contractors to extract guano from the Islas Chincha for Peruvian agriculture.

The costs and benefits of this agreement to the parties involved have been hotly debated ever since. But it is safe to say that the Peruvian Corporation managed its railroads incompetently during its first two decades of existence and paid low dividends to its stockholders while providing mediocre, expensive service to most Peruvian users. From the point of view of Peruvian state officials, the railroads did provide some measure of integration necessary for control of national territory, although they had the contradictory effect of increasing the regional compartmentalization of Peru's internal economy between north, central, and south. Railroad construction also helped reinitiate the exchange of technology and expertise between Europe and Peru interrupted by the War of the Pacific. At least in one sense, the Grace Contract was an immediate failure. After canceling their debt, Peruvian officials expected to raise new foreign loans, but a downturn in the Argentine economy caused an intense financial crisis in European banks (the so-called Baring Panic of 1890) and made North Atlantic financiers wary of loaning large sums to Latin American countries. As a consequence, the Peruvian government was unable to contract a foreign loan until 1905 and could not do so on a large scale until the 1920s. This agreement proved to be an immense boon, however, for Michael Grace and his family's New York-based firm, and eventually for other multinationals owning mining concerns in the Andes and large sugar cane plantations on the coast.[8]

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8. Rory Miller, "The Making of the Grace Contract: British Bondholders and the Peruvian Government, 1885-1890," *JLAS* 8:1 (1976), 73-100; idem, "Railways and Economic Development in Central Peru, 1890-1930," in *Social and Economic Change in Modern Peru*, ed. R. Miller, C. Smith and J. Fisher (Liverpool: Center for Latin American Studies, 1975), 27-52; idem, "The Grace Contract, The Peruvian Corporation, and Peruvian History," *Ibero-Amerikanisches Archiv*, n.s., 9:3/4 (1983), 319-348; idem, "Transferring Techniques: Railway Building and Management on the West Coast of South America," in *The State and the Market: Studies in the Economic and Social History of the Third World*, ed. Clive Dewey (New Delhi: Manohar, 1987), 155-191; Bishel, "Business Ideology and U.S. Foreign Policy," passim; C. Alexander G. DeSecada, "Arms, Guano, and Shipping: The W. R. Grace Interests In Peru, 1865-1885," *Business History Review* 59:4 (1985), 597-621; Manuel Burga and Alberto Flores Galindo, *Apogeo y crísis de la república aristocrática* (Lima: Rikchay Peru, 1979), 71-74; Jorge Basadre, *Historia de la República del Perú, 1822-1933*, 6th ed. (Lima: Editorial Universal, 1968), 9:107-136. On the Baring crisis, see Marichal, *A Century of Debt Crises in Latin America*, 149-170. Cf. Lawrence A. Clayton, *Grace: W.R. Grace and Company: The Formative Years, 1850-1930* (Ottawa, IL: Jameson Books, 1985).

After more than a decade of almost constant civil war, Peru regained a measure of political stability when the charismatic strongman Nicolás de Piérola (1839-1913) from the southern city of Arequipa grabbed the reins of power in 1895. Piérola was the son of the technocrat who had served on the 1853 guano island commission and worked with Mariano de Rivero to organize Peru's first scientific institutions after independence. The younger Piérola deserves much of the blame for Peru's instability during the quarter century leading up to 1895. As Minister of Finance, he had been the mastermind behind the notorious Dreyfus contract and guano loans of 1870 and 1872. He came from a city that was often rebellious against the dictates of the capital, and he led a series of armed rebellions against Manuel Pardo and his followers belonging to the Partido Civil. One such revolt catapulted Piérola to power but seriously undermined Peruvian unity during the War of the Pacific. His followers vociferously--sometimes violently--opposed attempts by other factions to establish political hegemony after the war, including the Grace Contract. But when Piérola returned to power in 1895, he agreed to share influence over the central government with his old enemies in the Partido Civil. This confederation gained further strength by recognizing the regional power of the landed aristocracy of the Sierra. These factions came to an agreement largely because they had grown tired of squabbling and shared a desire to put Peru back on the path to prosperity. Much of Peru then entered a relatively peaceful period from 1895 to 1919 known by historians as the Aristocratic Republic. This was followed by the relatively stable rule of dictator Augusto B. Leguía from 1919-1930 known as the *oncenio*.[9]

Internal political peace and the recovery of the world economy from the crisis of the early 1890s allowed economic expansion to return to Peru. Plantation sugar production along the coast grew rapidly thanks to burgeoning international demand. Mine owners and wool producers enjoyed greater access to markets with the expanded railroad system in the Sierra. Even the remote Amazon region prospered briefly during the rubber export boom. This growth trend lasted thanks to the development of local industry, the initiation of copper, cotton, and petroleum exports, and the influx of U.S. investment.[10] These foreign business connections were particularly important since they potentially linked Peru to U.S., British, and German expertise. Scientists and engineers from these countries supplanted former French dominance in most areas.

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9. There is an abundant literature on the political and economic elite during the Aristrocratic Republic. In this study, I take a position emphasizing the power and cohesive nature of the planter class and their ability to share control of the Peruvian state with other progressive-minded elites, even during Leguia's dictatorship. Key works include: Burga and Flores Galindo, *Apogeo y crísis de la república aristocrática*; Mc Evoy, *La utopía republicana*, ch. 6-7; Michael J. Gonzales, "Planters and Politics in Peru, 1895-1919," *JLAS* 23:3 (Oct. 1991), 515-531; idem, *Plantation Agriculture and Social Control in Northern Peru*; Alfonso W. Quiroz, "Financial Leadership and the Formation of Peruvian Elite Groups, 1884-1930," *JLAS* 20:1 (1988), 49-81; Peter F. Klarén, "The Origins of Modern Peru, 1880-1930," *CHLA* (1986), 5:587-640; idem, *Modernization, Dislocation and Aprismo: Origins of the Peruvian Aprista Party, 1870-1932* (Austin: University of Texas Press, 1973); Miller, "The Coastal Elite and Peruvian Politics, 1895-1919," *JLAS* 14:1 (May 1982), 97-120; Julio Cotler, *Clases, estado y nación en el Perú* (Lima: Instituto de Estudios Peruanos, 1978), ch. 3, 4; Dennis L. Gilbert, *The Oligarchy and the Old Regime in Peru*, Latin American Studies Program Dissertation Series, no. 69 (Ithaca, NY: Cornell University, 1977).

10. For a detailled discussion of these economic trends, see Rosemary Thorp and Geoffrey Bertram, *Peru, 1890-1977: Growth and Policy in an Open Economy* (London: Macmillan, 1978), part 2.

The return of prosperity nurtured the development of a progressive, nationalist ethos among the coastal elite and encouraged the formation of a coherent, self-conscious class of professional intellectuals. Like their brethren in other parts of Latin America, the vast majority of these educated individuals idealized rational development through science and technology, education, European immigration, foreign investment, and public hygiene. These self-proclaimed "positivists" especially promoted the scientific study of natural resources and hoped to use these studies to craft plans for rational state development. They certainly were not unimaginative promoters of orthodox free-market economics. Moreover, their support for scientific investigation and state-directed development extended far beyond mere rhetoric: As we shall soon see, positivist principles determined the form of a spectacularly successful conservation project. For those who have not already done so, it is high time to abandon the fatalistic view that turn-of-the-century Latin American intellectuals neglected to produce innovative ideas and lasting institutions that had a significant impact on material life--at least for the privileged class that gave birth to them. In short, the rulers of country after country during this era looked to "scientific politics" as the answer to the ubiquitous problem of "order and progress."[11]

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11. On intellectual life and the growth of scientific investigation in Peru during the late nineteenth and early twentieth centuries, see Gootenberg, *Imagining Development*, esp. 182-187, 203-210; Marcos Cueto, *Excelencia científica en la periferia: Actividades científicas e investigación biomédica en el Perú, 1890-1950* (Lima: CONCYTEC, 1989), esp. 55-60; Jesús Chavarría, "The Intellectuals and the Crisis of Modern Peruvian Nationalism, 1870-1919," *HAHR* 50:2 (May 1970), 257-278; Pike, *The Modern History of Peru*, 159-168.

On positivism and elite ideology in Latin America more generally, see Baud, "The Quest for Modernity"; Hale, "Political and Social Ideas in Latin America, 1870-1930," esp. 391-396; E. Bradford Burns, *The Poverty of Progress: Latin America in the Nineteenth Century* (Berkeley and Los Angeles: University of California Press, 1980), 18-71; *Dictionary of the History of Ideas:*

One new, explicitly nationalist scientific organization exemplified this postivist logic like no other in Peru. Akin to a similar institution founded in Costa Rica about this time, the Sociedad Geográfica de Lima (est. 1888) gave enormous impetus to the description--and ultimately to the exploitation--of Peru's natural and human resources.[12] Its members, the cream of scientific and political life in Peru, gave birth to the "El Niño" phenomenon as a scientific category. In 1891, Luis Carranza (1848-1898), the society's founding president and a major architect of the peace of 1895, directed the society's focus to the torrential rains and catastrophic floods that were threatening Lima, as well as the northern Peruvian coast. Camilo N. Carrillo (1830-1900), a naval hydrographer and prominent science educator, passed on the report from local fishermen living near his hometown Paita that a weak ocean current that normally appears every summer about Christmas along the northern coast was very strong that year. Carrillo attached the folk name "El Niño" (referring to the advent of the Christ Child) to the more general oceanic changes of 1891. To keep track of such events around Peru, the Sociedad Geográfica organized a network of meteorological observers. As part of this project, the Piura physician Víctor Eguiguren (1852-1919) compiled and published regional oral

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Studies of Selected Pivotal Ideas (New York: Charles Scribner's Sons, 1973), s.v. "Positivism in Latin America"; Arturo Ardao, "Assimilation and Transformation of Positivism in Latin America," *Journal of the History of Ideas* 24 (1963), 515-522; Leopoldo Zea, *The Latin American Mind*, trans. James H. Abbott and Lowell Dunham (Norman: University of Oklahoma Press, 1963), originally published as *Dos etapas del pensamiento en Hispanoamérica: Del romanticismo al positivismo* (Mexico City: Colegio de México, 1949).

12. Leoncio López-Ocón Cabrera, "El nacionalismo y los orígenes de la Sociedad Geográfica de Lima," in *Saberes andinos: Ciencia y tecnología en Bolivia,Ecuador y Perú*, ed. Marcos Cueto (Lima: Instituto de Estudios Peruanos, 1995), 109-125; cf. Marshall C. Eakin, "The Origins of Modern Science in Costa Rica: The Instituto Físico-Geográfico Nacional, 1887-1904," *Latin American Research Review* 34:1 (1999), 123-150.

tradition of similar climate anomalies in northern Peru since 1791. This folk tabulation now forms the backbone of all global chronologies of the ENSO phenomenon. A digest of this work was presented in English at an international congress in London in 1896.[13] But for many years, foreign scientists viewed Peru's "El Niño" as little more than a regional geographical curiosity, even though this 1891 event again corresponded with severe climate anomalies in many parts of the globe, including a catastrophic summer drought, extreme winter, and major famine in central Russia.[14]

Political peace allowed state officials to turn their attention from the establishment of order toward the material interests of Peruvians, particularly those on the coast closest to the center of state power in Lima. In Janurary 1896, the same year that he eliminated export taxes for the benefit of agro-exporters, President Piérola carried through an initiative to establish a Ministerio de Fomento (Ministry of Development) first proposed when he was dictator during the War of

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13. Luis Carranza, "Climatología y meteorología del Perú," *BSGL* 1 (1891), 392-413; Camilo N. Carrillo, "Estudios sobre las corrientes oceánicas y especialmente de la corriente de Humboldt," *Boletín de la Sociedad Geográfica de Lima* 2 (1892), 72-111; Víctor Eguiguren, "Las lluvias en Piura," *BSGL* 4 (1894), 241-257; Federico A. Pezet, "La Contracorriente 'El Niño' en la costa norte del Perú," *BSGL* 5 (1896), 457-461. Besides appearing in the *Report of the 6th International Geographical Congress* (London: John Murray, 1896), Pezet's article was abstracted in *Annalen der Hydrographie und Maritimen Meteorologie*, 23 (1895), 466. See also Luis Carranza, *La ciencia en el Perú en el siglo XIX: Selección de artículos publicados por el Dr. Luis Carranza, médico fundador y presidente de la Sociedad Geográfica de Lima* (Lima: Editorial Eddili, 1988).

14. The physical relationship between ENSO and climate anomalies in Central Russia is moderately robust. As with the events of 1877-1878, their global *coincidence*, not their causal connection, is the important point. See Davis, *Late Victorian Holocausts*, ch. 4; James Y. Simms, Jr., "The Crop Failure of 1891: Soil Exhaustion, Technological Backwardness, and Russia's Agrarian Crisis," *Slavic Review* 41:2 (1982), 236-250; Richard G. Robbins, Jr., *Famine in Russia, 1891-1892: The Imperial Government Responds to a Crisis* (New York: Columbia University Press, 1975).

the Pacific. This ministry was authorized to develop the "moral" and "physical energies and natural riches of the country . . . enlarge the initiative and energy . . . of industrial life," and diffuse "all classes of useful knowledge." In line with ministries of development elsewhere in Latin America, its formation was a clear message that Peruvian state bureaucrats would take an active role in the planning, funding, and direction of progressive endeavors within Peru's territorial boundaries. To accomplish these ends, the Ministerio de Fomento sponsored a series of scientific expeditions and learned studies and published them in an illustrated journal. More concretely, it took over the administration of all state-financed civil engineering projects in Peru, such as the reconstruction of bridges, irrigation canals, and dikes destroyed by the 1891 El Niño in the northern department of Piura.[15]

As their predecessors had done, officials in the Ministerio de Fomento moved to take advantage of scientific and practical expertise developed in other parts of the world. The Ministerio translated and published many foreign studies to great effect and sent locally trained Peruvians to study agricultural and industrial practices and obtain advanced degrees overseas. Circa 1908, after completing degrees in agronomic engineering, Alfredo Ferreyros traveled to the United States,

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15. *MMFOM* 1 (1896), 3, 7-8, 70; Leopoldo Cortez, "El Ministerio de Fomento del Perú, Dirección de Fomento," *BMFOM* 1:5 (May 1903), 84; Basadre, *Historia de la República*, 10:258-259; "Obras proyectadas por el Ing. Demetrio Pérez para defensa de Paita, Piura, Catacaos," 1893, AMFOM 25:1181; "Pago al Ing. Carlos Findlay contratista para la construcción del Puente de Piura, etc.," 1893, AMFOM 25:5987-5989; "Irrigación de Catacaos," 1888-1896, AMFOM 28:351; "Constr. Puente de Piura," 1898, AMFOM 32:5993. Examples of Ministerio de Fomento sponsored agricultural studies include C. Saillard, "Aplicación de abonos completos para el cultivo intensivo de la caña de azúcar," *BMFOM* 4:10 (Oct. 1906), 43-69; Alfredo Broggi, "Porvenir del cultivo del algodón en el Perú," *BMFOM* 7:3 (Mar. 1909), 1-37.

Hawaii, and Java to study sugar production, while Gerardo Klinge journeyed to the United States, Argentina, and Australia to make a comparative study of cattle raising. Klinge (1887-1961) returned to play a key role in the development of agronomic science in Peru over the following years, first as chief of a cotton experimental station in Lima, later as founder of an agricultural research center at La Molina (now the site of the Universidad Nacional Agraria). He eventually tried to meld his scientific and economic interests in export agriculture with right-wing politics.[16]

Peru's Agricultural Revolution

This kind of state support for science and technology was hardly new, but this trend did represent a major increase in scientific activity in Peru. In the case of agronomy, this was indicative of the economic vigor and growing political power of export agriculture. Interest in science and expertise marked this sector's turn toward modern, input-intensive practices--Peru's agricultural revolution.

At the turn of the century, export agriculture was one of the most dynamic economic sectors in Peru, and it provided the basis of wealth and social status for much of the coastal elite. In 1896, Piérola organized by decree the Sociedad Nacional de Agricultura (reorganized in 1914 as the Sociedad Nacional Agraria), a state corporation designed to represent the interests of the agricultural and livestock

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16. *BMFOM* 6:6 (June 1908), 87-88; *Diccionario histórico y biográfico del Perú*, s.v. "Klinge, Leonidas [sic.]" On the Ferreyros family's agricultural machinery import business and vast financial empire, see Enrique Vásquez Huamán, *Estrategias del poder: Grupos económicos en el Perú* (Lima: Universidad del Pacífico, Centro de Investigación, 2000), 256-262.

sector to the state. It rapidly developed into one of the most influential corporate interest groups in Peruvian politics and was dominated from the beginning by sugar planters.[17]

Like their brethren in the Caribbean, many plantation owners who produced sugar and cotton for export realized the value of scientific agriculture and looked around the world for new ideas, techniques, and expertise. Through the Sociedad Nacional de Agricultura, they pushed for agricultural studies by state-employed agronomists and the establishment of a national agricultural school. In 1901, the Peruvian state invited a team of Belgian agronomists from the Faculté Universitaire des Sciences Agronomiqes de Gembloux, a leading center for sugar beet research, to do an agricultural survey of the country. In 1902, this team revived a project from Pardo's Practical Republic of the 1870s and founded the Escuela Nacional de Agricultura y Veterinaria in Lima to train a corps of Peruvian agronomic engineers. The leader of this mission, George Vanderghem (1875-1932), stayed in Peru the rest of his life, where he worked variously as director of the Escuela Nacional, the manager of the British Sugar Company's San Jacinto estate, and after the destructive El Niño floods of 1925-1926, as the organizer of the Peruvian government's first true network of meteorological observatories. Progress-minded Peruvians also published a series of agricultural manuals and journals, such as José Luis Torres's *Cartilla de agricultura del Perú* (1896), and continually lobbied for state investment in expensive irrigation systems. These actions introduced many

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17. Basadre, *Historia de la República*, 10:301.

innovations made during the Guano Age elsewhere in the world to coastal Peruvian agriculture.[18]

Irrigation management soon became a focus of this rationalizing drive. The key to successful farming on the extremely arid Peruvian coast has always been access to water for irrigation. Coastal agriculture ultimately relied on rivers fed by seasonal precipitation and snowmelt in the Sierra. The expansion of thirsty sugar and rice estates during the late nineteenth century placed an increasing strain on the traditional system of water rationing inherited from the era of Spanish colonial rule. In this system, water rights were tied to the ownership of specific plots and were adjudicated by local judges (*jueces*) organized in a complex bureaucracy. Water frequently inspired violent struggles over its control, so to followers of the positivist maxim "order and progress" it was a prime target for governmental reform. In 1899, Piérola's Minister of Justice formed a commission of large landowners and prominent lawyers to frame a national water code ostensibly intended to rationalize and democratize access to this vital natural resource. In 1902, the Peruvian Congress officially adopted a revised version of the commission's recommendations modeled on the Spanish water code of 1879.

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18. Ernesto Yepes, "La Escuela Nacional de Agricultura," in *Estudios de historia de la ciencia en el Perú*, 1:193-213; Bruno Revesz, "Ciencia y tecnología en el desarrollo agrario regional: El caso de Piura," in *Estudios de historia de la ciencia en el Perú*, 1:215-243; Cueto and Jorge Lossio, *Inovación en la agricultura: Fermín Tangüis y el algodón en el Perú* (Lima: Universidad del Pacífico, Centro de Investigación, 1999), ch. 1; George Vanderghem, "Servicio Meteorológico Nacional, Lima: Resumen de las observaciones efectuadas en el año 1929," *BSGL* 47:1 (Mar. 1930), 59-60; Federico G. Fuchs, "Los cambios de clima en el mundo: Posibles causas del cambio de clima, en la costa del Perú," *BSGL* 54:3-4 (1937), 166; Pablo Macera, "El guano y la agricultura peruana de exportación, 1909-1945," in *Trabajos de historia*, vol. 4 (Lima: Instituto Nacional de Cultura, 1977), 362; *Enciclopedia ilustrada del Perú*, s.v. "Vanderghem, Jorge." Cf. McCook, *States of Nature*.

Ministerio de Fomento officials had final authority over this new system. But real power lay with district water boards (*comunidades de regantes*), each run by an elected full-time administrator overseen by an elected three-man executive committee (*sindicato regional*). Large landowners dominated this new system since voting for administrative officials was apportioned to individual landowners according to the amount of land cultivated, or--in an even more egregious example of those "with" dominating those "without"--the existing size of their water allocation. This contributed directly to the growth of latifundia, particularly on Peru's north coast, as smallholders prevented from gaining regular access to water were forced to sell out to large landowners and become proletarians.[19]

In 1918, the government of José Pardo y Barreda (1864-1947)--two-time President, three-time graduate and professor of the Faculty of Political and Administrative Sciences, patriarch of a sugar-growing empire, and symbol of the fragile consensus that unified the Aristocratic Republic--threw out this ostensibly democratic system for a technocratic reform that would have made his father, Manuel Pardo, proud. At a tense moment when agro-exporters in Peru were prospering and wage workers were suffering from high prices during World War I, the Peruvian state gave power over water allocation to local boards (*comisiones técnicas de irrigación*) composed of state-appointed hydraulic engineers. It was hoped that this move would boost domestic food production, lower local food prices, and put a lid on social unrest. It largely failed on all these counts, and there is little evidence that it put an end to the dispossession of smallholders, at least near

19. Klarén, *Modernization, Dislocation, and Aprismo*, ch. 3.

the centers of cane cultivation. In fact, both cotton and cane planters enjoyed record profits during the "dance of the millions" after the war, and cultivation of both crops increased steadily for several years thereafter.[20] Still, this was an important victory for the technocratic ideal, and the Peruvian state invested unprecedented sums in the extension of this hydraulic network during the 1920s. This included the Lambayeque Irrigation Project managed by U.S. civil engineer Charles W. Sutton, a vast scheme to divert a tributary of the Amazon beneath the Andes in order to conquer Peru's desert frontier for export agriculture (map 2).[21]

But the most notable triumph of Peruvian scientific agriculture in the twentieth century was accomplished by a local plant breeder without ties to any of these new organizations or projects. The Puerto Rican immigrant Fermín Tangüis (1851-1932) arrived in Peru in 1873 after the Ten Years' War against Spanish colonial rule forced him to abandon his medical education in Cuba. He eventually settled down as a yeoman cotton farmer along the Peruvian coast near Pisco. In response to the spread of the fungal disease cotton wilt to his locale in 1904, an unwelcome consequence of the global transportation revolution of this era, Tangüis began an experiment in empirical plant selection using wild cotton varieties native to the Peruvian coast, a center of natural genetic diversity for cotton. Meanwhile, Gerardo Klinge independently tried to do the same at a state-funded experimental station in Lima using resistant cotton varieties provided by the U.S. Department of

20. See app. 5.

21. Klarén, *Modernization, Dislocation, and Aprismo*, ch. 3; *Enciclopedia ilustrada del Perú*, s.v. "Pardo y Barreda, José"; George R. Johnson, *Peru from the Air*, Special Publication no. 12 (New York: American Geographical Society, 1930), 15. Cf. Kroeber, *Man, Land, and Water*.

Agriculture. By the 1910s, without such help, Tangüis had bred a disease-resistant strain (*Gossypium barbadense* hybrid) with ultra-long fibers particularly suitable to use in high-speed textile machinery. As an added bonus from the point of view of Peruvian economic nationalists, this strain would only grow readily in the cool, arid environment of the central and southern coasts of Peru and had no equal competitor on the global market. Tangüis freely shared knowledge of his new cultivar in line with his belief that the fruits of science should belong to the public. He consciously chose not to profit selfishly from his discovery. The blossoming of cotton agriculture in this region after World War I grew directly from Tangüis's innovation. The prestige of agronomic science in Peru--and Tangüis's status as a national hero--grew right along with it.[22]

These developments in scientific agriculture were hardly unique to Peru. A flurry of recent historical research has revealed that many regions of Latin America and the Carribean experienced a similar "agricultural awakening" during the first decades of the twentieth century. As with Peruvian cotton, this awakening was driven not only by the pressures of a global agricultural market, but also by the global exchange of cultivars, crop diseases and pests. Moving beyond the triumphal histories of the past, newer students of the history of Latin American agronomy have identified some unintended consequences of "success." For example, the South American cane toad (*Bufo marinus*) was introduced to Australia and many other locales worldwide after its successful use by scientists to control an

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22. See app. 5-6; Cueto and Lossio, *Inovación en la agricultura*, passim; Macera, "El guano y la agricultura peruana de exportación," 380, 385.

insect pest of sugar cane in Puerto Rico. Experts thereby unleashed a biological plague of Biblical proportions on the island continent.[23] More troublingly, selective breeding and the war against plant disease were so successful that they drove down prices and profits for sugar cane growers over the long term. This created a situation in many countries where only the most highly capitalized firms administered by trained technicians with control over huge expanses of land and resources could survive international competition. This raised the stakes for agronomic success ever higher.[24]

Coastal farmers in Peru at the turn of the century came to resent the Grace Contract because the Islas Chincha could not provide enough fertilizer for existing coastal agriculture, much less for its expansion or the eventual modernization of

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23. The cane toad has become a subject of popular culture thanks to Mark Lewis's hilarious but troubling nature documentary *Cane Toads: An Unnatural History*, 47 min., First Run Productions, 2001, videocassette. Its connection to the American tropics and a "success" story for Latin American science is less-well known. See McCook, *States of Nature*, 72, 74 [which misleadingly identifies *B. marinus* as the "Surinam toad"]; Darrel R. Frost, *Amphibian Species of the World: An Online Reference*, v2.21, 15 July 2002, s.v. "Bufo marinus" [cited 4 Mar. 2003], available from http://research.amnh.org/herpetology/amphibia/index.html; and the exhaustive list of sources compiled by Rick Speare, *Bibliography of Bufo marinus*, Mar. 1997 [cited 4 Mar. 2003], available from http://www.jcu.edu.au/school/phtm/PHTM/staff/biblio1.htm.

24. See McCook, *States of Nature* (on the "agricultural awakening" in Costa Rica, Venezuela, Puerto Rico, Cuba, and Colombia); John Soluri, "People, Plants, and Pathogens: The Eco-social Dynamics of Export Banana Production in Honduras, 1875-1950," *HAHR* 80:3 (Aug. 2000), 463-501; idem, "Landscape and Livelihood: An Agroecological History of Export Banana Growing in Honduras, 1870-1975," (Ph.D. diss., University of Michigan, 1998); Eakin, "The Origins of Modern Science in Costa Rica"; Alan Dye, *Cuban Sugar in the Age of Mass Production: Technology and the Economics of the Sugar Central, 1899-1929* (Stanford, CA: Stanford University Press, 1998); J. H. Galloway, "Botany in the Service of Empire: The Barbados Cane-Breeding Program and the Revival of the Caribbean Sugar Industry, 1880s-1930s," *Annals of the Association of American Geographers* 86:4 (1996), 682-706; Joseph Eugene Cotter, "Before the Green Revolution: Agricultural Science Policy in Mexico, 1920-1950," (Ph.D. diss., University of California, Santa Barbara, 1994); Warren Dean, "The Green Wave of Coffee: Beginnings of Agricultural Research in Brazil (1885-1900)," *HAHR* 69:1 (Feb. 1989), 91-115. Cf. Scobie, *Revolution on the Pampas*, 131-150; Stein, *Vassouras*, ch. 9.

farming in the Sierra. Although Peruvian river valleys are blessed with fertile, alluvial soils derived from other recently formed soils (entisols) along its dry coast, any crop grown intensively on the same plot of ground for several seasons will naturally deplete the soil of nutrients. These profit-minded farmers, some of whom were in the process of building huge export-agribusiness empires, found it much more sensible to apply concentrated Peruvian guano than to use other methods to recover these nutrients, such as spreading ash produced by burning sugar-cane bagasse, rotating legume crops like alfalfa, or applying expensive imported fertilizers. Though guano production and sales in Peru were on the increase, they could not keep up with growing local interest.[25] Sugar and cotton growers began to fight each other for access to the limited guano supply. The sugar interest dominated the Sociedad Nacional de Agricultura, and they used their superior wealth and influence to obtain special discounts and preferential access to guano. Thus, the guano shortage most immediately threatened Peruvian cotton growers, who were also dealing with cotton wilt. Meanwhile, the Peruvian Corporation of London was exporting much larger quantities of guano than it had in previous years.[26]

From the point of view of Peruvian nationalists--and not a few foreign-owned businesses that owned a stake in export agriculture--something had to be

25. See app. 2-3.

26. See app. 1; Tomás F. Sedgwick, "La industria azucarera en el Perú," *BMFOM* 4:3 (Mar. 1906), 13, 24-29, 76-82; Saillard, "Aplicación de abonos completos," 66-67; Broggi, "Porvenir del cultivo del algodón," 19; José Antonio de Lavalle y García, *El guano y la agricultura nacional* (Lima: La Opinión Nacional, 1914), 9-10; Macera, "El guano y la agricultura peruana de exportación," 323-324; S.W. Buol, F. D. Hole, and R. J. McCracken, *Soil Genesis and Classification*, 3d ed. (Ames: Iowa State University Press, 1989), ch. 21, 22.

done to stop the Peruvian Corporation of London from exporting more than its fair share of the guano supply. As they did for so many things, these "aristocrats" looked to the Peruvian state for an answer. José Otero, an engineer working for the Ministerio de Fomento, spoke for many coastal growers--and the growing middle class of technicians that served them--when he declared,

> It is time for the Government to solve definitively the matter of providing guano . . . exclusively for the agriculture of this country, by prohibiting its exportation, properly regulating its extraction, and seeing that it arrives . . . to small farmers, in quantities related to need.

In 1906, he proposed that Peru establish an expertly managed assay and sales offices that could provide a certified product at a price related to its fertilizing content; this office would also distribute propaganda to encourage its diversified and efficient use. Peruvian officials were already well aware that Peru's *living* colonies of guano birds were valuable and that they needed protection. The original directive that created the Ministerio de Fomento enforced a ban on egg hunting on the guano islands and required this state ministry to dedicate itself to "the *reproduction* of fertilizer." In 1906, Peru closed the Islas Chincha to guano harvest during the summer nesting season to give the bird population a chance to recover from human activity. This only increased pressure for action.[27]

Peruvians knew they had a lot to gain if they could somehow revive and redirect the guano industry for their own use. By supporting state intervention

27. Emphasis added; José I. Otero, "Generalidades sobre la costa del Perú," *BMFOM* 4:7 (Aug. 1906), 35-41; "La producción de algodón en el Perú," *BMFOM* 2:4 (Apr. 1904), 30-31; *MMFOM* 1 (1896), 7-8; *MMFOM* 12 (1908), 12-13, 18; Robert E. Coker, "Estudios sobre la pesca en el Perú," *BMFOM* 8:4 (Apr. 1910), 12; idem, "The Fisheries and the Guano Industry of Peru," *Bulletin of the Bureau of Fisheries* 28, pt.1 (1910), 363-364; idem, "Peru's Wealth-Producing Birds," 547.

schemes like these that served their immediate interests, agro-exporters, the supposed arch-liberals of Peruvian politics, adopted a political economy that corresponded with the agro-exporters of Brazil's "Old Republic" and the científicos of Porfirian Mexico.[28] They set the stage for a technocratic solution to the "guano problem" to be instituted by the Peruvian state.

The Coker Mission, 1906-1908

Peru's progress-minded elite concentrated their efforts on agriculture and mining for export, but they also hoped to benefit someday from the incredible richness of Peru's coastal waters, one of the most productive marine ecosystems in the world. One foreign observer, the globe-trotting U.S. ornithologist Robert Cushman Murphy, provided vivid testimony to this effect. He noted "many times a day" while sailing off the Peruvian coast in the late 1910s, "vast, seething schools of surface fish, breaching whales, incredible flocks of birds . . . bands of frolicking lobos . . . [and] enormous shoals of porpoises, far larger than any I had ever seen throughout a hundred degrees of latitude on the Atlantic." Coastal Peruvians began to conceive of the Pacific Ocean as their next great frontier about this time.[29]

The Peruvian state looked to a budding conservation technocrat from the United States to provide some developmental advice on this matter. In June 1906, the Ministerio de Fomento made funds available to hire a pisciculturist "to procure, with scientific principles as a guide, the conservation and reproduction of species of

28. See Steven Topik, *The Political Economy of the Brazilian State, 1889-1930* (Austin: University of Texas Press, 1987).

29. Murphy, *Bird Islands*, 42.

fish" in Peruvian territorial waters. It decided to consult the U.S. Bureau of Fisheries. This was a good place to go for expertise: the Bureau was one of the most precocious of the young scientific institutions in the United States and a world leader in its field. It had been founded by the U.S. Congress in 1870 to study the sharp decline of commercial catches on the Atlantic coast. Ocean science was one of the strongest points of scientific institutionalization in the United States during the late nineteenth century. As we shall see in later chapters, Peru followed a similar path in the development of its own scientific institutions during the twentieth century.[30]

The Bureau of Fisheries recommended one of its young employees, Robert E. Coker (1875-1967), the son of a prominent cotton planter from South Carolina. Despite his Old South upbringing, Coker was one of the new breed of professional scientists trained in the United States according to the German research model. This "graduate school" system combining formal education with sustained basic research had proven its worth as far back as Justus von Liebig's reknowned chemistry lab at the University of Giessen; it had become the hallmark of Germany's dominance in so many intellectual disciplines during this era. Coker had a newly minted Ph.D. in zoology from Johns Hopkins University, the training ground for several of the architects of the biology profession in the United States. Even before he graduated, Coker had already used his expertise to affect change in

30. *MMFOM* 10 (1906), xxiv; *BMFOM* 4:7 (1906), 7, 93; Bruce, *The Launching of American Science*, 324; Nathan Reingold, "Alexander Dallas Bache: Science and Technology in the American Idiom," *Technology and Culture* 11:2 (1970), 163-177; Susan Schlee, *The Edge of an Unfamiliar World: A History of Oceanography* (New York: Dutton, 1973), 67.

the laws governing oyster production in North Carolina. In 1905, he advised the North Carolina General Assembly to limit access to coastal estuaries in the public domain by leasing fishing rights on a rotational basis. Not only did legislation following his recommendations allow for a sustained yield, protection from competitive overfishing led to a thousand-fold increase in the oyster harvest over the next several years. Fresh off this success, Coker turned down a post-doctoral fellowship from his alma mater to take up Peru's challenge.[31]

Coker arrived in Lima in February 1907. He spent the rest of the year exploring coastal Peru by land and sea. A bubonic plague epidemic delayed his voyage to Tumbes to study the depleted tropical oyster beds near the Ecuadorian border. This event not only diverted Coker's research, but also radically strengthened the authority of hygienists in Peru's coastal ports. In fact, this was a local extension of the global plague pandemic of the 1890s that had done so much to empower public-health technocrats in Asia. Thus, Coker tangentially encountered one of the ecological phenomena that led so many men like him to the tropics to bolster "civilization" during this era. From May to July, Coker spent a total of 25 days observing the bird colonies and the activities of guano workers on the Islas Chincha and Islas Ballestas. He negotiated a contract extension to

31. H. Eugene Lehman, "Robert Ervin Coker, 1876-1967," *The Journal of the Elisha Mitchell Scientific Society* (Chapel Hill, NC) 84:2 (Summer 1968), 333-334; George Lee Simpson, Jr., *The Cokers of Carolina: A Social Biography of a Family* (Chapel Hill: University of North Carolina Press, 1956), esp. 247-249; *Who Was Who in American History--Science and Technology* (Chicago: Marquis Who's Who, 1976), s.v. "Coker, Robert E." On Liebig's teaching lab, see J. B. Morrell, "The Chemist Breeders: The Research Schools of Liebig and Thomas Thomson," *Ambix* 19 (1972), 1-46. On Johns Hopkins University, its relation to the German research model, and the foundations of twentieth-century American biology, see Jane Maienschein, *Transforming Traditions in American Biology* (Baltimore: Johns Hopkins University Press, 1991); Laurence R. Veysey, *The Emergence of the American University* (Chicago: University of Chicago Press, 1965).

February 1908 so he would have a chance to observe the guano islands during peak nesting season. This itinerary gave Coker the opportunity to make comparative observations for almost the entire coast of Peru, although it gave him little time for sustained scientific investigation.[32]

Even though he had the most advanced scientific training available at the time, Coker did not introduce any techniques during his voyages that were unknown in Peru. In fact, he did not decisively break with the basic pattern of traveling naturalistic study established by Humboldt over a century before.[33] Coker made use of a few simple, accurate, durable traveling instruments, gathered statistics, and made extensive specimen collections with a view toward the sophisticated scientific description of complex environmental phenomena. He observed the behavior and breeding of the guano birds and made some rough bird population estimates "by eye." He took regular air and water temperature measurements and noted the great regularity of the "cold Humboldt current." Coker collected over 801 total specimens: including 54 birds, 302 fish, 134 mollusks, 111 crustaceans, 60 echinoderms, and 82 marine alga (illus. 8). He sent several specimens to the United States for study, classification, and formal description. Following the instructions in his contract, Coker submitted a formal report on his "preliminary study" of marine production in Peru, including the reason for the apparent decline in several economic species. The Ministerio de

32. *BMFOM* 5:7 (1907), 94-98; Coker, "Pisicultura y ostricultura," *MMFOM* 12: anexo 150 (1908), 406, 409, 412-414. On plague, hygienism, and their importance to the power of experts during this era, see Cueto, *Excelencia científica en la periferia*, 120-127; idem, *El regreso de las epidemias: Salud y sociedad en el Perú del siglo XX* (Lima: Instituto de Estudios Peruanos, 1997), ch. 1; Hays, *The Burdens of Disease*, 182-185, 191-192, 197-200.

33. On the features of Humboldtian science, see ch. 1.

Fomento translated and published his work in Spanish in its illustrated journal, a firm indication of its dedication to the public dissemination of useful science.[34]

At first glance, Coker's methods were neither original nor particularly elaborate; a Peruvian like Camilo Carrillo could have accomplished something similar. But Coker's work had other, less tangible virtues that are the essence of scientific expertise and technical "know-how." Coker brought with him to Peru the highly trained eye and indoctrination of a conservation scientist. He considered the opinions of interested locals, especially where their knowledge reached beyond his in time and space. He then used his judgment to recombine local "common wisdom," his own theoretical and empirical understanding, and earlier scientific theory regarding the Peruvian coast. This new scientific knowledge cannot be separated from either Coker's personality or his social status as a foreigner working among natives, nor the fact that he did this work in the field. Such social relations in the production of knowledge are one of the most distinctive, though often overlooked, features of the old, nineteenth-century paradigm of Humboldtian science. They lived on among the international consultants who came to dominate twentieth-century science and engineering in the "developing world."

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34. *MMFOM* 12: anexo 149 (1908), 409; Coker, "Aves guaneras y extracción de guano," *MMFOM* 12: anexo 161 (1908), 5-6, 11; idem, "The Fisheries and the Guano Industry of Peru," 358; idem, "Pisicultura y ostricultura," 413, 468, 482, 500-501; idem, "Estudios sobre la pesca," 15; idem, "Informe preliminar sobre los estudios que practica el piscicultor contratado," *BMFOM* 5:7 (July 1907), 94-98; idem, "La disminución de peces en la Bahía del Callao," *BMFOM* 5:10 (Oct. 1907), 101-104; idem, "La caza de lobos y pesca de ballenas y bufeos en el Perú," *BMFOM* 5:12 (Dec. 1907), 64-95; idem, "Condiciones de la pesquería en Mollendo," *BMFOM* 8:10 (Oct. 1910), 50-64. The Academy of Natural Sciences of Philadelphia published a taxonomic description of Peruvian barnacles by Henry A. Pilsbury based on Coker's specimens; see its Spanish translation, Pilsbry [sic], "Los barnacles del Perú," *Anales del Ministerio de Fomento* (Lima) 1:2 (1912), 32-47. On Coker's interest in the El Niño phenomena, see "Ocean Temperatures off the Coast of Peru." *The Geographical Review* 5:2 (1918), 127-135.

In the short term, Coker revolutionized the ornithological study of Peru's guano-producing Pelicaniformes. Based on his knowledge of the entire Peruvian coast, Coker identified the gregarious guanay as the most important guano contributor. During the time of his visit, it nested in the largest colonies and seemed to be able to compete most successfully, in a Darwinian sense, for "a home" on the flat areas of the guano islands. The second most important guano bird in his view, the alcatraz, also nested on flat parts of the main guano islands. It appeared to suffer greatly from the guano industry because it was much more skittish than the guanay, although it continued to breed successfully along the far northern coast. The piquero nested year-round mainly in cliff colonies where its guano could not be exploited effectively, although it sometimes colonized the level areas of a couple important guano islands, such as the Islas Guañape. He thought it was the third-most important guano bird, in contrast to J. J. von Tschudi and Antonio Raimondi who, based on limited observations, believed it to be the most important. Even though the camanay did not nest in colonies, Coker thought it produced significant amounts of phosphate-rich guano *pobre* (less than three percent nitrogen by weight) on two islands, Lobos de Afuera and Lobos de Tierra, near the tropical waters of Ecuador. He rejected Raimondi's old assertion that the potoyunco or Peruvian diving petrel (*Pelecanoides garnotii*) produced significant amounts of useful guano in its nest burrows.[35]

35. *MMFOM* 12 (1908), xci, Coker, "Pisicultura y ostricultura," 470, 520; idem, "Aves guaneras y extracción de guano," 13, 17; idem, "Estudios sobre la pesca," 8-16; idem, "Peru's Wealth-Producing Birds," 553-554; idem, "The Fisheries and the Guano Industry of Peru," 361-362. Cf. Raimondi, "Apuntes sobre el huano y las aves que lo producen," *BCAG* 2:9 (Sept. 1926), 450, originally published as "Mémoire sur le guano et les oiseaux que le produisent," in *Comptes Rendus*

Coker's conclusions do not necessarily represent an objective improvement in scientific understanding of Peru's guano ecology. As we have already seen with the 1877-1878 and 1891 El Niño events, this ecology has a history of its own and in no way represents an eternal, unchanging "geographic basis" for human history. Differences in opinion regarding the dominance of the piquero, for example, may indicate a real change over time in the species composition of Peru's marine environment, due either to climate change or transformations caused by the guano industry. As we shall see, such changes in marine-bird biodiversity definitely happened later in the twentieth century under the careful watch of ornithologists.

Right or wrong, Coker's conclusions had a huge impact on the management of Peru's marine environment. Among all of Peru's marine extraction activities, Coker considered the plight of the guano industry to be "most urgent" and most amenable to immediate solution. The exhaustion of Peru's last remaining ancient deposits was imminent. But in line with some Peruvian observers, he thought the remaining birds could easily produce enough excrement to supply both Peruvian agriculture and the Peruvian Corporation if they were rationally managed. This meant Peruvians would have to stop acting "like beasts of prey" towards the guano birds and begin to treat them as "domestic animals"--under the shepherding eye of conservation technocrats--as North Carolinians were treating their oysters. For example, on Isla Lobos de Afuera, Coker watched Peruvian Corporation workers displace an entire rookery of 80,000 pelicans, one of the only colonies along the

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Hebdomadaires des Séances de l'Académie des Sciences 42 (1856); idem, "Islas, islotes y rocas del Perú,"; Tschudi, *Ornithologie*.

entire coast. For good reason, he thought this bird to be in danger of extinction because of the guano industry. Peru's 1906 closure of the Islas Chincha to protect the guano birds was a step in the right direction, but inadequate in Coker's view. Since the birds never completely deserted the islands voluntarily, "There can be no season when the islands may be worked without disturbance of the birds."[36]

Using what he termed "entirely scientific criteria," Coker outlined a five-part policy the Peruvian state would have to impose if the guano industry was to continue. It was posited entirely on the concept of yearly, sustained-yield production from living birds. First, Peru should immediately turn all coastal islands into a bird sanctuary, and any private use of island resources, such as egg collecting and hunting, should be permanently prohibited. Second, only one contractor per island should receive the concession for guano extraction; it was hoped this would relieve the disruption of breeding caused by intense competition for deposits. Third, Peru should establish a permanent closed season during the peak November to March breeding period to allow the birds to reproduce in peace. Fourth, since the entire year was important to the cycle of breeding, Peru should implement a long-term rotation policy. Each island should be closed for at least one year between each season of guano production--the longer the closed period,

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36. Coker, "Estudios sobre la pesca," 11; idem, "Regarding the Future of the Guano Industry and the Guano-Producing Birds of Peru," *Science* 10 July 1908, 59-60; idem, "The Fisheries and the Guano Industry of Peru," 12-13, 357, 360, 363-364; Cortez, "El Ministerio Fomento del Perú," 84.

Coker's observations regarding the impending end of the ancient guano deposits were validated by the 1910 survey of the northern guano islands by Peruvian mining engineer Marco Aurelio Denegri. Denegri's study and twentieth-century statistics of guano pobre production confirm that mid-nineteenth-century "experts" had vastly overestimated the size of these deposits; see Denegri "Informe sobre la calidad y cantidad del guano que existe en algunos depósitos situados al norte del Callao," *BCAG* 9:2 (Feb. 1933), 35-60.

the better the birds could reproduce. Fifth, Peru should create a national monopoly responsible for the entire process of guano production and distribution. This company would guarantee its quality, not only when it left the islands, but when it reached consumers. Coker strongly believed that a single company with a long-term stake in the birds' welfare could best provide guano for the Peruvian common weal because it would eliminate the rapacious competition of interests intent only on short-term material gain. Finally, Coker "conservatively appraised" the worth of each pair of guanay at US$1.43 per year in terms of the guano and up to a pair of offspring they produced. This clinched his argument by creating the dual appearance of scientific accuracy and economic value for his judgments. In essence, Coker wanted the Peruvian state to implement the core principles of scientific conservation to protect what amounted to "the most valuable bird in the world."[37]

When he returned to the United States late in 1908, Coker left Peru with a viable technocratic plan to reform its guano industry. In later years, he did not forget what he had accomplished as a young consultant in Peru, even after he reached the top of his field, first as Chief of the U.S. Bureau of Fisheries' Division of Scientific Inquiry (1915-1922), then as an eminent ecology professor at the University of North Carolina (1922-1947), and finally as a science popularizer and organizer of marine science studies in the Caribbean (1947-1962). Coker

37. *MMFOM* 12 (1908), xciv; Coker, "Regarding the Future of the Guano Industry," 59-64. For other examples of Coker's guano arithmetic, see "Peru's Wealth-Producing Birds," 540, 552-553. "The most valuable bird in the world" was Robert Cushman Murphy's favorite phrase to describe the guanay. Murphy used this phrase, based on Coker's guano arithmetic, for decades in his outspoken advocacy of the reformed Peruvian guano industry; see later chapters and Murphy, "The Most Valuable Bird in the World," *National Geographic Magazine* Sept. 1924, 278-302.

repeatedly praised Peru's conservation experiment in American scientific journals and popular works. In his view, Peru's "far-sighted" environmental managers compared quite favorably to those who irrationally squandered rich marine resources in the United States like the Chesapeake Bay oyster beds.[38] He also served as an early mentor of Howard T. Odum, one of the founders of systems ecology and a major proponent of ecosystem management.[39] Coker was neither the first nor the last notable foreign talent who strongly influenced the management of Peru's marine environment and then moved on to nurture the spirit of "technocratic optimism" among scientists elsewhere in the world.

Founding a Public-Private Monopoly

A foreign scientific consultant prepared the ground for the revival of the Peruvian guano industry, but prominent Peruvians actually planted the seed. As is so often the case in post-colonial countries, the opinions of a foreign expert provided technocratic justification for the implementation of a group of policies already advocated by locals.

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38. Lehman, "Robert Ervin Coker"; Simpson, *The Cokers of Carolina*, 249-256; *Who Was Who in American History--Science and Technology*, s.v. "Coker, Robert E."; Coker, "Regarding the Future of the Guano Industry"; idem, "The Fisheries and the Guano Industry of Peru"; idem, "Habits and Economic Relations of the Guano Birds of Peru," *Proceedings of the U.S. Natural History Museum* 56 (1919), 449-511; idem, "Peru's Wealth-Producing Birds"; idem, "An Illustration of Practical Results from the Protection of Natural Resources," *Science* 1 Apr. 1921, 295-298; idem, "The Protection of Birds Made Profitable," *Science* 5 July 1935, 10-12. Coker featured the guano birds, anchoveta, and Humboldt Current in an award-winning popular textbook, *This Great and Wide Sea: An Introduction to Oceanography and Marine Biology*, Harper Torchbooks, Science Library (1947; New York: Harper & Row, 1962).

39. Peter J. Taylor, "Technocratic Optimism, H. T. Odum, and the Partial Transformation of Ecological Metaphor after World War II," *Journal of the History of Biology* 21:2 (1988), 224.

The Cuban-born financial wizard José Payán de Reyna (1844-1919) gave crucial support to Coker's plan. Payán was Peru's analogue to Porfirian Mexico's powerful Minister of Finance, José Yves Limantour. Both were major proponents of centralized state planning and economic diversification, and they led the progressive vanguard that provided the political opening for the birth of the conservation technocrat in both Mexico and Peru. Payán is usually given a lot of credit for the "autonomous development" Peru achieved at the turn of the century. In many ways, he was a precursor of the plutocrats who stand behind the economist-technocrats of today.

Like Tangüis, Payán was a refugee from the Ten Years' War against Spanish colonial dominance in Cuba. He abandoned his medical education when hostilities began and soon emigrated to Peru in search of better opportunities. Like many of his generation, Payán's attitudes were powerfully shaped by the debacle of the 1880s. He believed "a fever of unproductive works and lamentable system of fiscal prodigality" posited on a universal belief in the inexhaustibility of guano and nitrates had led to Peru's downfall. Before the end of the War of the Pacific, Payán began working to place Peru's financial system on a sure footing. Using the capital of 120 Peruvian notables, he revived the Banco del Callao, one of only two financial institutions in Peru to survive the war. In 1897, it was reorganized as the Banco del Perú y Londres, an international bank based on the British gold standard and open to foreign investors. This bank was Peru's key financial institution until it met its demise during the Great Depression. As the long-time president of Peru's stock exchange and an influential member of the board of directors of many key businesses, Payán stood at the apex of Peru's capitalist system.[40]

Payán was the mastermind behind several quasi-state monopolies at the turn of the century, including the Compañía Recaudadora de Impuestos, an organization for collecting taxes, and the Compañía Salinera del Perú, a salt monopoly. He firmly believed that the state and private investors should work in tandem to promote the establishment of capitalist institutions in Peru. This view stemmed from Payán's declared dedication to Spencerian positivism and Social Darwinism. Though Social Darwinism is better known for its amoral defense of "survival by the fittest" and environmental destruction, many thinkers--especially Latin Americans concerned with living in backward, "degenerate" societies--adopted the view that nature requires moral (i.e., human) intervention if civilization is to achieve true progress. Payán believed some business endeavors needed protection from ruthless competition. This fit well with Coker's contention that the guano birds required a refuge from rapacious man if they were to survive. This benevolent, managerial understanding of the implications of Darwinian selection had a profound impact on conservationism and provided abundant opportunities for technocratic intervention during this era.[41]

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40. Carlos Camprubí Alcazar, *José Payán de Reyna, 1844-1919: Su trayectoria peruana* (Lima: Talleres Gráficos P. L. Villanueva, 1967), passim, quote p. 24; Basadre, *Historia de la República*, 10:294; Macera, "El guano y la agricultura peruana de exportación," 325-326; Luis Ponce Vega, "Siglo XX: La República Aristocrática," in *Compendio Histórico del Perú*, ed. Luis Durard Florez (Lima: Editorial Milla Batres, 1993), 6:679; Thorp and Bertram, *Peru, 1890-1977*, 31-36; Bertram, "Peru, 1930-60," in *CHLA* (1991), 8:412.

41. On "soft" Social Darwinism in Latin America, see Nancy Leys Stepan, *"The Hour of Eugenics": Race, Gender, and Nation in Latin America* (Ithaca, NY: Cornell University Press, 1991), esp. ch. 3; Zea, *The Latin American Mind*, esp. 280-282; Dain Borges, "'Puffy, Ugly, Slothful and Inert': Degeneration in Brazilian Social Thought, 1880-1940," *JLAS* 25 (1993), 235-

Even with Payán's backing, it still took a while to gather support for Coker's plan. Many of Payán's schemes met with opposition. The Peruvian Corporation of London, for example, blocked his plan to establish a European-based financial market for Peruvian land. Prominent agro-exporters frequently took sides against Payán's interventionist and protectionist positions on state monetary policy. After guano production and sales fell sharply in 1908, Coker's plan provided an amenable way to reconcile their differences.[42]

The crucial decision fell to a new president. On 1 March 1909, Augusto B. Leguía (1863-1932) issued an executive decree to create a limited stock company--the Compañía Administradora del Guano (CAG). He reserved government funds totaling 30,000 gold *libras peruanas* (Lp.) to capitalize this parastatal organization, a sum equal to 3 million *soles* (S/.) or US$628,000. Such a decision befitted this president, a prominent businessman who left managing the British Sugar Company to serve the Aristocratic Republic as Minister of Finance. It presaged Leguía's long, controversial second term as executive, when he used dictatorial powers to build a new Peruvian Fatherland (*Nueva Patria*) on the principle that "the State is .

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256. Mike Hawkins provides a lucid analysis of the Janus-faced quality of Social Darwinist thought, in which nature is seen, on the one hand, as a model for human emulation or, on the other hand, as a threat requiring human counteraction; *Social Darwinism in European and American Thought, 1860-1945: Nature as Model and Nature as Threat* (Cambridge, UK: Cambridge University Press, 1997), esp. ch. 7-8. The connection between Social Darwinism, ecology, and conservationism has received inadequate attention, though see Donald Worster, *Nature's Economy: A History of Ecological Ideas*, 2d ed. (Cambridge, UK: Cambridge University Press, 1994), ch. 9; Gregg Mitman, *The State of Nature: Ecology, Community, and American Social Thought, 1900-1950* (Chicago: University of Chicago Press, 1992).

42. See app. 2-3.

. . the most efficacious agent for carrying out the beautiful work of human solidarity."[43]

This law followed Coker's recommendations closely. It turned over to CAG all guano-bearing properties under government jurisdiction for five years, and it gave CAG the sole right to extract, transport, unload, and sell guano for national agriculture at a price in proportion to its total nitrogen content. The law also strictly required the company to guard the guano birds in "whatever relates to the reproduction of the fertilizer." An accompanying law divided the guano islands between CAG and the Peruvian Corporation. Peru no longer simply reserved the Islas Chincha for national agriculture--it now claimed nearly all islands and points south of Callao, although still not the rich guano-producing regions from the Islas Ballestas to Punta Doña María.[44]

The rules that established CAG's administration reflected the range of political and economic interests behind this technocratic experiment. A board of nine directors periodically formulated official company policy and regulations. The Peruvian state held a majority of shares in CAG, although private stockholders elected the majority of CAG directors. No private individual was allowed to own more than five percent of CAG. Its directorial board also had permanent

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43. Leguía quoted by Drake, *The Money Doctor in the Andes*, 220; Basadre, *Historia de la República*, 15:151-152; Miller, "British Firms and the Peruvian Government, 1885-1930," in *Business Imperialism, 1840-1930: An Inquiry Based on British Experience in Latin America*, ed. D. C. M. Platt, (Oxford: Clarendon Press, 1977), 377-378; *Enciclopedia ilustrada del Perú*, s.v. "Leguía, Augusto B."; Felipe Portocarrero S., Arlette Beltrán B., and María Elena Romero P. *Compendio estadístico del Perú, 1900-1990* (Lima: Universidad del Pacífico, Centro de Investigación, 1992), 88; Pike, *The Modern History of Peru*, 195-196; note that Pike's account of the origins of CAG is inaccurate on several points.

44. *ECAG*, 5, 15-16, 29-31; *MCAG* 5 (1914), 23.

representatives from the Sociedad Nacional Agraria, state creditors, and the government itself. During the first weeks after the initial offering of CAG stock on the Bolsa Comercial de Lima, a large number of investors bought shares. Prominent agro-exporters from several coastal regions bought the largest portion. This administrative structure and its financial underpinnings embodied Payán's belief that a public-private consortium was the best way to raise capital, spread risk, and broaden the financial and political stake in new enterprises in Peru's potentially unstable political and economic environment. Institutions like CAG held the Aristocratic Republic together. Even though shareholders were theoretically allowed to influence board governance, few bothered to attend shareholder meetings. Corporate control remained firmly in the hands of a select few, with high state officials retaining decisive authority. A tiny oligarchy actually governed the Aristocratic Republic.[45]

During CAG's first years of existence, businessmen like Payán, CAG's first president, dominated its board of directors. But as the years passed, more and more men claiming doctoral or engineering degrees came to serve on CAG's board. This indicated both the partial infiltration of professionals into the higher eschelons of political and economic power in Peru and a growing interest in obtaining professional degrees among the sons of Peru's ruling class. In this way, Peruvians with technical training gained some say regarding CAG's general affairs over the years. They first worked to ensure that CAG provided a profit to its shareholders

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45. *ECAG*, 6-12, 18-19; Macera, "El guano y la agricultura peruana de exportación," 324, 327-330. Note that Macera's study was partly based on access to CAG's central archive before it burned in the 1990s; it provides an indispensable insider perspective on some matters.

and creditors, but they also used CAG from the beginning to provide subsidies to agriculture and funds for other state development plans. Over time, CAG's managerial culture became technocratic even at the very top.

In accord with the emerging theory of scientific management, this was also true at the level of day-to-day operations. CAG was centrally managed from its headquarters in Lima by the company general manager (*gerente*). Francisco Ballén Valle Riestra (1875-1949, illus. 9) served as CAG gerente for 33 of the 54 years CAG operated. Ballén did not have the same technical qualifications as subsequent general managers, though he came from a family that had made its name in the professions: His father was an Ecuadorian medical doctor and his mother was the daughter of a Peruvian military hero. In line with Leguía's ongoing attempt to appoint men with foreign business training to offices of prominence, Ballén had schooling from the "*colegio* of Mr. Williams" in Lima and ten years of travel and experience in Europe and the United States. By appointing him, Leguía also made Ballén into a client in his growing patronage network. In 1914, in a classic social move that bolstered his professional position, Ballén married into another important political family, just as Leguía had done when he married into the family of Scottish sugar-exporter Henry Swayne. Ballén's brother-in-law, Hernán Velarde Diez Canseco, was extremely close to Leguía: he served as Peru's ambassador to the United States during the last six years of Leguía's notorious *oncenio*.

Patron-client and family relationships were also vital to the construction of a technocratic class in Mexico, both during Limantour's reign as chief of the Porfirian "wizards of progress" and decades later when political cliques (*camarillas*) within the ruling Partido Revolucionario Institutional (PRI) provided the means for deciding which *técnicos* would be appointed to positions of authority--even who would be "elected" president. The same can be said for how most economists acquire political influence in the Peru of today.[46]

Such connections were as unavoidable as they were indispensable within Peru's inbred ruling elite. Nevertheless, Ballén's actions as a manager were consistently in accord with the technocratic ideal. As we shall see, he had immense influence over CAG's history and garnered both local prestige and international recognition for his actions to protect the guano birds, modernize Peruvian agriculture, and promote other conservation programs in Peru. Like his scientific forebears in the eighteenth and nineteenth centuries, Ballén was given foreign membership in several international scientific and conservation organizations for these accomplishments. During the celebration of his 25th anniversary as CAG general manager, he received a plaque engraved with the motto "Organization, Efficiency, Probity" that proclaimed him "the organizer of the guano industry in Peru." These honors were fitting indications of the technocratic values behind the reorganization of guano production in Peru, even if Ballén did not exactly fit the technocratic prototype.[47]

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46. On the continuing role of patronage in the recruitment of technocrats in Mexico and Peru, see Tenorio, *Mexico at the World's Fairs*, ch. 4; Camp, *Political Recruitment across Two Centuries*, esp. ch. 1; Centeno, *Democracy within Reason*, ch. 6; Smith, *Labyrinths of Power*, passim; Catherine M. Conaghan, "Stars of the Crisis: The Ascent of Economists in Peruvian Public Life," in *The Politics of Expertise in Latin America*, 142-164.

47. Sources for this section on Ballén include *Diccionario biográfico de peruanos contemporáneos*, ed. Juan Pedro Paz-Soldan (Lima: Librería e Imprenta Gil, 1917, 1921), s.v. "Ballén, Francisco"; *Diccionario histórico y biográfico del Perú,* s.v. "Velarde Diez Canseco, Hernán"; "Nota editorial," *BCAG* 14:8 (Aug. 1938), 303-305; Murphy, "The Most Valuable Bird in the World," 298; idem, *Bird Islands*, 57; "Sobre el premio del Franklin Institute de Pensilvania a

During the following years, Ballén oversaw the gradual construction of an integrated industry with control over many aspects of fertilizer production, transport, and sale in Peru. One of Ballén's first acts was to hire a group of cartographers to map precisely the guano islands and their distance from agricultural ports so CAG could maximize the efficiency of guano extraction and transport. CAG also passed out a farming questionnaire to try to determine the fertilizing needs of coastal agriculture.[48]

Nevertheless, CAG faced a crisis of public confidence almost as soon as it began producing guano. CAG's guano production fell during its first three years of operation, as it rotated extraction on the Islas Chincha, the most productive area under its jurisdiction. Its annual profits were minuscule, leading many to suggest that CAG's scientific administration cost too much. Even though the act that created CAG granted a much larger guano-producing area to Peru for national agriculture than it had before, Peruvian agricultural interests complained that the Peruvian Corporation still received too much preference since it retained control of the richest guano islands. They had reason to complain: the Peruvian Corporation exported almost twice as much guano as CAG produced for Peruvian farmers during these years, and this foreign interest made no attempt to rotate production or conserve the bird stock. To make matters worse, a "sinister ocean current" arrived from the north in late 1911 and caused the birds to flee breeding islands en masse;

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nuestro gerente," *BCAG* 19:2 (Feb. 1943), 155; William Vogt, *Road to Survival* (New York: William Sloane, 1948), 186; Enrique Ávila to Vogt, 16 Sept. 1949, Vogt papers, box 1:1.

48. CAG, Sección Técnica, *Las necesidades de guano de la agricultura nacional: Informe presentado por el jefe de la sección Ingeniero Agrónomo Sr. José Antonio de Lavalle y García* (Lima: Librería e Imprenta Gil, 1916), 13-16; Macera, "El guano y la agricultura peruana de exportación," 341-345.

this El Niño nearly ruined the season's production of fresh guano and caused the deaths of millions of nestlings and eggs. Even though CAG production recovered somewhat during the next two seasons and the Peruvian Corporation curtailed guano exports, demand for guano in Peru skyrocketed as farmers hoarded whatever they could of the limited supply and threatened to make a mockery of plans to distribute this scarce resource "rationally."[49]

CAG survived this rough beginning because Peruvian agricultural modernizers rushed to its defense. The agronomist José Antonio de Lavalle y García was one of the most outspoken advocates of CAG during its early years. He unequivocally declared in 1912, "The guano problem is eminently a national problem." He believed Peru was endowed "by Nature to have a prosperous and intensive agriculture" and grimaced as foreigners drained the "vital forces and productive energy of the nation" for agriculture on the other side of the world. Lavalle agreed with Payán that the Age of Guano was an "orgiastic waste" based upon "inexhaustible intellectual myopia and egoism" for which all Peruvians had "to pay the consequences." Only "just and energetic administration" of "a rational system of rotation and exploitation . . . that takes into consideration the conservation and better utilization of the [guano] birds" would solve Peru's "commercial inferiority." Lavalle had a relatively straight-forward answer to the guano problem: Peru should actively enforce the 21st clause of the Grace Contract which allowed "the government of Peru to consume the guano that is necessary for

49. See app. 1-4; *MCAG* 3 (1912), 3, 47, 49; Basadre, *Historia de la República*, 15:151-152; Lavalle, "Una hipótesis sobre la mortalidad de las aves productores de guano y su emigración de las islas," *MCAG* 3 (1912), 51-56.

its agriculture" and which gave the Peruvian Corporation the right to export only "guano existing" at the time of its signing. Lavalle's attack conveniently displaced criticism from CAG to an unpopular foreign corporation.[50]

A Peruvian consortium of farming and industrial interests chimed in with a statement that further reveals the modernizing mentality behind CAG's support and anti-Peruvian Corporation rhetoric. "The rational fertilizing of the earth," they claimed, acted as the key to agricultural growth, since it "put in circulation . . . materials that exist in a latent state in nature." This practice enabled the "necessary progressive evolution *from an extensive to an intensive system*" of agriculture. With its unique capacity to produce guano, Peru could make up for its "inferior economic conditions" and catch up with rich agricultural nations. Repeating an upper-class mantra that became increasingly threadbare as the twentieth century progressed, they believed modern agriculture would lead to "progressive enculturation" of the rural poor and lower food prices for the coastal "proletarian masses." In other words, guano had the potential to carry the Peruvian nation forward into the prosperous, modern world of the twentieth century by enabling input-intensive agriculture.[51]

The Forbes Mission, 1911-1913

As soon as CAG was founded, a battle for control of Peru's guano islands was probably inevitable. But the Peruvian Corporation of London realized that

50. Lavalle, *El guano y la agricultura nacional*, 5-8, 44, 47-58.
51. Ibid., 45-48.

guano-bird conservation was in its own long-term interest and agreed to debate Peru's ruling elite on technocratic terms. Meanwhile, it looked to another expert for a resolution of this budding controversy.

The Peruvian Corporation handpicked its own scientific consultant, the Scottish naturalist Henry Ogg Forbes (1851-1932), to study the guano bird populations and determine the best policy for their "conservation and increase." Forbes had recently retired as director of the Museums of Liverpool and was a distinguished scientific explorer. Like Charles Darwin and so many other nineteenth-century British naturalists, Forbes left the study of medicine for field science and established his reputation with a best-selling travel account, *A Naturalist's Wanderings in the Eastern Archipelago* (1885), and scientific papers based on his explorations.[52]

Forbes was the quintessential colonial scientist of the age of British imperial expansion.[53] From 1885-1887, he led an expedition for the Royal Geographic Society and Colonial Office to explore the Owen Stanley Range of New Guinea, the high spine of mountains lying between German claims on the northeast coast of the island and Port Moresby, the colonial capital of the newly established British

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52. *MCAG* 3 (1912), 5, 44; *MCAG* 4 (1913), vi; *Who Was Who, 1929-1940: A Companion to Who's Who Containing the Biographies of Those Who Died during the Period 1929-1940* (London: Adam & Charles Black, 1941), s.v. "Forbes, Dr. Henry Ogg"; Henry O. Forbes, *A Naturalist's Wanderings in the Eastern Archipelago: A Narrative of Travel and Exploration from 1878 to 1883* (London: S. Low, Marston, Searle & Rivington, 1885).

53. On the relationship between science and European imperialism during this era, see Anker, *Imperial Ecology*; Drayton, *Nature's Government*; MacLeod, ed., "Nature and Empire"; Pyenson, *Civilizing Mission: Exact Sciences and French Overseas Expansion, 1830-1940* (Baltimore, MD: Johns Hopkins University Press, 1993); Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca, NY: Cornell University Press, 1989), pt. 2; Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940* (New York: Oxford University Press, 1988).

Protectorate (illus. 10). Forbes named the highest peak of this chain Huxley Pinnacle after his "honoured master in biology," the famed Darwinian T. H. Huxley, only to see it renamed Mt. Victoria by another colonial scientific explorer in competition for prestige. The rest of Forbes's colonial career mixed administrative and scientific duties in Oceania: he served variously as acting deputy commissioner of New Guinea, director of the Canterbury natural history museum in New Zealand, and explorer of the Chatham Islands in the far South and Kuril Islands in the far North Pacific.[54] Back in Britain, Forbes became best-known in scientific circles for his contribution to primatology; his two-volume *Handbook to the Primates* was published in several editions. He and his wife Annabella Keith Forbes, who acompanied him on his early travels and acquired a reputation of her own as a naturalist, remained bird enthusiasts and made substantive contributions to the ornithological literature.[55] In stark contrast to Coker, Forbes was a senior member of the last generation of British professional scientific polymaths. Would his career as a scientist and agent of British imperial expansion mean that the

54. J. W. Lindt, *Picturesque New Guinea. With an Historical Introduction and Supplementary Chapters on the Manners and Customs of the Papuans* (London: Longmans, Green, 1887), 8, 19-20, 55; *Who Was Who, 1929-1940*, s.v. "Forbes, Dr. Henry Ogg"; Gavin Souter, *New Guinea: The Last Unknown* (Sydney: Angus and Robertson, 1963), 59-69; Forbes, "The Chatham Islands: Their Relation to a Former Southern Continent," *Supplementary Papers of the Royal Geographical Society* 3 (1893), 605-637; idem, "A List of the Birds inhabiting the Chatham Islands," *Ibis*, 6th ser., 5 (1893): 521-546; Forbes and W.R. Oglivie-Grant, *Natural History of Sokotra and Abdel Kuri, Being the Report upon the Results of the Conjoint Expedition to These Islands in 1898-9* (Liverpool: n.p., 1903).

55. Forbes, *A Handbook to the Primates*, 2 vol. (London: W. H. Allen, 1894); Forbes's contribution to *British Birds, with Their Nests and Eggs*, 6 vols. (London: Brumby & Clarke, 1896, 1898); Annabella Keith Forbes, *Insulinde: Experiences of a Naturalist's Wife in the Eastern Archipelago* (Edinburgh and London: W. Blackwood and Sons, 1887).

Peruvian Corporation could count on him to decide in favor of British interests in Peru?

Forbes arrived in Peru on Christmas Day, 1911, just in time to witness the advent of a significant El Niño event. Although he did not know it, Forbes had the fortune to be one of the first scientists to observe in detail the effects of the El Niño-Southern Oscillation on both sides of the Pacific, for he had been witness to the ravages wrought by the tremendous drought of 1877-1878 on the forests and plantations of Dutch-ruled Indonesia. After receiving the blessing of President Leguía and other Peruvian officials, Forbes spent more than a year studying the guano birds. He first visited the northern coast to observe the impact of the 1911-1912 El Niño on the bird population in response to a report of a stream of floating bird corpses 200 kilometers long. But Forbes spent most of his time near Pisco focusing on the human impact on the guano birds. In his May 1913 report, he concluded that ill-timed extraction of guano often interfered with mating and nesting. He particularly condemned practices on the Islas Ballestas, where for ten consecutive years independent contractors hired by the Peruvian Corporation had begun harvest in April, before guano-producing nestlings could fly. "This is without a doubt one of the principal causes of the decline of the birds" and guano production, Forbes admonished, discounting the effects of the 1911-1912 climate anomaly on bird reproduction. Not only had contractors tried to maximize profits without regard for the birds' welfare, but they also had made huge piles of stone on the islands that made subsequent harvests difficult. Forbes also pointed out the threat posed by predatory birds, coastal fishermen, and Peruvian Corporation workers who preyed upon guano bird eggs and chicks. Production statistics corroborate his observations: the Peruvian Corporation harvested guano on the Islas Ballestas, Ferrol, Guañape, Huaura, Lobos de Afuera, Lobos de Tierra, Macabí, and Pescadores almost continuously from 1909 to the onset of World War I in 1914.[56]

Like Coker, Forbes concluded his study with a series of policy suggestions. First, Forbes interpreted the 21st clause of the Grace Contract to prohibit the Peruvian Corporation from harvesting new guano deposits, much to its chagrin. Forbes agreed with Peruvian nationalists that the Peruvian Corporation only had the right to mine deposits that existed in 1890 when the Grace Contract was signed and that most of the Peruvian Corporation's harvest since that date had been fresh guano taken illegally. He declared that all guano islands except for Isla Lobos de Afuera should be put under CAG's more-competent administration. The Peruvian Corporation could mine guano *pobre* on this island to fulfill its remaining quota. This was a position even more extreme than that taken by the Peruvian mining engineer Marco Denegri whose 1910 stratigraphic study had determined that guano from Islas Lobos de Afuera *and* Lobos de Tierra would be required to fulfill the Grace Contract. Second, Forbes suggested policies that would improve the guano birds' welfare: private contractors should be banned from harvesting guano; yearly extraction should only take place during the winter from 1 June to 10 September; the period between harvests on each island should be increased to three or four years; no unauthorized visitor should come within one mile of the islands at any

56. Forbes, *A Naturalist's Wanderings in the Eastern Archipelago*, 51-117; *MCAG* 5 (1914), 67, 70-72, 86-91; *MCAG* 12 (1921), 34.

time; a guardian force with gasoline-powered boats should patrol the coastal waters to keep the islands in "a state of perfect rest"; and professional hunters should shoot or poison the predators that threatened the birds. Finally, Forbes suggested that Peru should hire permanent scientists to systematically inspect the guano islands and gather baseline data on bird behavior and biology. After making these clear-headed recommendations, Forbes, who was at the end of his scientific career, retired to Britain and published two brief articles on Peruvian sea birds.[57]

Indeed, proponents of guano nationalization and state centralization in Peru had gained an important ally, although this should not have come as a big surprise to those who believed in government by experts. The technocratic ideal, after all, is premised on scientific objectivity. Experts tend to lose their authority if they are nakedly subject to the powers they serve. Social circumstances entitled Forbes to make such a forthright pronouncement against his employer's interests: His career did not depend on his decision, a luxury denied to many who followed in his footsteps. Moreover, as a foreigner, he did not have to stay in Peru and live with the consequences of his recommendations. His situation clearly reveals why foreign consultants remain so vital to the politics of expertise in Latin America: their prestige depends on their social distance from the problem at hand. Without a doubt, Forbes was a tremendous boon for technocracy in Peru.

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57. *MCAG* 5 (1914), 96-101; Lavalle, *El guano y la agricultura nacional*, 52-53; Denegri, "Informe sobre la calidad y cantidad del guano que existe en algunos depósitos situados al norte del Callao"; Forbes, "The Peruvian Guano Islands," *Ibis*, 10th ser., 1 (1913), 709-712; idem, "Notes on Molina's Pelican (*Pelicanus thagus*)," *Ibis*, 10th ser., 2 (1914), 403-420.

A Technocratic Solution

The Aristocratic Republic was not governed by consensus. Peru's oligarchs constantly bickered over how to divide the spoils of power, and their conflicts occasionally became contests of military force. This is clearest in the case of Guillermo Billinghurst (1851-1915), once one of Peru's most successful nitrate entrepreneurs. He despised the peace his close ally Nicolás de Piérola had made with the Partido Civil. In 1899, Piérola chose Eduardo López de Romaña (1847-1912), a British-trained civil engineer from Arequipa who had served as Peru's first Minister of Development, to succeed him as President. López was elected almost unanimously by Peru's tiny electorate. Nevertheless, Billinghurst, whom most viewed as Piérola's heir apparent, tried to organize an insurrection. He failed, and the first technocrat to hold the Peruvian Republic's highest office accomplished a peaceful transfer of power, the first since the end of the Guano Age.[58]

Billinghurst had his revenge, at least temporarily. Intense factionalism during the 1912 election to replace Leguía threw the decision into the hands of the Peruvian Congress. Billinghurst, who had returned to political prominence as the popular mayor of Lima, won this parliamentary contest, cheered on by crowds of supporters. As President, he forced through a series of populist reforms that finally unified his elitist opponents. Billinghurst tried to dissolve Congress and call new elections to eliminate their resistance. Masses of unruly working-class protestors

58. Pike, *The Modern History of Peru*, 186-187; Contreras and Cueto, *Historia del Perú contemporáneo*, 178; *Enciclopedia ilustrada del Perú*, s.v. "Romaña, Eduardo López de." Rory Miller analyzes the forces of disunity of the Aristocratic Republic in "The Coastal Elite and Peruvian Politics"; cf. Gonzales, "Planters and Politics in Peru."

paraded the streets in support of further reforms. This threat to constitutionalism, elite dominance, and public order led to Billinghurst's overthrow by the military in February 1914.[59]

In this context, a technocratic solution to the guano problem helped mend the divisions that were tearing apart the Aristocratic Republic. The installation of an authoritarian junta headed by Colonel Oscar Benavides created ideal conditions to implement Forbes's recommendations. This junta closed the Islas Ballestas, the Peruvian Corporation's biggest guano producers, by decree only weeks after taking power. This closure was intended to give the bird population and guano levels time to regenerate; the islands would be allowed to reopen in 1916, but only to provide fertilizer for Peruvian agriculture. Thus, Peruvan state officials used scientific opinion and resource conservation as rationale to act in the interest of their biggest supporters, Peru's agricultural modernizers.

Ignoring Forbes's conclusions, the Peruvian Corporation cried foul immediately and warned that this unilateral action could threaten Peru's ability to negotiate foreign loans. Although CAG and the Benavides regime stood by the decree at first, the government eventually backed down and rescinded the closure of the Islas Ballestas in May 1914. In January 1915, the executive adopted a law passed by the legislature that again confiscated the Peruvian Corporation's exploitation rights (evidence of the popularity of this attack among Peru's political

59. Pike, *The Modern History of Peru*, 198-202; Contreras and Cueto, *Historia del Perú contemporáneo*, 188-189; *Enciclopedia ilustrada del Perú*, s.v. "Billinghurst, Guillermo E." Cf. Peter Blanchard, "A Populist Precursor: Guillermo Billinghurst," *JLAS* 9:2 (1977), 251-273; Steve Stein, *Populism in Peru: The Emergence of the Masses and the Politics of Social Control* (Madison: University of Wisconsin Press, 1980), ch. 2.

class). Later that year, the government made a deal that finally resolved this controversy: CAG would purchase guano from the Peruvian Corporation at international market prices and guarantee fertilizer at subsidized prices to all Peruvian farmers who wanted it. This followed a precedent set by the Peruvian Corporation: by special arrangement with the Peruvian government, it had sold guano at export prices to Peruvian haciendas owned by the British Sugar Co. beginning in 1914. The Benavides regime bowed to international pressure but did not forget the class whose interests it served.[60]

This mostly took care of the problem of guano supply, but CAG still had to do something about Peruvian guano demand in order to rationalize guano distribution fully. Hoarding and speculation were big problems. Many coastal farmers routinely asked for far more guano than they could use during a year and then kept it for the next season or sold it to other farmers at a markup. Furthermore, many farmers were applying guano in proportions unsuited for their chosen crop or local soil type. From the beginning, CAG tried to forestall this by distributing agricultural questionaires, but most coastal growers were not willing to give in so easily to CAG's supervision when it had little to offer in return. Some falsified their responses; most simply failed to return them.[61]

In 1914, CAG hired its first real technocrat to resolve this problem. Agronomic engineer José Antonio de Lavalle y García (1888-1957, illus. 11), one

60. *MCAG* 5 (1914), 29-41, 44; *MCAG* 7 (1916), iv, 86-87. This account differs substantially from Miller, "British Firms and the Peruvian Government," 377-378.

61. See app. 3; CAG, Sección Técnica, *Las necesidades de guano de la agricultura nacional*, 13-16; Macera, "El guano y la agricultura peruana de exportación," 388, 396.

of Peru's foremost young scientific talents, was the obvious choice to head its new Technical Section. As we have seen, he had already come to the rescue of CAG's embattled managers on more than one occasion. Lavalle was solely a product of professional scientific education in Peru, and he had received the gold medal as the outstanding graduate of the new Escuela de Agricultura in 1909. After graduation, he succeeded Gerardo Klinge as director of the Lima cotton experimental station. Like most professional scientists in twentieth-century Peru--even those from the best families--Lavalle also had to work as a chemistry professor and agricultural administrator to make ends meet. He soon became a major figure in several scientific organizations in Peru, including the important Sociedad Geográfica de Lima. Lavalle was also a prolific scientific author and attended several international scientific meetings.

But he was not a technocrat whose power and influence were based solely on expertise. His father had served as Piérola's Minister of State, and he was the grandson of the conservative diplomat José Antonio de Lavalle y Árias de Saavedra, founder of the *Revista de Lima*, an important mid-nineteenth-century outlet for scientists and other intellectuals, and head of the ill-fated diplomatic mission to Chile that tried to forestall the War of the Pacific. The Lavalles were closely tied by blood, marriage, and business--though not by politics--to the Pardo clan and, according to a biographer of the time, "related by marriage to the most ancient Spanish families of the colonial epoch" that held "the highest social position . . . at the aristocratic center" of *limeña* cultural life. Lavalle had immense social prestige and political connections that might serve him where his expertise could not. Even more than Ballén, he was both an aristocrat and a technocrat.[62]

Beginning in June 1914, Lavalle and a team of assistants embarked on an agricultural census of the Peruvian coast focused on fertilizer use. Lavalle, who had been trained by Belgian agricultural chemist George Vanderghem, paid special attention to coastal soils. From thousands of analyses, he discovered--somewhat to his surprise considering how intensively this region was being cultivated--that they were quite rich in nitrogen and phosphorus. This was clear evidence that coastal farmers had paid careful attention to the fertility of their soils over the long term. Unsurprisingly, he discovered that farmers used a variety of fertilizers and techniques for applying them. Cotton growers depended most heavily on guano *rico*. Nevertheless, cane plantations consumed the overwhelming majority of the fertilizer supply, and many farmers would not or could not purchase fertilizers at all (table 1). In Lavalle's view, one major cause of the guano shortage was the indiscriminate *overapplication* of fertilizer by some farmers; in a few cases, he thought its overuse reduced crop yields. In short, this was prime territory for technocratic management.[63]

Lavalle's surveys established an independent basis for calculating "national demand" for fertilizer and rationing the guano supply. CAG immediately used them for this purpose, and they served as the backbone to CAG's guano

62. *Diccionario biográfico de peruanos contemporáneos*, s.v. "Lavalle y García, José Antonio de" and "Lavalle y Pardo, José Antonio"; *Diccionario histórico y biográfico del Perú*, s.v. "Lavalle y Árias de Saavedra, José Antonio de."

63. CAG, Sección Técnica *Las necesidades de guano de la agricultura nacional*, passim; Macera, "El guano y la agricultura peruana de exportación," 397-401.

distribution regime for years to come. The publication of Lavalle's results also bolstered CAG's prestige as a scientifically managed institution. As we shall see in the next chapter, these calculations allowed CAG's managers to significantly extend their technocratic control over Peruvian agriculture.

Nature also cooperated with CAG's designs. In 1915-1916, guano production nearly doubled from the previous year, suggesting that the guano bird population had recovered from the shock of the 1911-1912 El Niño and that CAG's conservation policies were beginning to bear fruit. With Lavalle's statistical knowledge regulating guano demand and a diplomatic agreement with the Peruvian Corporation guaranteeing guano supply, CAG was able to meet national demand for guano for the first time in 1915-1916. It even started to make a decent return to its investors.

The Conquest of Nitrogen

Two external factors helped strengthen CAG's hand. First, hostilities on the other side of the globe dramatically increased international demand for foodstuffs and raw materials, especially Chilean nitrates. Second, a series of technological innovations by German chemical manufacturers initiated an epochal change in the relationship between industry, agribusiness, and the environment that soon made guano completely irrelevant as a global commodity.

The latter change had the longest-term implications. In fact, the premature belief at the turn of the century that Chilean nitrates would soon be exhausted like Peru's fossil guano deposits helped to bring about these far-reaching innovations.

In an influential 1898 address focused on England's persistent agricultural depression, a prominent physical scientist spoke for many who were frightened by depletion of the world's natural resources. He announced, "Our wheat-producing soil is totally unequal to the strain put upon it." He thought things would worsen when Chilean nitrate deposits failed. Therefore, "all *civilised* nations stand in deadly peril of not having enough to eat"--not just British-ruled India and other "southern" regions affected by recurring famines. (India, Indonesia, the Philippines, China, and East Africa again experienced devastating precipitation extremes and mortality in 1896-1900.)[64] Such catastrophist ideas had a profound influence on conservationism during this era and, as we shall see in chapter 5, on the environmental movement after World War II.

German scientists, with keener foresight, were less concerned with food security than with the threat that a war with Great Britain would cut them off from Chilean nitrate supplies needed to produce explosives. Both sides looked for a techno-fix: a renewed effort toward fixing nitrogen directly from the atmosphere. In short order, experts in several industrial countries developed two new, high-temperature techniques to synthesize nitrogen compounds directly. These were so energy intensive, however, that they were only barely viable commercially.[65]

Beginning in 1909--the same year CAG was founded--things began to change rapidly insofar as the human relationship with nitrogen was concerned. In one of the farthest-reaching scientific discoveries of all time, the chemist Fritz

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64. Emphasis added, William Crookes quoted in Smil, *Enriching the Earth*, 58; Davis, *Late Victorian Holocausts*, ch. 5-6.

65. Smil, *Enriching the Earth*, 51-60.

Haber (1868-1934), a German Jew, discovered a workable catalytic process for synthesizing ammonia (NH_3) from purified, gaseous nitrogen and hydrogen at high pressure. (Recall from chapter 1 that atmospheric nitrogen must be converted from its unreactive molecular form, N_2, to be incorporated into organic systems.) As an added bonus, ammonia can be used to synthesize an infinity of nitrogen-based chemicals. The industrial engineer Carl Bosch (1874-1940) then developed a complicated technological system that scaled-up Haber's basic process in order to produce ammonia and its derivatives in commercial quantities. Germany's preexisting water-coal-steel complex made it possible to industrialize this new Haber-Bosch process quickly and profitably. By the end of 1913, their employer, the chemical giant BASF, was operating a plant producing 20 tons a day of ammonium sulfate, a derivative of ammonia and sulphuric acid, using the Haber-Bosch process. This stable compound could be used directly as a fertilizer or shipped to munitions plants for conversion into explosives. During its first full year of operation, 1914, BASF produced the equivalent of 5,500 metric tons of nitrogen. This was about the same amount of nitrogen produced by Peru's depleted guano birds that year--but less than six percent of the quantity of nitrates Germany imported from Chile that year before its supplies were cut off by the onset of World War I. War on an industrial scale required the dramatic growth of all types of nitrogen production in a morbid race to see which side could blow up the other first (table 2). BASF successfully expanded its productive capacity to keep pace with the war, and this spectacular achievement of technoscience made it possible for Germany to keep fighting to the bitter end.[66]

The Versailles Treaty compelled BASF to share the intricacies of the Haber-Bosch process with the war's victors, though the "technological momentum" built up by the German chemical industry during the 1910s enabled it to maintain its primacy in nitrogen synthesis and similar techniques until World War II. This high-technology process quickly surpassed all other forms of inorganic nitrogen-compound production worldwide. The even greater demand for explosives during World War II strengthened its dominance. Since 1945, the widespread adoption of high-yielding, hybrid grain varieties and input-intensive agricultural practices (the so-called Green Revolution), tied to continuing improvements in the efficiency and scale of the basic Haber-Bosch process, has driven the consumption of nitrogen fertilizers ever higher. Since 1960, the United States, Germany, Japan, Soviet Union, and other industrial powers have made a big business exporting technology, expertise, and capital to build fertilizer production facilities in the post-colonial world. By the year 2000, this industry had become so vast that fertilizer manufacturers using the Haber-Bosch process worldwide only needed ten days to synthesize compounds containing more nitrogen than Peru's guano and nitrate miners extracted during the entire 19th century. Human ingenuity has conquered the supply side of the nitrogen cycle.[67]

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66. Ibid., ch. 4-5. On U.S. attempts to produce nitrogen compounds using the cyanimide and experimental Haber-Bosch processes in Muscle Shoals, Alabama, see Brian F. Coffey, "Fertilizers to the Front: HAER and U.S. Nitrate Plant No. 2," *IA: The Journal of the Society for Industrial Archeology* 23:1 (1997), 25-42.

67. Smil, *Enriching the Earth*, ch. 6-7; Thomas Parke Hughes, "Technological Momentum: Hydrogenation in Germany, 1900-1933," *Past and Present* 44 (Aug. 1969), 106-132.

Over the long term, the triumph of the Haber-Bosch process contributed powerfully to a fundamental shift in the relationship between humans and the environment during the twentieth century. The widespread consumption of nitrogen fertilizers has had a number of ecological costs and benefits. On a global scale, it dramatically increased the productivity of agricultural land and labor--for some regions and crops much more than others. This removed some of the pressure to expand the extent of agricultural lands, the most important human force driving ecological change on a global scale during the nineteenth century. Abundant fertilizer also allowed many farmers to dispense with crop rotation and legume cultivation while maintaining yields, in other words, to establish monocultures of enormous scale. The consequent increase in the global food supply made it possible for the human population to surpass six billion by the end of the century.

On the other hand, cheap nitrogen fertilizers created major water pollution problems, directly through leaching and inefficient overapplication, and indirectly via the vast increase in nitrogen-rich manure produced by protein-hungry livestock that consume much of this agricultural surplus. Synthetic nitrogen fertilizers are so inexpensive that this once-valuable manure is often thrown away as waste. The increasing consumption of meat and animal fats and declining direct consumption of beans and other pulses, in turn, has had a detrimental effect on the long-term health of the world's more affluent. As we shall see in later chapters, many of the world's poor have benefited little from this glut of food, and the immediate nutritional health of those on the margins of this agro-industrial system has declined in many cases. Perversely, smallholding farmers have benefited least from these improvements. Thus, the change in world nitrogen production and consumption during the twentieth century has mirrored the growth of an ever-widening gap between the fantastic wealth of the few (on both sides of the North-South divide) who have benefited most from industrialization and the stark poverty of the many who remain at farthest remove from industrial livelihoods. Enormous energy is needed to create the high temperatures and pressures required for ammonia syntheses, as well as to run the machines needed to transport and apply these compounds. Therefore, the conquest of nitrogen has contributed significantly to the rise in fossil fuel consumption and the consequent production of greenhouse gases, which may cause big problems for humanity in the near future. In short, this human-caused change radically accelerated the cycling of nitrogen through natural systems with far-reaching consequences, perhaps requiring a return to the concern for nitrogen conservation that existed circa 1900.[68]

By stoking demand for external nitrogen inputs, the widespread use of Peruvian guano and nitrates paved the way for these epochal changes, even though their quantities were minuscule in comparison to later production via the Haber-Bosch process. Peru's Guano Age was a crucial stage in the human conquest of nitrogen.

But these changes still lay decades in the future for the story at hand. In the short term, World War I created an immense economic opportunity for Peruvian

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68. Smil, *Enriching the Earth*, ch. 8-10. J. R. McNeil makes almost no mention of these revolutionary changes in *Something New under the Sun: An Environmental History of the Twentieth-Century World* (New York: W. W. Norton, 2000).

businessmen, but also social and political challenges. Even though Peru and many other countries experienced a sharp economic crisis at the beginning of the war when the British navy cut Germany off from overseas trade, the Allies soon demanded vast quantities of agricultural staples and minerals from South America. British, U.S., Peruvian, even German firms in Peru got rich supplying the European war effort, especially W. R. Grace & Co., which both produced and transported these goods. Though Peru may have gained in a moral sense, the Great War made it abundantly clear how much it lost economically during the War of the Pacific: From 1914-1918, Chile's salitre factories exported over 12 million metric tons of nitrates to keep the Allies' guns firing, more than three times the total exported by Peru from 1830-1879. But escalating wartime prices--and stagnant wages--hurt the situation of both blue- and white-collar Peruvian workers. As in many other parts of the world, the abrupt depression that accompanied the return of peace brought class conflict in Peru to a head, leading to the brutally repressed general strike of 1919. In this context, Augusto Leguía seized power from the weakening lords of the Aristocratic Republic and opened the way for technocrats to gain even more prominence under his 11-year dictatorship.[69]

Meanwhile, high international freight rates, disruptions to European agriculture, and a glut of nitrogen fertilizer immediately after the war all prevented

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69. See app. 5-6; Klarén, "The Origins of Modern Peru," 627-628; Smil, *Enriching the Earth*, app. G; Michael Monteón, *Chile in the Nitrate Era: The Evolution of Economic Dependence, 1880-1930* (Madison: University of Wisconsin Press, 1982), 111-115. On the connection between wartime trends and labor unrest in Peru, see D. S. Parker, *The Idea of the Middle Class: White-Collar Workers and Peruvian Society, 1900-1950* (University Park: Pennsylvaia State University Press, 1998), esp. ch. 4; Peter Blanchard, *The Origins of the Peruvian Labor Movement, 1883-1919* (Pittsburgh, PA: University of Pittsburgh Press, 1982); Klarén, *Modernization, Dislocation, and Aprismo*.

the Peruvian Corporation from exporting any guano from mid-1916 to mid-1920. This fertilizer instead went straight to Peruvian sugar and cotton growers, who earned a combined US$92 million, 41 percent of Peru's total export income, from their fertilized crops during these years. The Peruvian Corporation again exported guano during the 1920s, but by this time, CAG had reinforced its industry monopoly, and the Peruvian Corporation was forced to mine guano under the supervision of CAG's conservation technocrats. In 1929, faced with increasingly poor prospects for guano as the Haber-Bosch process conquered the world fertilizer market (and permanently destroyed the demand for Chilean nitrates), the Peruvian Corporation gave up its remaining control over exports after 38 years in the guano trade. By this date, the Peruvian Corporation had only sold 1.376 million long tons of guano of the two million promised by the Grace Contract: 938,469 long tons (mainly phosphatic guano *pobre*) before CAG's establishment, and an additional 322,413 long tons of guano *rico* and 114,622 long tons of guano *pobre* after 1909. Add guano extraction to the list of the Peruvian Corporation's endeavors in Peru that were never fully realized. Nevertheless, it still got something valuable in 1929 in return for giving up its claims: perpetual ownership of the main railway lines in Peru, a concession it had been trying to obtain since the end of World War I.[70]

Even though conservation technocrats were only partly responsible for the resolution of this controversy, the events described in this chapter reenforced the opinion that science and state intervention could serve the economic interests of

70. Miller, "British Firms and the Peruvian Government," 382, 386; idem, "The Making of the Grace Contract," 96-100; Macera, "El guano y la agricultura peruana de exportación," 334.

Peruvians in their quest for national order and progress. This quest, moreover, proved to be quite compatible with the interests of foreign investors, Peru's conflict with the Peruvian Corporation notwithstanding. In order to solve the "guano problem," Peruvian state officials followed the recommendations of two foreign scientific consultants and established a state guano monopoly based on the principle of sustained-yield conservation. Peru's ruling class, though divided on many problems, threw its almost full support behind this project. Now the Compañía Administradora del Guano had the political opportunity to deliver on its technocratic promise. Its managers were firmly installed as the Lords of Guano.

Chapter 3

Managing an Agroecological System:

The Compañía Administradora del Guano

The Peruvian Guano Administration . . . operates the greatest of all industries based upon the conservation of wild animals.

--Robert Cushman Murphy (1940)

With the formation of the Compañía Administradora del Guano in 1909, Peruvians established the barebones of an apparatus to control the guano industry. Support for the technocratic ideal in Peru gained enormously from the controversy that ensued between the Peruvian state and the Peruvian Corporation of London. But it remained to be seen whether the conservation science on which CAG based its managerial regime was founded on an accurate enough understanding of the natural world to fulfill its technocratic promise. Were guanayes, piqueros, alcatraces, and camanayes managable as “domestic animals” as Robert Coker and Henry Forbes hoped? Of course, wild animals were only part of CAG’s purview. Could the behavior of the people associated with the guano industry be controlled? The Lords of Guano who administered CAG looked to the fashionable principles of scientific management and social hygiene for help as they sought to manipulate the social relations of guano production, distribution, and use.

To understand how CAG’s management regime worked, it is useful to think of it as an interconnected agroecological system. An *agroecological system* or *agroecosystem* is a conceptual tool used to delineate the multiple ecological relationships present in a crop system. These differ from so-called natural ecosystems because they encompass large-scale human manipulation of biological productivity. The agroecosystem described in the pages that follow linked the tremendous productivity of Peru's marine environment to the production of export crops in the irrigated valleys of the adjacent coast.

It is important to recognize that the meaning of "agroecology" is itself tied to a present-day movement that seeks to apply "modern ecological knowledge and methods" to "the design and management of sustainable ecosystems." This movement is founded on normative principles distinctly different from those governing input-intensive agriculture. Its "guiding principles of sustainability" include recycling crop nutrients and relying on natural processes of nutrient fixation and exchange. Agroecologists seek to slow down, even reverse, the trend toward use of manufactured chemicals brought about by the unwavering drive to maximize crop and labor productivity. Many also oppose the concentration of ownership typical of modern agribusiness. In essence, the proponents of agroecology want to overturn many of the assumptions held by such old-school agronomists as José Antonio de Lavalle y García and Gerardo Klinge who saw farming tradition and peasant routine as major barriers to human progress.[1]

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1. Stephen R. Gliessman, *Agroecology: Ecological Processes in Sustainable Agriculture* (Chelsea, MI: Sleeping Bear Press, 1998), 13, 301-310. Donald Worster argued that environmental historians should make agroecosystems--and the social configurations they serve--their central empirical preoccupation in his widely read essay, "Transformations of the Earth: Toward an Agroecological Perspective in History," *Journal of American History* 76:4 (Mar. 1990), 1087-1106; for an example of a Latin American history that has accepted this challenge, see Soluri, "Landscape and Livelihood: An Agroecological History of Export Banana Growing in Honduras, 1870-1975." See also Gliessman, ed., *Agroecology: Researching the Ecological Basis for Sustainable Agriculture* (New York: Springer-Verlag, 1990), esp. 4-10; M. A. Altieri, ed., *Agroecology: The Scientific Basis of Alternative Agriculture*, rev. ed. (Boulder, CO: Westview Press, 1987).

From an agroecological perspective, it is possible in hindsight to make "expert" recommendations stating what Peruvians could have done to better manage their environment. But historical studies of Latin America, particularly of economic development and environmental change, often take a moralistic tone that dismisses the region as a failure. To be fair, the historian must respect the options that were available in the past. Therefore, rather than presupposing a normative position regarding what constitutes "sustainable" agriculture, I will use insights derived from the science of ecology to understand *how* input-intensive agriculture became conventional practice in Peru. The Compañía Administradora del Guano makes a fascinating case study because it promoted "sustainable" practices in one realm and "unsustainable" practices in another. In fact, the undeniable success of CAG's sustained-yield conservation program actually drove the development of input-intensive export agriculture in Peru.

This points to a major dilemma for those of us who want to mitigate or reduce the environmental damage caused by modern life and see that the costs and benefits of these practices are shared fairly by all classes of society: How do we draw boundaries around a practice and decide that it is sustainable, much less just? This issue mirrors a long-standing dilemma of working ecologists: How can we reduce nature into categories small enough to be studied (and manipulated) without violating the governing principle of ecology, that life on earth is interconnected? I will use the institutional history of Compañía Administradora del Guano to delineate the ecological and social relationships that linked Peru's marine environment to export agriculture.

Readers can draw their own moral conclusions from what transpired. From 1915 to 1934, CAG delivered perfectly on its technocratic promise. Thanks to its conservation policies, the guano bird population and guano production grew spectacularly. As a consequence, CAG was able to supply the growing demand for concentrated fertilizer in Peru. Only a narrow, already privileged segment of Peruvian society received most of the benefits provided by this regime.

Meanwhile, in adapting this agroecological system to the vagaries of the El Niño phenomenon and Great Depression, CAG's managers discovered how interconnected nature and modern society really are. In fact, they contributed to one of the most important environmental discoveries of the twentieth century. After the powerful 1925-1926 El Niño event, scientists with ties to the Peruvian guano industry and agribusiness produced observations crucial to the realization that the "Peruvian" El Niño is connected to the Southern Oscillation and that both are part of one vast climate mechanism affecting the entire Indo-Pacific Basin. Such discoveries opened new possibilities and bred new challenges for the Lords of Guano.

Shepherding the Guano Birds

CAG's control over this agroecological system linking Peru's marine environment to the export of agricultural staples started with the guano birds. The conservation science of Coker and Forbes fulfilled its promise in dramatic fashion under CAG's tenure: Annual guano production increased by more than a factor of four from the nadir following the El Niño event of 1911-1912 until 1938 when a

“La Niña” event with abnormally intense upwelling, cool surface waters, and high bioproductivity carried the guano bird population to its highest levels in decades (fig. 2). As in every ecological system, this change affected other species: some favorably, others negatively. CAG tried to manipulate these relationships to boost guano production. In accord with prevailing scientific fashion of the time, it focused on predators and parasites of the guano birds with varying success. Other species were affected as an unplanned consequence of these activities.

Without a doubt, the most significant action taken by CAG to aid guano bird reproduction during this era involved protecting the birds from the guano industry itself. This was the key to CAG’s initial success. “Thick beds of bones in hollows and gulches” on the guano islands evinced the industry’s destructive potential. According to locals, thousands of young birds “were driven to slaughter by wanton guano contractors in the old time purely [to get] them out of the way of the diggers.” In 1914, CAG permanently stopped contracting out the guano harvest. This gave CAG much more control over the behavior of island workers. Every visitor to the guano islands was strictly ordered to leave the birds alone. Even more significantly, CAG consistently set harvest times to come after the end of peak nesting on each island. These policies had an immediate impact: the ornithologist Robert Cushman Murphy credited the absence of the Peruvian Corporation on Islas Lobos de Afuera and Lobos de Tierra during the war for the noticeable expansion of the alcatraz colonies on these islands by 1919. The guano birds eventually became acclimated to the presence of workers. The guanay adapted best--even tolerating machines and colonizing some island buildings (illus.

12). The rough nesting census done by the ornithologist William Vogt in the early 1940s indicated that guano harvesting on the Islas Chinchas may have influenced many birds to flee to the nearby Islas Ballestas. But in regions and times when good nesting space was harder to come by, especially on the isolated, densely populated Islas Guañape and Macabí, workers had no discernable impact. Each harvest under CAG seems to have caused, at worst, only a brief decrease in the local bird population.[2]

In contrast, the rotation policy promoted by Coker and Forbes was not as important to bird conservation as these scientists thought. CAG rotated extraction on most islands and points, but did so quite haphazardly. CAG implemented this policy most consistently on the three Islas Chincha, its most important guano producers from 1909-1962; it extracted guano on each of the islands every other or every third year from the 1909-10 season until 1958 with only four exceptions.[3] But CAG extracted guano for many years consecutively during the 1910s and 1920s on several of its top guano-producing territories, including the Islas Ballestas. Only during the 1930s did CAG implement a rotation schedule for most of its top-producing territories, although it resumed intensive production on several islands in the 1940s, including its second-largest guano producer, the Islas Guañape. CAG made almost no attempt to alternate harvests on the Islas Macabí and Lobos de Tierra, largely because they were so remote from the rest of the

2. Murphy, *Bird Islands*, 66, 69, 278; *MCAG* 6 (1915), vii; *MCAG* 33 (1942), xliii. For harvest timing see *MCAG* 12 (1921), 84; *MCAG* 13 (1922), 37; *MCAG* 17 (1926), 11; *MCAG* 22 (1931), 208; *MCAG* 27 (1936), 180.

3. See app. 8.

guano islands, nor did it alternate extraction on the new properties it brought into production after 1946, including Isla La Vieja. It seems rotation did not significantly affect the reproductive success of the guanay and piquero populations along the Peruvian coast, though it may have discouraged the relative increase of the skittish alcatraz. It is possible that more elaborate statistical analysis may indicate a subtle but significant correlation between intensified extraction and declining guano production, but available evidence points to climatic variation as the overwhelming factor influencing guano production fluctuations before the 1960s. As figure 2 makes clear, the biggest drops in guano production from 1910-1985 all corresponded with strong El Niño events. Direct scientific studies of the guano bird population since 1939 directly support this conclusion. Rotation did serve another useful purpose, however: it allowed CAG to distribute its limited workforce and ships much more efficiently. In any case, it is clear that CAG's management did not fully implement scientific recommendations, although they continued to credit the rotation policy for production increases.[4]

Humans posed another threat to the guano birds. The presence of a human trespasser collecting guano, eggs, or chicks could spook an entire colony and raise tremendous havoc. Consequently, following Forbes's suggestion, CAG established permanent, military-style guard stations on its most important guano-producing islands and points to ensure their isolation (see map 1). In 1915-1916, CAG posted

4. These conclusions are based on an island schedule I constructed for this entire period using yearly reports in *MCAG*. See also *MCAG* 12 (1921), 11; *MCAG* 14 (1923), xii; *MCAG* 15 (1924), xiii; Coker, "Peru's Wealth-Producing Birds," 559; Humberto Tovar, Victor Guillén, and María E. Nakama, "Monthly Population Size of Three Guano Bird Species off Peru, 1953 to 1982," in *The Peruvian Anchoveta and Its Upwelling Ecosystem: Three Decades of Change*, ed. D. Pauly and I. Tsukayama (Callao: Instituto del Mar del Perú, 1987), 208-218.

its first guardians on nine islands and three coastal areas; by 1932, it operated stations on 31 islands and 13 coastal sites. CAG markedly increased real spending on these guardian installations from 1915 until the El Niño crisis of 1939-1941. In line with Forbes's recommendation, Lavalle supervised the establishment of meteorological stations on seven island groups. Guardians at these stations logged daily measurements of the ocean currents, prevailing winds, air and water temperatures, and the activity of the bird colonies. Lavalle hoped these observations would help CAG learn how climatic variations--especially the El Niño phenomenon--affected the guano birds, but later scientists found these readings to be too unreliable to be of much use. Guards were known to abandon their other duties on occasion to relieve their boredom at these isolated locations, but they generally did an adequate job of preventing trespassers from disturbing the colonies, despite the frequent presence of local fishermen against whom, as we shall see in chapter 6, CAG waged a political war for years.[5]

But CAG's guardian system had a decidedly negative impact on other coastal bird species. Island guards routinely hunted three birds to provide fresh meat for their sparsely provisioned tables: the *potoyunco* or Peruvian diving petrel (*Pelecanoides garnotii*), the *chuita* or red-footed shag (*Phalacrocorax gaimardi*), and the *pingüino* or Humboldt penguin (*Spheniscus humboldti*, illus. 13). Repeated guano extraction also disturbed the breeding of the potoyunco and Humboldt

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5. Each *Memoria* during this period lists all operating guard stations. See also *MMFOM* (1908), 17; Duffy, Hays, and Plenge, "The Conservation Status of Peruvian Seabirds," 253; *MCAG* 8 (1917), xii; *MCAG* 17 (1926), 120-121; Erwin H. Schweigger, "Temperaturas en las islas guaneras del Perú (1926-1930)," *BCAG* 7:3 (Mar. 1931), 121; Ávila to Vogt, 10 July 1947, Vogt papers, box 1:1.

penguin by removing the material they need to dig nesting burrows. These birds, common during the mid-nineteenth century, were virtually eliminated from the guano islands and came to nest only in sea caves or on a handful of lofty islands unamenable to colonization by the principal guano birds, such as Isla San Gallán. Of course, these guardians did nothing to prevent others elsewhere along the coast from hunting or collecting eggs from these birds or capturing penguins for the pet and zoo trade. As a consequence of these pressures, today the chuita is classified as near-threatened and the Humboldt penguin as "vulnerable." The potoyunco only breeds in four locations and is in imminent danger of extinction.[6]

CAG cared little for most coastal birds that did not contribute to guano production. But it cared deeply for the guano birds' natural enemies, if only to get rid of them: The *simeón* or band-tailed gull (*Larus belcheri*), the *cleo* or kelp gull (*L. dominicanus*), the *pájaro ladrón* or southern skua (*Catharacta skua chilensis*), the *gallinazo* or turkey vulture (*Cathartes aura*), and the *buitre* or Andean condor (*Vultur gryphus*) all preyed on eggs, chicks, dead birds, and stole fish from the guano bird colonies. The *halcón real* or peregrine falcon (*Falco peregrinus*) and *cernícalo* or kestrel (*Falco sparverius*) occasionally caught adult guano birds on the wing.[7] In his 1913 report, Henry Forbes recommended either shooting these predatory birds or killing them with poisoned bait to protect the guano birds and

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6. Raimondi, "Apuntes sobre el huano y las aves que lo producen," 450; Coker, "Peru's Wealth-Producing Birds," 557-558; Murphy, *Bird Islands*, 266-268, 276-277; idem, *Oceanic Birds*, 1:292-293, 453-454, 2:774-775, 778, 877; Duffy, Hays, and Plenge, "The Conservation Status of Peruvian Seabirds," 246, 253; C. Hilton-Taylor, ed., *2000 IUCN Red List of Threatened Species* (Gland, Switzerland and Cambridge, UK, 2000) [cited 6 Aug. 2001], available from http://www.redlist.org/search/details.php?species=16485 [also species=16832, 20609].

7. Murphy, *Bird Islands*, 282-283, 287-289; idem., *Oceanic Birds*, 2:1013-1016, 1052-1071.

their young. Within a few years CAG got government permission to hire military marksmen, then to arm its own guardians and lighthouse keepers for this purpose. Robert Cushman Murphy reported that 5,000 gulls were shot in February and March of 1917 on the southern islands, although he thought this measure had little effect since these pests were "extremely abundant" again when he visited a few years afterward (illus. 14). Murphy was a bit more concerned about the condors. At first, he thought it "seemed criminal that sharpshooters . . . should be employed for the express purpose of killing such magnificent creatures." But then one day over Isla Asia in December 1919 Murphy sighted 18 condors, "several whose bare, distended crops hung down like goiters from the weight of stolen eggs." He directly blamed the condors for creating "a waste of empty nests and broken egg-shells . . . deserted for the season" on half of the island. This led to a change of heart: "After witnessing the damage that these birds had done at Asia, my sympathies inclined more toward the victims and the practical attitude of the guano administration." CAG, after all, was raising "defenseless" guano birds in "a system of more or less artificial culture" instead of protecting the harmonies of a natural community. Therefore, Murphy's moral calculus allowed these "veritable harpys" to be executed without remorse (illus. 15). From 1937 to 1940, when CAG was making record profits, it purchased 47,500 shotgun cartridges, 38,000 Winchester rifle cartridges, and 35,000 carbine cartridges to kill predatory birds--an indication of the immense scale of this organized killing.[8]

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8. *MCAG* 5 (1914), 88-91; *MCAG* 6 (1915), vii; *MCAG* 8 (1917), ix, 43-46; *MCAG* 9 (1918), 9; *MCAG* 13 (1922), 53; *ECAG*, 16, 50-51; Murphy, *Bird Islands*, 88-89, 122-23, 204-06, 283, 287; *ICAG*, 46, 50, 66.

Since it was following conservation orthodoxy of the time, which identified "varmints" either as unworthy of protection or deserving of extirpation, CAG never questioned the efficacy of its predator policy. As a direct consequence, today the band-tailed gull and condor are reputedly much less common along the Peruvian coast. Contrary to common wisdom, however, Andean condors today are not classified as threatened or endangered as is their close relative the California condor (*Gymnogyps califorianus*), and they still seasonally visit the coast to raid sea lion and guano bird colonies.[9]

Even though this experiment in ecological alteration affected several other bird species negatively, it undoubtedly helped increase guano production for several decades. CAG's guardian and predator-control policies achieved their greatest success on Isla La Vieja, the lofty island guarding the entrance to the rich Bahía de Independencia. Even though it harbored a large breeding colony of the *zarcillo* or Inca tern (*Larosterna inca*), Isla La Vieja was insignificant as a producer of guano until 1948 when CAG installed a guard station and undertook a systematic campaign against its large population of condors after preparing the island surface on its windward side to make it more amenable to nesting. Guanayes then colonized this territory in unprecedented numbers and made it CAG's largest

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9. Duffy, Hays, and Plenge, "The Conservation Status of Peruvian Seabirds," 251; Marcia Bonta, "A Peruvian Safari," *Americas*, Mar.-Apr. 1986, 16-23; Hilton-Taylor, ed., *2000 IUCN Red List of Threatened Species* [cited 6 Aug. 2001], available from http://www.redlist.org/search/details.php?species=40258.

For a discussion of conservationist ire toward "varmints" and the change in environmental perceptions that led to their partial rehabilitation later in the twentieth century as symbols of wildness and ecosystem health, see Susan Jones, "Becoming a Pest: Prairie Dog Ecology and the Human Economy in the Euroamerican West," *Environmental History* 4:4 (Oct. 1999), 531-552; Worster, *Nature's Economy*, ch. 13; Thomas R. Dunlap, *Saving America's Wildlife* (Princeton, NJ: Princeton University Press, 1988).

guano-producing territory during the 1950s.[10] CAG's predator control policy was good for its bottom line but, ironically, it ended up hurting CAG politically. As we shall see in chapter 7, in its conflicts with the nascent anchoveta industry during the 1950s, CAG was accused of allowing the guano bird population to grow too large and too domesticated with this policy, and thus setting up the industry for collapse.[11]

CAG looked to a different set of experts to orchestrate its campaign against the guano birds' smaller natural enemies. Bio-medicine was the most advanced sector of Peru's scientific establishment during the early twentieth century, as it was in many parts of Latin America. This was due in part to the far-reaching triumph of tropical medicine, Pasteurian bacteriology, and hygienism, but also to growing interest in tropical plant pathology and livestock diseases, as well as a vigorous local tradition of environmental medicine in Peru, known as "Andean biology."[12] The persistent belief that bio-medical science would soon conquer the world's worst diseases infected CAG's managers and strongly influenced their attempts to manage Peru's marine environment.

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10. See app. 8. Vogt journal, Isla Santa Rosa, 5 May 1939, Vogt papers, box 3:1; *MCAG* 45 (1953), iii-vi.

11. In later years, CAG's ornithologists also questioned the efficacy of this policy; Ávila to Vogt, 12 Apr. 1948, Vogt papers, box 1:1; Duffy, Hays, and Plenge, "The Conservation Status of Peruvian Seabirds," 257.

12. On biomedical trends in Peru, see Cueto, *El regreso de las epidemias*; idem, *Excelencia científica en la periferia*; idem, "Andean Biology in Peru: Scientific Styles in the Periphery," *Isis* 80 (1989), 640-658. More generally, see idem, ed., *Salud, cultura y sociedad en América Latina: Nuevas perspectivas históricas* (Lima: Instituto de Estudios Peruanos/Organización Panamericana de Salud, 1996); McCook, *States of Nature*, esp. 21-22, 78-79, 82-102; Julyan G. Peard, *Race, Place, and Medicine: The Idea of the Tropics in Nineteenth-Century Brazil* (Durham, NC: Duke University Press, 2000); Michael Worboys, "Tropical Diseases," in *Companion Encyclopedia of the History of Medicine*, eds. W. F. Bynum and Roy Porter (London: Routledge, 1993), 521-536; as well as ref. listed in ch. 1.

Henry Forbes unwittingly inspired CAG's campaign to "sanitize" the guano islands for the birds' protection. When he visited the northern coast of Peru in search of the cause of the casualties of 1911-1912, he dissected a handful of bird corpses and found no clear signs of disease, only large numbers of ectoparasites. Forbes tentatively concluded that lack of food related to the incursion of warm waters was the primary cause of guano bird migration and death. Forbes's criticized the Peruvian Corporation's habit of piling stones on the islands primarily because they took space away from the nesting colonies and made the guano harvest more difficult. CAG workers then began systematically dumping tons of stone into the ocean to "clean" the islands for guano extraction.[13]

José Antonio de Lavalle y García almost single-handedly changed the way in which this cleaning was conceived. The 1911-1912 and 1917 El Niño events directly inspired this shift in thinking. In three ground-breaking scientific papers, Lavalle analyzed the impacts of these events on Peru's coastal ecology. In line with his training in plant pathology and direct experience in the battle against cotton wilt, he thought a disease was the most likely cause of the increased bird mortality he observed during these years. After studying a number of corpses, Lavalle concluded that heat and humidity associated with these events encouraged the growth of the common fungus *Aspergillus fumigatus* to such an extent that it killed many birds. (This is the same type of organism responsible for the "white plague" currently destroying fan corals in the Caribbean.) Lavalle felt this disease directly threatened the well-being of the guano industry, so he recommended the

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13. *MCAG* 5 (1914), 77-78, 91; *MCAG* 8 (1917), ix; *ECAG*, 16; *MCAG* 12 (1921), 11.

burning of all bird corpses, the direct killing of sick birds, and spraying the islands with sanitizing disinfectant or hot water after each harvest. Lavalle thought these procedures (and, interestingly, the artificial breeding of endemic island spiders as a biological control) would also help eradicate blood-sucking *garrapatas* or ticks (*Ornithidorus amblus*) that lived under surface rocks and infested both the birds and guano workers. Lavalle suspected these arthropods served as vectors for disease, in the same manner that insects were known to carry plague, typhus, malaria, and sleeping sickness.[14]

Other Peruvian scientists followed Lavalle's lead and researched this epidemiological angle for years. In 1924, Peruvian bacteriologist Julio César Gastiaburú Rocco (1881-1960) made a major discovery among sick guano birds: He isolated the first wild instance of "bird cholera" (the bacillus *Pasteurella*), a deadly bacterial disease infecting domestic fowl. This discovery had ominous implications: it suggested that this disease might have jumped the species barrier from chickens to Pelecaniformes quite recently. If the guano birds had developed no immunity to this bacteria, there was potential for the spread of a cataclysmic epidemic--perhaps one on the apocalyptic scale of the rinderpest pandemic widely known to have passed from domestic to wild African ungulates during the 1890s.[15]

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14. Lavalle, "Una hipótesis sobre la mortalidad de las aves"; idem, "Informe preliminar sobre la causa de la mortalidad anormal de las aves," *MCAG* 8 (1917), 61-88; idem, "Estudio sobre los factores que influyen sobre la distribución de los nidos de aves productoras de guano," *MCAG* 9 (1918), 207-213; idem, "La destrucción de las garrapatas en las islas guaneras por sus enemigos naturales," *MCAG* 14 (1923), 165-170; *MCAG* 8 (1917), 32; Ian James, "Fragile Coral Reefs are Dying," Associated Press wire release, 18 Nov. 2001.

15. Peruvians had reason to be worried, as they had been with bubonic plague during Coker's visit. From the late 1880s until after the turn of the century, rinderpest, persistent drought, and a series of other ecological disasters devastated vast swaths of eastern Africa from Eritrea all the way to South Africa, opening the way for European colonization in the region. See Helge Kjekshus,

Gastiaburú's discovery inspired more suggestions to clean the islands with antiseptic, and it led Luis Gamarra Dulanto, one of Lavalle's successors as chief of CAG's Technical Section, to ban domestic fowl from the islands in the early 1930s--eliminating one of the island workers' only sources of fresh meat. In the interest of hygiene, Gamarra later organized a campaign using poison against rats, another non-native species on the guano islands (illus. 16). In 1960, CAG's resident ornithologist tried a different tack: he tested the efficacy of Aldrin, benzene hexachloride, and other chemical pesticides against the *garrapatas*. Fortunately, this experiment failed. In the United States, bioaccumulation of such chlorinated hydrocarbons was directly responsible for the near extinction of several bird species, including the brown pelican--the northern variety of one of Peru's main guano birds![16]

As part of their zeal to control the environment of the guano islands, this obsession with infection led Peruvian scientists to make some frightening proposals regarding island sanitation. Without a doubt, this was a reasonable approach to the

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Ecology Control and Economic Development in East African History: The Case of Tanganyika, 1850-1950, rev. ed. (London: James Currey, 1996), ch. 7-8; Douglas H. Johnson and David M. Anderson, eds., *The Ecology of Survival: Case Studies from Northeast African History* (Boulder, CO: Westview Press, 1988), esp. ch. 2-3; Pule Phoofolo, "Epidemics and Revolutions: The Rinderpest Epidemic in Late Nineteenth-Century Southern Africa," *Past & Present* 138 (Feb. 1993), 112-132; Davis, *Late Victorian Holocausts*, 200-205.

16. MCAG 15 (1924), 93-108; *MCAG* 19 (1928), 254-255; Murphy, "Los invertebrados terrestres de las islas guaneras del Peru," trans. Lavalle, *MCAG* 12 (1921), 95-116; Johannes Wille, "Algunas observaciones entomo-parasitológicas sobre los pájaros guaneros," *BCAG* 10:8 (Sept. 1934), 271-274; Raúl Rebagliati, "Informe sobre recientes enfermedades de las aves," *BCAG* 12:5 (May 1936), 149-154; Luis Gamarra Dulanto, "Los peligros que implica la cría de aves de corral en las islas guaneras," *BCAG* 10:1-4 (Jan.-Apr. 1934), 43-44; idem, "Destrucción de animales dañinos: La lucha contra las ratas," *BCAG* 16:12 (Dec. 1940), 389-411; Rómulo Jordán to Ing. Luis Massa Giuffré, "Ref.: Informe sobre experimentos con garrapaticidas," 15 Apr. 1960, ACAG-Isla Don Martín;

problem of variation in the guano bird population, especially in view of the spectacular discovery by other Latin American scientists that insects served as the vectors of yellow fever, Chagas disease, and mosaic disease in sugar cane. But in this case, this epidemiological bias led to a scientific dead end. Forbes's suggestion that the availability of fish for the guano birds was the proximate cause for ups and downs in guano production later turned out to be correct. In other words, the success of bio-medical science in Peru stood in the way of the development of new techniques to foment guano production.[17]

But the short-sightedness and limitations of some of CAG's conservation policies should not be interpreted as a failure. Far from it. Where things counted most--the protection of the guanay and piquero to ensure the sustained production of fertilizer for national agriculture--CAG succeeded marvelously under technocratic control.

Disciplining Workers

Meanwhile, CAG applied many of these same principles of contagion and control to the humans who worked on the guano islands. Rather than resorting to violence, as conservationists did against the guano birds' natural enemies, CAG relied on hygiene and quantification to discipline its workers into increasing guano

17. See Cueto, *Excelencia científica en la periferia*, ch. 4, esp. p. 134; McCook, *States of Nature*, ch. 4; Stepan, *Beginnings of Brazilian Science*; idem, "The Interplay between Socio-Economic Factors and Medical Science: Yellow Fever Research, Cuba and the United States," *Social Studies of Science* 8 (1978), 397-423.

production. CAG employed physicians and statisticians to implement this new efficiency-minded managerial regime.

As it did during the nineteenth century, guano extraction still depended on back-breaking labor with simple hand tools: pickaxes, shovels, and now screens to remove worthless stones, and brooms to pick up valuable leftover dust (illus. 17-18). To further minimize losses, CAG replaced the wasteful, labor-saving chutes used during the Guano Age to load ships directly (see illus. 2) with jute-fiber sacks imported from South Asia. Guano workers continued to rely primarily on burros, small railway cars, and cable trolleys to move guano and drinking water around the islands, though CAG gradually supplemented these with an extensive infrastructure of docks, roads for motorized tractors, administration and service buildings, guard houses, even lighthouses to aid coastal navigation.[18]

The guano industry no longer depended on coolie workers imported from China as it had during the Age of Guano. Instead, CAG recruited seasonal wage laborers from the Sierra through the *enganche* system, just as railroad contractors and nitrate miners, then coastal planters and highland miners had done during the nineteenth century.[19] In this system, CAG paid an agent (*enganchador*) to journey to the highlands and recruit indigenous male peasants--adults, adolescents, and sometimes children--with a cash advance. These seasonal laborers then worked off the advance with usurious interest (typically 20 to 30 percent of their wages for five

18. Murphy, *Bird Islands*, 96; Coker, "Peru's Wealth-Producing Birds," 562, 564; "La producción de fibra de yute," *BCAG* 30:8 (Aug. 1954), 28-30.

19. See Klarén, "The Origins of Modern Peru," 616-617; Gonzales, "Capitalist Agriculture and Labour Contracting in Northern Peru, 1880-1905," *JLAS* 12:2 (1980), 291-315; Blanchard, "The Recruitment of Workers in the Peruvian Sierra at the Turn of the Century: The Enganche System," *Inter-American Economic Affairs* 33 (1979), 63-83.

months of work) and ideally made a little additional cash to take back to the highlands. Since workers could not run away once they arrived on the islands, this was a secure investment for CAG, although potentially even more exploitative for employees than plantation work. During the 1920s, CAG obtained approximately three-fourths of its laborers in this way, the majority from the department of Ancash and a minority from the department of Ayacucho. This pattern changed little over the years. During the period 1937-1941, for example, CAG recruited 60 to 70 percent of the 3,000-plus workforce it employed each year from just one highland province, Yungay, which was connected by railway to the port of Chimbote. Many individuals returned year after year to the guano islands.

Compared to other manual jobs on the coast available to migrant workers, employment on the guano islands offered fairly good pay and benefits. In 1919, CAG implemented the eight-hour day when it became national law after a sustained, sometimes violent campaign led by urban workers. In that year, guano workers typically received S/.7.20 (US$1.63) and rations for working a six-day week with national holidays off. This compared favorably to the pay given highland migrants on coastal plantations: At Cayaltí, a sugar plantation owned by the politically powerful Aspíllaga brothers in the Saña river valley southeast of Chiclayo, contracted laborers in 1919 received S/.6.72 per week for completing set tasks that typically took ten to 12 hours each day to complete. Likewise, the Aspíllagas paid S/.6 to S/.9 per week to workers on their cotton plantation near Pisco in 1919, depending on the season. CAG raised its wages steadily over the years, though periods of rapid inflation consumed most of these gains in real terms (table 3).[20]

Working conditions on the guano islands were difficult if not downright dangerous, although they were a marked improvement over the dark days of the nineteenth-century guano industry. Like their earlier counterparts, most guano workers contracted conjunctivitis, chronic coughs, and other respiratory problems acquired from exposure to pulverized guano. Bronchitis, malaria (the scourge of highland migrants to the coast), and influenza were the most common causes of worker hospitalization. Their disease environment also overlapped with the guano birds: ticks--especially in their larval stage when they were known as *chui-chuis*--easily adapted to feasting on human hosts, day and night. Like coastal plantations, CAG provided a spartan diet of easily transportable foods: rice, beans, dried meat, hard bread, and tea with sugar. During CAG's early years, workers occasionally suffered from scurvy from lack of fresh food. Guano workers had to provide their own bedding and usually slept in crude tents made from wood frames, woven cane, and old sacks. To make matters worse, these habitations typically harbored clouds of flies bred by poor sanitation which made gastrointestinal problems like dysentery all too common. Everything metal on the islands was painted with poisonous red lead to prevent corrosion.

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20. *MCAG* 11 (1920), ix; F. García Llaque, "Contribución al estudio de las condiciones higiénicas de la industria del guano de las islas," *BCAG* 18:11 (Nov. 1942), 343-401; Macera, "El guano y la agricultura peruana de exportación," 410-414, 470. On cane workers, see Gonzales, *Plantation Agriculture and Social Control,* pt. 2, esp. p. 132; Klarén, *Modernization, Dislocation, and Aprismo*, ch. 2; on cotton workers, see Vincent C. Peloso, *Peasants on Plantations: Subaltern Strategies of Labor and Resistance in the Pisco Valley, Peru* (Durham, NC: Duke University Press, 1999), 147; on mining workers, see Mallon, *The Defense of Community in Peru's Central Highlands*.

Hygienists and labor activists routinely complained about this work environment. In response, beginning in 1916, CAG paid a series of physicians to study health conditions on the islands, recommend improvements, and provide free medical care to its workers. CAG's managers eagerly published their periodic reports which tended to rate island working conditions much better than those encontered by plantation and mine workers, and the military rank-and-file. CAG kept the highly critical 1929 report by Humberto Bravo Otayza under wraps, however. Intervention by hygienic experts led to the gradual construction of new "scientifically prepared, hygienic habitations" and hospitals during periods when guano production was most profitable. In its later years, CAG even offered life insurance to its workers and sports facilities on the islands. But it is important to note that sanitation campaigns against human excrement on the islands were designed to protect the guano birds more than they were the workers.[21]

As one might expect, some of CAG's managers and overseers treated their workers with disdain. For example, Murphy reported that one boss on Isla Chincha Norte, "adopted the policy of selecting only the stupidest of the Indians as his own workmen, his philosophy being that if he chose blockheads, and taught them nothing, they would never become fit for other work. . . . He had kept the same

21. Murphy, *Bird Islands*, 195, 341-342; *MCAG* 9 (1918), 12; *MCAG* 14 (1923), xv-xvi; *MCAG* 15 (1924), xix-xx; *MCAG* 17 (1926), 54; *MCAG* 23 (1932), xvii; *MCAG* 27 (1936), 241-248; William Vogt journal, Isla Santa Rosa, 5 May 1939, Vogt papers, box 3:1; photograph, Aug. 1939, roll 29, Vogt papers, box 4:1; Murphy, "Los invertebrados terrestres de las islas guanera"; M. Federico Ocampo, "Las condiciones sanitarias de las islas del sur: Informe presentado por el Doctor M. Federico Ocampo, medico de las islas del sur, a la Compañía Administradora del Guano al finalizar la campaña 1924-1925," *BCAG* 2:1 (Jan. 1926), 37-52; García, "Contribución al estudio de las condiciones higiénicas." On the Bravo report (now lost), see Macera, "El guano y la agricultura peruana de exportación," 414-419. On disease and hygienism in Peru, see Cueto, *El regreso de las epidemias*.

dull, steady crew for years." The presence of physicians was not all good for the workers; it exposed them to the hygienists' disciplinary zeal: Alcohol was forbidden. Even worse, Bravo complained that the lonely, prison-like conditions of the guano islands caused frequent fights and "a lamentable confusion of instincts" among the highlanders that he claimed led to sodomy and pederasty. Bravo argued that workers, therefore, required much greater vigilance and control--by experts in hygiene, of course. I am not aware of any notable cases of organized labor unrest during CAG's history, but that did not stop CAG from worrying about it. In the mid-1930s, CAG organized special Guardia Civil detachments on the islands to keep order, and it accused the Yungay newspaper *Adelante* of promoting discontent among guano workers. I also know of one case from the 1960s in which a known labor activist used seasonal work on the guano islands to make money to support his onshore organizing activities during the rest of the year.[22]

In line with the theories of scientific management, CAG gradually developed an elaborate written set of quantified work standards. For its first 30 years, CAG organized its workers according to the gang system, with workers divided according to physical capacity into small groups under a foreman. During the early 1940s, CAG began paying its workers by the task, and it hired a new class of overseers (*tarjadores*) to carefully record every sack and every kilo of guano produced by each worker. This made it much easier for higher officials to

22. Murphy, *Bird Islands*, 184, 341-342; *MCAG* 9 (1918), 12; *MCAG* 11 (1920), xiii; *MCAG* 17 (1926), xiv, xx; *MCAG* 22 (1931), xiv; *MCAG* 23 (1932), i, xvi; *MCAG* 26 (1935), v; Macera, "El guano y la agricultura peruana de exportación," 419-420, 471; Daniel Castro, Southwestern University, Georgetown, TX, personal communication, Feb. 2002.

supervise the efficiency of operations from afar, though it is difficult to gauge how much--if at all--this changed the arbitrariness of labor relations on the islands.[23]

Over the years, coastal planters pressured CAG to reduce the pay and social services it offered. This would have allowed CAG to charge them the lowest price for guano possible without sacrificing CAG's profitabily--and their stock dividends. By keeping *enganche* wages low, it would also have allowed them to pay their own peons less. Even though CAG's managers served Peru's agricultural czars on most matters, they were also state employees and, therefore, vulnerable to political pressure to improve working conditions, especially after 1940 when APRA, Peru's leading pro-labor party, consolidated its power and influence. The technocratic ideal enabled CAG to operate with some autonomy on the issue of labor relations. Like a few of their brethren who managed Peru's mines and agribusiness, CAG's managers generally favored an ameliorative, paternalistic labor policy intended to discipline and civilize their workers through codified work rules, hygienic reform, and a small measure of technological progress. To please both pro-business and pro-labor forces, they installed a middle class of statisticians and physicians on the guano islands to execute and quantify the results of these new policies. These statistics were then used to prove to the public that CAG was not slighting efficiency, profitability, or worker health. CAG's higher officials were proud of their progressive attitudes: they published scores of photographs over the years glorifying working conditions and installations on the islands.

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23. See ACAG-Zona Norte, esp. Guido A. Razetto T., "Trabajos de explotación de guano rico, baja ley, pobre y mezclas. Rendimiento y costos de las tareas--Zona Norte, año 1969," 22 Sept. 1969.

In short, CAG was an experiment in the scientific management of workers as much as it was a venture in scientific conservation. Nevertheless, guano extraction has remained labor intensive and working conditions spartan to the present day, despite occasional attempts to mechanize aspects of production, such as the pulverization of guano.[24]

Serving Agribusiness

CAG existed to provide services and income to Peruvian agribusiness. Ultimately, the Lords of Guano were vassals to the lords of the Peruvian Republic. But CAG's managers did this job so efficiently that they were allowed to exercise autonomy in many parts of their technocratic fiefdom. Under some circumstances, they extended this authority back to Peru's agricultural estates.

From CAG's foundation, it worked to integrate its control over guano transport, distribution, and sale and submit these operations to quantifiable principles of quality and efficiency. CAG acquired a fleet of boats to transport guano from the islands to the coast. It purchased its first steamer in 1912, and by 1926, the company controlled a large, diverse fleet operated according to the precise charts and transportation tables Francisco Ballén had developed as one of his first acts as CAG general manager. In 1914, the Forbes report provided CAG with the political impetus it needed to end the old contract system of guano

24. The film *El mar y los dioses*, dir. Alejandro Guerrero, Panamericana Televisión, 1997, videocassette, vividly shows the conditions guano workers encountered in the mid-1990s when returning to CAG's decrepit installations after years of inactivity. See also the illustrated propaganda pamphlet CAG, *El Guano* (Lima: n.p., 1954), 7-14.

extraction and take direct control over work on the islands. CAG's income and returns to its stockholders jumped dramatically by eliminating this middle man.[25] CAG gradually developed a network of warehouses and shops to distribute guano, including several offices in the Sierra that provided agricultural extension services. In the mid-1920s, after years of bitter negotiations, CAG obtained a 50 percent discount on the fare charged to transport guano on railroad lines owned by the Peruvian Corporation. Such acts were necessary to promote guano use by highland farmers--and to bolster CAG's weak claim that it existed to serve *all* Peruvian farmers.

CAG's most important innovation involved setting the price of each bag of guano. As we have seen, guano sales were highly susceptible to fraud. From the outset, CAG used its technical capacity to standardize this system. A CAG official removed a scoop of guano from every sack that arrived at a mainland port, mixed it in a bag with samples from all other sacks in the same shipment, and sent the combined sample to Lima for chemical assay. Purchasers promised to pay (on credit) a price based on the average nitrogen content of the lot. To establish trust in this pricing system, CAG did this under the shared supervision of the port authority and a local representative from Sociedad Nacional Agraria. A watchful state official policed this transaction--in this case to check the arbitrary action of another quasi-state official. At least for the moment, this pricing system retained an ancient practice of the marketplace: shared participation in the exchange of goods by interested parties. Faith in chemical science guaranteed the hidden content of this

25. See app. 4.

product and the value of the exchange. This "objective" system replaced the face-to-face negotiation once used to set prices with an impersonal standard set far away. But this process never became truly transparent. Real power to negotiate the price of guano fell to a small board of technocrats and politicos that met each year in Lima. This is just one example of a centralizing trend that has allowed technocrats to gain power over trade in societies all over the world.[26]

There were limits to CAG's attempts to dominate fertilizer supply in Peru. By this time, agronomists and farmers knew that guano was an unbalanced fertilizer and that many crops responded better to other nutrient inputs. CAG tried to market other forms of fertilizer to serve this need, and on a couple of occasions it obtained a monopoly concession from the Peruvian government to sell all forms of fertilizer in Peru. But during most of its existence, CAG had to compete with other, much more powerful transnational companies on the fertilizer market. Before World War II, the importation of most concentrated fertilizers in Peru was controlled by local subsidiaries of the Stickstoff-Syndikat and Pottasche-Syndikat, two German fertilizer cartels that, thanks to Haber and Bosch's innovation and Germany's resource endowment, dominated the global market for synthetic nitrogen and potassium fertilizers.[27] The German-Peruvian sugar giant Gildemeister & Co.--which got its initial start producing nitrates in Tarapacá before the War of the Pacific--served as the main Peruvian distributor of Chilean nitrates.

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26. On this point, see Porter, *Trust in Numbers*; Witold Kula, *Measures and Men*, trans. R. Szreter (Princeton, NJ: Princeton University Press, 1986).

27. See Monika Friedrich, "Die Aktivitäten des deutschen Stickstoff-Syndikats in Ägypten 1924-1939," *Zeitschrift fürUnternehmensgeschichte* 38:1 (1993), 26-48.

Independent agents (usually large agricultural firms like Gildemeister & Co. or Peruvian Corporation railroads) retained the right to sell guano directly to farmers in many coastal valleys. The cheapness of CAG's main product, not technocratic control over the Peruvian fertilizer market, was ultimately what made CAG competitive and allowed it to succeed as a business.[28]

CAG's duties went far beyond overseeing fertilizer extraction and delivery. Its mission to promote scientific development in Peru also meant that it should use its profits and distribution apparatus to introduce science to the people CAG served--Peruvian farmers. Besides providing the all-important assays that determined the quality and price of Peruvian guano, CAG agricultural chemists performed free fertilizer, soil, water, plant disease, and pesticide analyses for farmers interested in using the latest scientific techniques to manage their crops. José Antonio de Lavalle y García and other CAG technicians often visited farmers personally, and they eventually ran three regional laboratories that provided technical services to coastal farmers. In 1925, Lavalle regularized CAG's publication of technical pamphlets by establishing the monthly *Boletín de la Compañía Administradora del Guano* to "instruct farmers in a simple manner on the principles of . . . soil types and the application of guano." The *Boletín* also published meteorological data, agricultural studies, and scientific papers, taking over some of the earlier duties of the *Boletín* published by the Ministerio de

28. Ref. for the preceding paragraphs: *MCAG* 3 (1912), 4-5, 43; *MCAG* 14 (1923), xv; *MCAG* 15 (1924), 29; *MCAG* 17 (1926), xiv, 1; *MCAG* 19 (1928), 260; *BCAG* 1:2 (Feb. 1925), inside front cover; Macera, "El guano y la agricultura peruana de exportación," 338-339, 448. CAG listed all boats owned by the company in each *Memoria*. See the advertisements for competing fertilizers in *BCAG* 9:3,4 (Mar.-Apr. 1933), 89; *BCAG* 18:3 (Mar. 1942), 78. *MCAG* 29 (1938), xv-xvii, clearly shows the amount of integration that CAG developed over three decades.

Fomento. At least initially, it was circulated free-of-charge to Peruvian farmers and notable scientists and engineers, as well as to agricultural schools and extension services throughout Peru and the Americas. Its circulation remained about 500 in the late 1940s, and it was published continuously until the late 1960s--a remarkable achievement for a technical periodical in Latin America, in terms of both continuity and distribution. By law, CAG also provided special discounts and loans to farmers, including food producers and smallholders, to help extend and strengthen scientific, input-intensive agriculture in Peru. Meanwhile, CAG's agronomists continued to supervise the distribution of guano through the request system initiated by Lavalle in 1915.[29]

In these ways, CAG enabled professional agronomists to gain a measure of control over Peruvian agriculture. As we have already seen, such policies paralleled technocratic measures taken by the Ministerio de Fomento, for example, when José Pardo's government inaugurated a new irrigation management system to forestall social conflict in 1919. During the 1920s, Augusto Leguía's dictatorship took these state interventions in Peruvian agriculture to a new level with the help of millions of dollars in loans and investment poured into the country from abroad, mostly from the United States. Besides hiring Charles Sutton to build the giant Lambayeque Irrigation Project, Leguía's government established a series of experimental farms and cattle ranches in less-developed regions, relocated the

29. *ECAG*, 30-31; *MCAG*, 3 (1912), 59; *MCAG* 13 (1922), 14; *MCAG* 14 (1923), xiv, 11; *MCAG* 17 (1926), xvi-xvii; *MCAG* 20 (1929), xiv, xvi; *MCAG* 22 (1931), xiv; *MCAG* 23 (1932), v, xiv; cf. Wines, *Fertilizer in America*, 126-35; "Nómina de las personas e institutciones nacionales y extranjeras entre las que se distribuye gratuitamente este Boletín," *BCAG* 2:11 (Nov. 1926), 592-606; Ávila to Vogt, 23 July 1945, Vogt papers, box 1:1.

Escuela Nacional de Agricultura to the La Molina estate on Lima's outskirts, and placed the Banco Agraria under foreign management. Only months before Leguía's overthrow, he issued a decree attempting to organize *all* farmers and herders in Peru into societies under the supervision of the Ministerio de Fomento.[30]

Agro-exporters in Peru reaped enormous benefits by turning over some of their concerns to these technocrats. Until the early 1940s, large-scale agribusiness profited so exclusively from this agroecological system under CAG's control that patterns of guano consumption become a marker of the changing fortunes of this dominant economic sector. As table 4 shows, a total of 567 different large purchasers consumed nine times more guano than the tens of thousands of smallholders who bought fertilizer from CAG during its first 26 years of operation. This was particularly true during World War I and the initial shock of the Great Depression. Even among large purchasers, only a handful received the majority of CAG's output. As table 5 shows, the top 25 Peruvian guano purchasers consumed almost exactly half of CAG's total production from 1909-1935, even though they represented only 4.4 percent of all large purchasers and a tiny fraction of the number who purchased some quantity of guano during this period. As with irrigation water, the other major input needed for agriculture along Peru's arid coast, guano was "evenly" distributed on the basis of number of planted hectares. Thus, guano distribution during this period is a reflection of the extraordinary concentration of land holdings in the hands of a few. Patterns of guano distribution began to change in the mid-1930s when CAG's overseers elected to ration the

30. See ch. 2; Pike, *The Modern History of Peru*, 228; *MCAG* 47 (1956), 12-13.

guano supply and distribute it preferentially to smallholders and the growers of food crops for reasons discussed below.

The largest single guano purchasers were sugar plantations, indicative of the concentration of ownership among a handful of sugar companies, their technological advancement, and their continuing ability to influence Peruvian politics. Sugar cane growers were the first to be integrated into this agroecological system connecting Peru's marine environment to coastal agriculture. During the 1910s, more guano went to sugar cane than to all other crops put together.

Two giant multinational firms consumed the largest share of guano. Most of their product ended up in the United States or Europe, either as refined sugar or rum under the Cartavio label. Gildemeister & Co.'s Casa Grande estate led the way in guano purchases and its ability to takeover its neighboring competitors. After swallowing the 1,687 hectare Sausal estate in the 1910s, the 19,777 hectare Roma estate in 1927, and many other smaller properties, Casa Grande came to control 40,848 hectares in the Valle Chicama (map 3). Gildemeister & Co. later acquired the 7,048 hectare Laredo and 1,479 hectare El Deán sugar estates in the Moche Valley near Trujillo, as well as an additional 3,800 hectares planted with rice and cotton in the Jequetepeque Valley. By the time the Revolutionary Government of the Armed Forces expropriated its vast properties in the 1970s, Gildemeister & Co. cultivated over 32,000 hectares of the best agricultural land in northern Peru and owned a whopping 435,000 hectares (4,350 square kilometers), an area larger than Rhode Island. This made it the largest private landowner, by far, in the entire country. W.R. Grace & Co. went from being a major player in the nineteenth-century guano trade, to one of the biggest beneficiaries of the Grace Contract, to becoming the twentieth century's second-most important guano consumer with its vast Cartavio estate in the Valle Chicama (5,196 cultivated hectares, acquired in the 1880s) and Paramonga estate in the Valle Pativilca (7,203 cultivated hectares, acquired in 1927).

Several of Peru's prominent political families also numbered among CAG's biggest customers, such as the 6,632 hectare Tumán y Calupe estate near Chiclayo owned by the family of President José Pardo. The British Sugar Company, a multinational firm tied up with Augusto Leguía's political fortunes, purchased vast quantities of guano for its Santa Bárbara and 3,895 hectare San Jacinto estates before it dissolved.

Cheap fertilizer helped many of CAG's largest benefiaries make big profits, even during times of economic adversity: The Larco Herrera brothers, owners of the 8,941 hectare Chiclín estate, made US$3.03 million during the glory years of the Peruvian sugar industry from 1909-1920. Casa Grande was able to show a profit of US$7.22 million and return US$4.30 million to its shareholders as dividends during the chaotic 1919-1934 period.[31]

This systematic concentration of landholdings, guano (and water) consumption, and sugar production in Peru illustrates a global trend in twentieth-century agriculture: Large-scale, input-intensive, mechanized agriculture required huge capital investments. The need to keep these implements running near

31. Gonzales, *Plantation Agriculture and Social Control*, 39, 42, 46-47, 52-56, 58-60, 65-66, 80; Carlos Malpica, *Los dueños del Perú*, 12th ed. (Lima: Ediciones PEISA, 1981), 87, 103-105, 108-114, 117-118.

maximum capacity to make a profit from economies of scale created periodic market gluts and low prices. In this vicious cycle, only the biggest, most efficient producers could stay in business. Faced with these demands, some of Peru's richest families of agro-exporters ended up selling out to their larger competitors during periods of low prices or after bad harvests. As a result of these trends, a few highly capitalized companies turned several northern valleys into great irrigated monocultures of cane surrounding small islands of modern industry totally dependent on the outside world for food, machinery, expertise, and other ammenties (illus. 19). This replicated trends typical of the history of the plantation complex, as well as Peruvian nitrate, metals, and fishmeal extraction.[32] For all these reasons, CAG was often under intense political pressure to provide sugar planters with low prices, a preferential guano supply, and other technical services in order to keep marginal Peruvian producers in business.

With these economic forces at work, many Peruvian planters along the central and southern coast converted their holdings to other crops, especially to cotton. A few cotton estates show up on the list of major guano purchasers, most notably the Nosiglia brothers' San Benito estate and Esquivel y Retes. The latter had been buying guano as long as any in the world: Mariano de Rivero listed Esquivel y Retes among the haciendas that purchased guano in 1827.[33] But it

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32. The literature on the plantation complex is enormous. Useful comparisons include McCook, *States of Nature*, ch. 4; Watts, *The West Indies*; Dye, *Cuban Sugar in the Age of Mass Production*; Galloway, *The Sugar Cane Industry: An Historical Geography from its Origins to 1914* (Cambridge, UK: Cambridge University Press, 1990); Manuel Moreno Fraginals, *El ingenio: Complejo económico social cubano de azúcar*, 3 vols. (Havana: Editorial de Ciencias Sociales, 1978). On Peruvian trends, see Thorp and Bertram, *Peru, 1890-1977*.

33. Rivero, "Razón de las haciendas del valle de Chancay," in *Colección de memorias científicas*, 1:171.

attained new prominence in the twentieth century under the management of one of the leading lights of the Aristocratic Republic.

Esquivel y Retes was owned by Amador del Solar Cáceres (1863-1922), the most notable son of a family of staunch supporters of the Partido Civilista. The pattern of his career reveals the ties that bound together guano, agriculture, and power in Peru. Rather than choosing a profession like many of his brothers, one of whom was an important highway engineer, Amador mixed business and political pursuits. He and his brother Grimaldo were reputedly among the first to grow cotton on a large scale in the Valle Chancay. Few cotton farmers acquired such large concentrations of land. Thanks to a close friendship established when they were schoolmates, Amador was given key governmental posts during both presidential administrations of José Pardo. Amador's prestige also translated into positions on the directorial boards of three of the firms masterminded by financier José Payán: the Compañía Peruana de Vapores (a merchant shipping company), the Compañía Internacional de Seguros (one of Peru's first insurance companies), and CAG itself, where he served from 1914 until 1920 when Leguía's authoritarian takeover forced his exit from public life. Despite Pardo and Payán's occasional technocratic schemes, the social standing of men like Amador del Solar, not technical accomplishment, overwhelmingly determined who succeeded in politics and business under the Aristocratic Republic.[34]

34. *Diccionario biográfico de peruanos contemporaneos*, s.v. "Solar, Amador del," "Solar, Pedro Abraham del," "Solar, Juan Miguel del," "Solar, Salvador del"; *MCAG* 5-11 (1914-1920), cover; Camprubí, *José Payán de Reyna*, 69.

That said, CAG's beneficiaries during this period were not all multinational corporations and born-members of Peru's ruling elite. Cotton allowed a few newcomers to join Peru's coastal aristocracy, which fostered the illusion that Peru's national oligarchy was open to men of merit. Cotton cultivation had much smaller start-up costs than sugar cane, and its complex social relations of production (especially its dependence on sharecropping) allowed a broader segment of society to have some control over estate management and its benefits. Fermín Tangüis himself bought no small amount of guano for the Urrutia estate he rented and later owned near Pisco.[35]

Nikumatsu Okada acquired a more substantial quantity of guano for his cotton plantation. Like so many Japanese immigrants, including Alberto Fujimori's parents, Okada came to Peru early in the century as a laborer contracted by one of the sugar companies on Peru's northern coast. After completing his indenture, he walked south across the coastal desert seeking his fortune. He settled as a sharecropper (*yanacón*) on a cotton estate in the Valle Chancay and gradually worked his way up to water manager, a position of great responsibility in the agricultural regime of the arid Peruvian coast. In 1923, he rented the derelict La Huaca hacienda (another guano purchaser on Rivero's 1827 list) and proceeded to restore its buildings and infrastructure, some dating from the colonial period when the Jesuits managed it as a sugar cane plantation. He eventually made it big as a cotton planter, urban benefactor, local politician, and leader of the extended

35. See table 5; Peloso, *Peasants on Plantations*; Gonzales, "The Rise of Cotton Tenant Farming in Peru, 1890-1920: The Condor Valley," *Agricultural History* 65:1 (winter 1991), 51-71; Macera, "El guano y la agricultura peruana de exportación," 441.

community of Japanese-Peruvians. Obviously, Okada was an exceptional customer for CAG, though he was not the only Japanese immigrant to profit handsomely from cotton cultivation. In 1941, the Emperor Hirohito decorated him as one of Japan's most prominent expatriates. This was ill-timed. Soon after Pearl Harbor, Peru made an alliance with the United States, and racist officials summarily expropriated Okada's hard-won property, then arrested and deported him to the United States where he lived in an internment camp with thousands of other innocent, disenfranchised Japanese for the duration of World War II. He returned to Japan penniless.[36]

Okada's short-lived fortune was based on the considerable economic advantage held by Peruvian cotton on international markets from the mid-1910s until the crisis of the late 1930s. Figures 3-4 illustrate the comparative edge enjoyed by cotton in Peru: Except for a noticeable spike in cane cultivation in 1929 (when the partially completed Lambayeque Irrigation Project started serving Peru's prime cane-growing region just before the bust of the Great Depression) and the period after 1964, cotton cultivation always far outpaced sugar cane. Meanwhile, both crops gobbled up thousands of coastal hectares once devoted either to food crops and forage or to natural desert and riparian vegetation. Figures 5-6 show that export income from cotton started at virtual parity with cane sugar and consistently grew at a faster rate except for the mid-1940s and the period after 1961. Prices and

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36. See table 5; Jochamowitz, *Ciudadano Fujimori*, 30-31; Thorp and Bertram, *Peru, 1890-1977*, 174, 388 n. 28.

income from both cane sugar and cotton oscillated wildly during this period, however, much to Peruvian agro-exporters chagrin.

Most of these gains for cotton must be credited to the success of disease-resistant Tangüis strain. This ultra-long-staple hybrid represented only 8.1 percent of national cotton production in 1918 but increased thereafter to a peak of 92.9 percent in 1937. Tangüis cotton did not succeed merely on its own merits. The ravages of the boll weevil in the U.S. South during the 1920s made market entry easier for Peruvian cotton exporters. Field experiments and promotional propaganda by CAG agronomists demonstrated to farmers that Tangüis cotton was nearly twice as productive as other popular varieties with the application of set amounts of nitrogen fertilizer. Farmers who adopted this new variety almost always adopted the use of guano along with it. Guano became the single-most-important input that cotton farmers purchased for cultivation: it represented approximately 20 percent of their costs, compared to ten percent for sugar cane planters. By the early 1930s, cotton consumed more guano than all other Peruvian crops put together. Several coastal regions, most notably the irrigated valleys served by the ports of Pisco and Cerro Azul, became more important customers for CAG as a consequence.[37] More than any other factor, Tangüis cotton propelled the expansion of the agroecological system linking marine to agricultural productivity along Peru's coast.

Tangüis cotton was a truly modern crop, depending on scientific expertise, substantial material inputs and credit, vast transport and marketing networks,

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37. See app. 7.

sustained political advocacy, and state largesse for its success. More than any other factor except for irrigation water, guano allowed cotton growers to maintain the intensity of their planting without suffering significant losses in productivity. Even though agronomists warned against the risks, Peruvian agribusiness kept large swaths of the central and southern Peruvian coast under a cotton monoculture during this period, only allowing their fields the briefest rest between crops. (This led to major problems in later years.) Such far-reaching changes accompanying the introduction of a new biological variety paralleled those brought by the introduction of new sugar cane and banana varieties elsewhere in Latin America and presaged the worldwide transformation of grain agriculture brought about by the development of high-yielding hybrids after World War II. "Tropical" plantation agriculture contributed greatly to the birth to what agroecologists now call "conventional" agriculture.

Both cotton and cane farmers obviously had a big stake in keeping the price of guano low. When the great international crash in crop prices of the early 1920s hit coastal planters, they put intense pressure on Leguía's government through the Sociedad Nacional Agraria to lower export taxes and to revoke the guano price increase Leguía had imposed when he came to power in 1919. After a couple years of foot dragging, he gave them what they wanted and established a guano price structure indexed to crop price changes that kept prices relatively low for the rest of his tenure. The Peruvian state further subsidized the expansion of export agriculture by building irrigation and highway networks along the arid coast, including 40,000 hectares of new irrigated land during Leguía's *oncenio*. A good portion of this was funded by the so-called London Contract of 1922 which provided a loan of £1.25 million to be paid off by the proceeds of guano sales. After Leguía passed from the scene, the Peruvian state continued to use the reformed guano industry to finance and amortize large foreign loans in order to build public works, just as it had done during the Age of Guano.[38]

CAG provided many other benefits to Peru's money-conscious coastal elite. Figure 7 and appendix 4 show that except for brief periods (especially the mid-1940s), CAG made substantial profits even though it kept its prices far below what it could have charged on an open international market. It consistently provided its investors--many of whom, like the Aspíllaga brothers, were agro-exporters and powerful members of Peru's ruling class--a guaranteed, though limited yearly return. As a bloc, they received Lp. 22,400 each fiscal year during the 1920s, and every shareholder received dividends worth ten percent of their shares' value every fiscal year after 1930. In all, from 1909 until CAG's reorganization in 1963, its investors made more than $180 million in 1979 U.S. dollars. Taxes on each bag of guano also funded a number of other government projects, including the Sociedad

38. See app. 3, 5, 6. Ref. for the preceding paragraphs: *MCAG* 12 (1921), 15; *MCAG* 13 (1922), 8-9; *MCAG* 14 (1923), 55-57; *MCAG* 29 (1938), x; *MCAG* 34 (1943), v-vi; Gamarra, "El abonamiento de las tierras, un problema nacional en los actuales momentos," *BCNPN* 2:1 (1945), 96; Macera, "El guano y la agricultura peruana de exportación," 438, 460-461; Thorp and Bertram, *Peru, 1890-1977*, 57-59, 60, 171, 177, 231; Cueto and Lossio, *Inovación en la agricultura*, ch. 5; Gonzales, *Plantation Agriculture and Social Control*, pt. 1; Klarén, *Modernization, Dislocation, and Aprismo*, ch. 1, 4; Pike, *The Modern History of Peru*, 227-228; Cotler, *Clases, estado y nación*, 189-192; Honorio Pinto, *Estadístidcas históricas del Perú: Sector agrícola: Algodón* (Lima: Universidad Nacional Mayor de San Marcos Centro Perano de Historia Económica, 1977), 45.

Nacional Agraria. Thus, CAG even paid for the defense of the political interests of Peruvian agro-exporters.[39]

CAG's management retained a share of this income to build an elaborate new office building in central Lima befitting their prominence on Peru's economic and political landscape: one block from the Congreso, two blocks from the Banco del Perú y Londres, three blocks from the cathedral and presidential palace, and just around the corner from Gildemeister & Co.'s Peruvian headquarters. In contrast to Gildemeister's daring Art Deco office design, CAG's main office had a neoclassical façade consciously intended to be "reminiscent of Saxon banking institutions" (illus. 20). Its colonnaded central hall was explicitly meant to convey the "sobriety" of CAG's administrators and create trust in their capabilities: Low wooden railings compartmentalized this open space into simple offices with "elegant and severe English-style furniture." These compartments made the bureaucratic categories delineated by CAG's organizational flowchart into a tangible reality. The adjoining salon of directors had ornately carved cedar furniture and wall paneling befitting the superior social station and power of the board of directors within CAG's administrative hierarchy. The well-equipped agricultural laboratory on the third floor was no less important for CAG's image and function. Lavalle routinely published a photograph in his *Boletín* advertising his domain as the model of scientific order and cleanliness and as a component

39. See app. 4; *ECAG*, 17, 27, 32-33, 73, 76-83, 94-100; *MCAG* 3 (1912), 18-19; *MCAG* 4 (1913), vii; *MCAG* 13 (1922), 10; *MCAG* 17 (1926), xi-xii; *MCAG* 37 (1946), vi; *MCAG* 48 (1957), xviii, 28; *MCAG* 50 (1959), xiii; Rómulo E. Lanatta, *Informe sobre la Compañía Administradora del Guano* (Lima: Librería e Imprenta Gil, 1948), 12.

vital to the success of Peruvian agriculture (illus. 21). On 23 September 1925, the first day of spring, President Leguía, the presidents of the Sociedad Nacional Agraria and both chambers of Congress (perpetuating the fiction that Peru was a democratic republic), the general managers of all of Lima's major banks, Lavalle's mentor George Vanderghem (director of both the Escuela Nacional de Agricultura and the newly established Peruvian Meteorological Service), CAG's entire Directorate and managerial staff, and many other notables attended the opening ceremony for this building with top hats in hand. An Augustinian friar said a benediction that blessed this new Palace of Scientific Administration built for the Lords of Guano.[40]

This ceremony showed for all to see that the rulers of the Aristocratic Republic and Leguía's *oncenio* and the main beneficiaries of CAG's services were one and the same.

Dealing with Crisis--The 1925-1926 El Niño

Agriculture was but one part of Augusto Leguía's grand strategy to "put an American"--or some other qualified expert--"in charge of every branch of our government's activities." Leguía's "Nueva Patria" of the 1920s placed public health, the postal service, telegraph communications, customs, tax collection, the Ministry of Education, secret service, national police, army, navy, air force academy, Lima traffic service, and countless construction projects under the direct

40. "La inauguración del edificio de la Compañía," *BCAG* 1:10 (Oct. 1925), 375-379; "Compañía Administradora del Guano: Esquema de su organización," *BCAG* 4:7 (July 1928), rear insert.

supervision of foreign technicians. Most importantly, Leguía established a new Banco de la Reserva in 1922, South America's first centralized "bank of banks," to orchestrate financing for these activities.[41]

Peru was hardly alone in adopting such policies. A generation of scientists, engineers, and physicians produced by the world's new "knowledge factories" moved into positions of power and influence all over the globe during and after World War I. From 1917-1934, the governments of Mexico, Guatemala, Colombia, Chile, Ecuador, Bolivia, Weimar Germany, South Africa, Poland, China, Turkey--and Peru--all invited Princeton economics professor Edwin Walter Kemmerer (1875-1945), one of the architects of the U.S. Federal Reserve system, to carry out financial reforms. The Rockefeller Foundation sent public health commissions to most Latin American countries as part of its all-out war against yellow fever and other epidemic diseases. Industrialists in Brazil, Colombia, Japan and many other countries embraced the doctrines of scientific management. In 1929, a wartime technocrat, Herbert Hoover, became the first engineer to occupy the U.S. White House.[42] In this context, an English engineer transplanted to

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41. Drake, *The Money Doctor of the Andes*, 212-221 [quote p. 217]. Cf. Cueto, "Sanitation from Above: Yellow Fever and Foreign Intervention in Peru, 1919-1922," *HAHR* 72:1 (1992), 1-22; Carl F. Herbold, "Developments in the Peruvian Administrative System, 1919-1930: Modern and Traditional Qualities of Government under Authoritarian Regimes," (Ph.D. diss., Yale University, 1973); Howard Karno, "Augusto B. Leguía, the Oligarchy, and the Modernization of Peru, 1870-1930," (Ph.D. diss., University of California, Los Angeles, 1970).

42. See Drake, *The Money Doctor of the Andes*, esp. 1-2, 36-37; Weinstein, *For Social Peace in Brazil*, ch. 1-2; McCook, *States of Nature*, ch. 5; Tsutsui, *Manufacturing Ideology*, ch. 1-2; Murray, *Dreams of Development*; McGrath, *Scientists, Business, and the State*; Noble, *America by Design*; Chandler, *The Visible Hand*; James D. Henderson, *Modernization in Colombia: The Laureano Gómez Years, 1889-1965* (Gainesville: University Press of Florida, 2001), ch. 5; Kendrick A. Clements, *Hoover, Conservation, and Consumerism: Engineering the Good Life* (Lawrence: University Press of Kansas, 2000); Cueto, "Los ciclos de la erradicación: La Fundación Rockefeller y la salud pública en Latinoamérica, 1918-1940," in *Salud, cultura y sociedad en América*, 179-202;

Berkeley, California, coined the neologism 'technocracy' to describe "industrial management on a nation-wide scale . . . [for] the accomplishment of a great national purpose."[43]

The 1920s are often portrayed as the last hurrah for laissez-faire capitalism, which they certainly seemed after the managerialism of the war years. The idea behind these endeavors was to place experts in positions where they could ensure the smooth operation of local government and business as part of a peaceful, international capitalist order. In the case of Peru, Leguía's reliance on foreign technocrats was meant to assuage the internal factionalism, economic instability, and intense class conflict that had led to the fall of the Aristocratic Republic in 1919--and to prevent his numerous political foes from occupying positions of influence. These projects did not work out as intended because these experts had to face a series of unforeseen crises that were beyond their understanding, much less their control. The international links forged by these experts turned out to be crucial to their response to these challenges.

The agroecological system linking the excretory production of three species of marine birds to the export of agricultural staples from Peru was not stable. Local

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idem, ed., *Missionaries of Science: The Rockefeller Foundation and Latin America* (Bloomington: Indiana University Press, 1994); Alberto Mayor Mora, *Etica, trabajo, y productividad en Antioquia* (Bogotá: Ediciones Tercer Mundo, 1984).

43. William Henry Smyth, "'Technocracy,'" *The Nation* 28 Dec. 1932, 646 [quote]; *A Supplement to the Oxford English Dictionary*, s.v. "technocracy"; *Who Was Who in America: A Companion Volume to Who's Who in America, 1897-1942* (Chicago: A. N. Marquis, 1942), s.v. "Smyth, William Henry." Smyth's original use of 'technocracy' was inspired by projects like Hoover's wartime Food Administration; see Smyth, "Human Instincts in Reconstruction: An Analysis of Urges and Suggestions for Their Direction," *Industrial Management* 57 (Feb. 1919), 89-91; idem, "Technocracy: National Industrial Management, Practical Suggestions for National Reconstruction," *Industrial Management* 57 (Mar. 1919), 208-212; idem, "Technocracy: Ways and Means to Gain Industrial Democracy," *Industrial Management* 57 (May 1919), 385-389.

manifestations of two, recurrent global phenomena were responsible for this instability: ENSO and economic depression. We must credit experts from this period, not only for recognizing that these were global phenomena, but also for influencing the outcomes of these crises, for better or for worse.

The first of these phenomena, El Niño, intensely affected the agroecological system described in this chapter due to its direct impact on the welfare of the guano birds and the hydrography of Peru's arid coastal valleys. These local impacts attracted so much attention, in fact, that an international network of environmental scientists came to the realization during the late 1920s that these "Peruvian" events were directly connected to climate anomalies elsewhere in the Pacific Basin. CAG and Peruvian agribusiness played a crucial role in the "discovery" of the large-scale climate phenomenon we now know as the El Niño-Southern Oscillation.

As we have seen, CAG's conservation policies did not work exactly as intended, but they functioned well enough where it counted most. From the five-year running average of new guano production, it is abundantly clear that the guano bird population grew dramatically during the first three decades of CAG's tenure. While these numbers cannot be used as an exact measure of the guano bird population, they definitely indicate a general increase in nesting colony size and duration.[44]

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44. See fig. 2. The five-year running mean averages out interannual variability due to CAG's rotation policy, short-term variations in demand, inter-island bird migration, and--most importantly--the El Niño phenomenon. Because managerial, economic, and environmental factors all affected the size of the guano harvest from year to year, production figures must be used with extreme caution as a measure of bird population size. The presentations of guano harvest as bird population in Rómulo Jordán and Humberto Fuentes, "Las poblaciones de aves guaneras y su situación actual," *Inf.Inst.Mar Perú* 10 (Apr. 1966), 5-6; Duffy, "Environmental Uncertainty and Commercial Fishing: Effects on Peruvian Guano Birds," *Biological Conservation* 26:3 (1983), 229,

The success of the guano birds meant success for Peruvian agriculture, since the deposit of excrement by these fish eaters represented the crucial step in an agroecological system that ultimately connected the biological productivity of marine phytoplankton to crop production on the adjacent coast. In 1915-1916, the first fiscal year that CAG produced enough guano to meet national demand, CAG and the Peruvian Corporation together extracted only 58,929 metric tons of guano *rico*; CAG's portion of which averaged 10.16 percent nitrogen by weight. In 1938, CAG produced what was then a record harvest of 168,619 metric tons for national agriculture with a nitrogen concentration of 13.96 percent. Thus, CAG was able to provide Peruvian farmers with almost five times as much nitrogen as it had two decades before.[45]

Though this growth in the average guano supply was sustained over 30 years, it varied greatly from year to year. As we have already seen, environmental shocks in 1911-1912 and 1917 caused great concern for José Antonio de Lavalle y García and other members of CAG's management because of their obvious, negative impact on the guano birds. In an attempt to explain these happenings, besides his studies of avian parasites and disease, Lavalle published ground-breaking scientific papers on guano bird nesting habits and the *aguaje* or "Callao painter," an algal bloom often associated with El Niño events known to cause the massive, localized deaths of marine plankton and fish. As we shall see, these

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and Duffy, Hays, and Plenge, "The Conservation Status of Peruvian Seabirds," 252, are therefore quite misleading. For comment on the use of CAG data for the reconstruction of bird populations, see P. Muck and D. Pauly, "Monthly Anchoveta Consumption of Guano Birds, 1953-1982," in *The Peruvian Anchoveta and Its Upwelling Ecosystem*, 219-233; Tovar, Guillén, and Nakama, "Monthly Population Size of Three Guano Bird Species off Peru," 208-218.

45. See app. 2-3.

studies turned out to have important implications for CAG's future management of the guano islands.[46]

Then, in 1925-1926, the most powerful El Niño event since at least 1891 hit Peru and caused widespread environmental disruption. Torrential rains and flooding affected at least 11 of Peru's 25 departments, from Tumbes in the north to Tacna in the south, to Madre de Dios in the Amazon Basin. Even Lima experienced rainstorms--an extreme rarity, and not at all typical of strong El Niño events. The greatest tragedies associated with this natural disaster were felt on a human scale: Torrential rains washed away the cemetery in Ascope and severely damaged the churches in several major towns in the cane-growing region of the arid north coast. Potable water was nearly impossible to come by in many places. The city mothers of Chiclayo wrote a detailed epistle directly to President Leguía pleading for assistance, though they had it good compared to the inhabitants of Uchucmara, whose entire town was obliterated by a giant landslide (*huayco*), an event all too common during periods of heavy precipitation or seismic activity in the Andes.[47]

46. *MCAG* 13 (1922), 14; Lavalle, "Una hipótesis sobre la mortalidad de las aves"; idem, "Aguaje y la contracorriente ecuatorial," *BSGL* 33:3 (1917), 313-330; idem, "Informe preliminar sobre la causa de la mortalidad anormal de las aves"; idem, "Estudio sobre los factores que influyen sobre la distribución de los nidos"; cf. Germán Stiglich, "El fenómeno marítimo del aguaje," *BCAG* 7:8 (Aug. 1931), 345-358.

47. *MCAG* 16 (1925), xiii, 41; Germán Luna Iglesias to Julio Revoredo, 14 Mar. 1925, expediente 5434, legajo 294; C. Aguínaga V. to Señor Director de Obras Públicas, 25 May 1925, exp. 1,363, leg. 5; "Expediente relativo al subsidio de £p. 300 para las reparaciones de las iglesias de Chiclayo y Ferrañafe," 1925, exp. 4582; "Expediente relativo a la translación del pueblo de Uchucmara a un sitio llamado Quñil que solicitan los vecinos de ese lugar," 1925, exp. 3360, leg. 196; "Expediente relativo al subsidio otorgado por el Min. de Gobierno de Lp. 200 al Dpto. de Madre de Dios para socorrer a los damnificados con motivo de las inundaciones a dos habitos, y solicitud del Prefecto para trasladar la población de Maldonado a una parte mas alta que evitaría tantas desgracias con motivo de las fuertes lluvias," 1925, exp. 3403, leg. 197; "Expediente relativo

This natural disaster affected the agroecological system managed by CAG on almost every level. The guano birds abandoned their northern nesting colonies en masse when the inflow of tropical waters caused the anchoveta, their main food source, to disappear beyond their reach. Guano production declined precipitously. Demand also declined because many farmers' fields, especially sugar planters north of Trujillo and Ica-valley cotton growers, were inundated. Most of Peru's railroads were damaged, which left the Peruvian Corporation with a big repair bill and cut off many producers from the external market (illus. 22). CAG sent Lavalle on a tour of the southern coast to determine ways that agricultural science could help mitigate this event's impact.[48]

But this environmental crisis was only one problem facing Peruvian agribusiness. CAG quickly recovered from this ecological disturbance thanks to the resilience of the guano birds. El Niño, after all, was a recurring feature of the marine ecosystem, and the guano birds had evolved adaptations to deal with it. Most adult birds simply migrated south during these lean years, and enough survived for the population to bounce back rapidly when conditions improved. But many sugar producers were not so adaptable: Their fortunes had been on a roller-coaster ride tied to the extreme volatility of agricultural prices since World War I. Many did not financially survive this environmental-economic one-two punch: Víctor Larco Herrera, one of the largest sugar planters in Peru, was forced to sell

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al subsidio de £p. 100 para la construcción del Nuevo cementerio en el pueblo de Ascope de la provincia de Trujillo," 1925-26, exp. 3580, leg. 202; "Expediente relativo a los daños causados por las inundaciones en el Dpto. de Lambayeque," 1925, exp. 3912, leg. 218; all from AMFOM.

48. *MCAG* 16 (1925), xiii, 41; Murphy, "Fenómenos oceánicos y climatéricos en la costa occidental de Sud-América durante el año 1925," *BCAG* 2:3 (Mar. 1926), 137-179.

his immense Roma estate to Gildemeister & Co. to get out from under a mountain of debt he had acquired during the wartime boom. Labor unrest contributed further to the demise of his agricultural empire. W. R. Grace & Co. bought out the owners of the flood-damaged Paramonga estate in 1927. Thus, the El Niño of 1925-1926 helped these two multinational corporations to become the undisputed kings of sugar along the Peruvian coast.[49]

This El Niño had even farther-reaching effects in the world of science thanks to the work of a scientific traveler from the United States and a resident German technician, both with intimate ties to the Peruvian guano industry and agribusiness. The fact that we know this large-scale climate phenomenon today as 'El Niño' is largely due to their work and would not have happened in the way it did without the existence of the agroecological system overseen by CAG.

In 1919-1920, three New York-based scientific institutions sent the marine ornithologist Robert Cushman Murphy (1887-1973) to Peru to study its famous guano birds. Murphy inevitably worked in close collaboration with CAG and its engineers, and he spent the rest of his noteworthy career promoting Peruvian guano extraction as "the greatest of all industries based upon the conservation of wild animals" in the world.[50]

Murphy happened to be on his second field expedition to Peru when a powerful El Niño event struck early in 1925. As a trained naturalist, Murphy

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49. Klarén, *Modernization, Dislocation, and Aprismo*, 16, 18-20.

50. Murphy, *Oceanic Birds*, 1:27; idem, "Inter-American Conservation," *Bird-Lore* May-June 1940, 226; besides the Audubon Society's main organ, popular magazines such as *National Geographic Magazine* and *Natural History*, television, and nature films provided media outlets for Murphy's outspoken advocacy of CAG.

readily noted the appearance of caimans, "man-eating sharks," dolphin-fish, frigate birds, and several other tropical marine species far south of their normal range along the Peruvian coast. He also noted the massive deaths of plankton, fish, and marine birds that depended on the Peru Current. Like any good environmental scientist, Murphy was not satisfied with his own limited perceptions, so he rapidly organized an observation network to help him investigate this major climate anomaly. But rather than asking CAG's engineers or other knowledgable Peruvians for help, Murphy followed a course typical of scientific travelers from the North: he looked to his own countrymen for "reliable" observations. Murphy looked first to engineers working for the International Petroleum Company (IPC), a subsidiary of Standard Oil of New Jersey. In an extreme case of technocratic rule under Leguía's "Nueva Patria," the IPC's foreign-born managers not only ran a huge industrial enclave working the oil deposits of far northwestern Peru, but they also had direct authority to govern this region. From Murphy's point of view, they were in an ideal position to observe--and as English-speakers to report--the environmental, economic, and social impact of the 1925-1926 El Niño along the far-northern coast of Peru.[51]

Other foreign technicians were watching the development of this phenomenon just as carefully. In 1915, with special permission from the first Benavides regime in the face of intense opposition from other Peruvian traders and

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51. Murphy, "Equatorial Vignettes: Impression of the Coasts of Peru and Ecuador, 1925," *Natural History* Sept.-Oct. 1925, 431-449; idem, "Oceanic and Climatic Phenomena along the West Coast of South America during 1925," *The Geographical Review* 17:1 (Jan. 1926), 26-54; idem, *Oceanic Birds*, 1:27-29; E. Willard Berry, "Meteorological Observations at Negritos, Peru, December, 1924, to May, 1925," *Monthly Weather Review*, 55:2 (Feb. 1927), 75-79. For a more detailed discussion of these events, see Cushman, "Enclave Vision."

sugar planters, Gildemeister & Co. began construction of a modern port at Puerto Chicama (Puerto Malabrigo). It wanted to have direct control over the shipment of goods to and from its vast Casa Grande Zuckerplantagen. Beginning in the 1910s, this multinational imported dozens of technicians from Germany to oversee such infrastructural improvements. One of these, Peter Reimers, the general manager of this new port facility, established a meteorological observatory on 1 December 1924 to track changing ocean conditions. As it turned out, this was just in time to observe the onset of the 1925-1926 El Niño, and Puerto Chicama happens to be in a good location on the north coast of Peru to detect the environmental variations of significant El Niño events. Thanks, in part, to Gildemeister & Co.'s long-term stability and interest in the project, this station has operated continuously ever since. As a consequence, its single sea-surface temperature thermometer has often been used by later scientists as *the* quantitative definition of an El Niño event.[52]

Meanwhile, Murphy's reports to friends back in New York City sparked the interest of the president of the American Geographical Society, the famed South American explorer Isaiah Bowman (1878-1950). Bowman offered to publish Murphy's eyewitness report. The resulting January 1926 article in *The Geographical Review* immediately became *the* authoritative account of these events for the international scientific community. Significantly, Murphy chose to use the term 'El Niño' that Carrillo had borrowed from Peruvian fisherfolk to refer to the

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52. Murphy, "Oceanic and Climatic Phenomena," 26 n. 1, 32 fig. 2; Erwin H. Schweigger, "Los fenómenos en el mar de 1925 a 1941 en relación con observaciones meteorológicas efectuadas en Puerto Chicama," *BSGL* 59:3-4 (1942), 247-250; Klarén, *Modernization, Dislocation, and Aprismo*, 66-83.

entire set of "oceanic and climatic phenomena" observed along the Pacific coast of South America that year. This article's almost immediate publication in Peru by CAG also made it the classic account of the 1925 event for readers in El Niño's homeland. Its translator, Lavalle, pointed out a major shortcoming of the English-language article: except for two brief mentions, Murphy had failed to credit him--or any native Peruvians for that matter--with making significant scientific observations of this event. Murphy also neglected to credit the source of data from Puerto Chicama or the origin of the term 'El Niño,' yet he found room to name approximately 30 North Americans who helped him to understand this event.[53]

This slight was not a figment of Lavalle's imagination. Bowman and his collaborators consciously excluded Peruvian locals from the network of "competent observers" they formed during the late 1920s to keep an eye out for future El Niño events. Instead, they relied almost entirely on British and U.S. residents in Peru, Ecuador, and Chile, including Grace Steamship Lines, the most important company involved in shipping goods and people from Pacific South America to the Northern Hemisphere. This underscores, yet again, the importance of foreign business in the growth of Peru's scientific capabilities and in creating the opportunity for these capabilities to be exploited outside Peru. The social differentiation this created between foreign and native scientists foreshadows the sort of attitudes that

53. Murphy, "Oceanic and Climatic Phenomena," 26, 32, 35 n. 9, 48, 53; idem, "Recent Oceanic Phenomena along the Coast of South America," *Monthly Weather Review* 53:3 (Mar. 1925), 117; idem, "Fenómenos oceánicos y climatéricos en la costa occidental de Sud-América durante el año 1925," 137-138, also published in *BSGL* 43:2 (1926), 87-125.

disrupted the relationships among the diverse team of experts CAG hired years later to extend its management of Peru's marine environment.[54]

Meanwhile, international interest in this powerful El Niño took on a life of its own once scientific knowledge of this event had been extracted from the Peruvian context. By the end of the 1920s, key environmental scientists from California, Java, Germany, and beyond were aware of the close connection between Peru and climate cycles all over the Indo-Pacific basin. The Pan-Pacific Science Congress, a new institution explicitly modeled after one of the pillars of Latin American science, the Pan-American Science Congress, made this connection possible. Its emergence, combined with the competing aspirations of colonial powers around the Pacific, made conditions perfect during the 1920s for the rapid spread of scientific knowledge across political and cultural boundaries.[55]

The basic facts of this growing awareness of the El Niño phenomenon are fairly straightforward, though little known. T. Wayland Vaughan (1879-1952) helped organize the first Pan-Pacific Science Congress held at Honolulu in 1920 to aggrandize the United States' most important overseas colony. Via a connection with Bowman, Vaughan became interested in the Peruvian El Niño because of its relevance to his grandiose plan to convert the Scripps Institution of Oceanography

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54. Bowman to David White, 15 June 1926, Vaughan papers, 1/21. On the significance of place in the production and movement of scientific knowledge, see Steven Shapin, "Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science," *Transactions of the Institute of British Geographers*, n.s., 23:1 (1998), 5-12; MacLeod, ed., "Nature and Empire"; Thomas F. Gieryn, "A Space for Place in Sociology," *Annual Reviews in Sociology* 26 (2000), 463-496.

55. Philip F. Rehbock, "Organizing Pacific Science: Local and International Origins of the Pacific Science Association," in *Nature in Its Greatest Extent: Western Science in the Pacific*, ed. Roy MacLeod and Rehbock (Honolulu: University of Hawaii Press, 1988), 195-221.

(SIO), where he was named director in 1924, into the preeminent scientific institution in the Pacific Basin. Latin America, where he had long experience as a working geologist, was pivotal to these plans. Moreover, Vaughan could not help but notice the correlation between extraordinary events in Peru and California in 1925: exceptionally warm winter ocean temperatures off the Scripps pier, the abrupt disappearance of the albacore tuna, disruptions in coastal sardine distribution, and immense damage to Scripps's own physical plant caused by torrential rains and wave action. South American observerations, thus, seemed to hold promise for an ongoing SIO project funded by local utility companies that was attempting long-range forecasts of Southern California rainfall.[56]

At Vaughan's behest, a summary of Murphy's Peruvian observations was read at the Third Pan-Pacific Science Congress held in Tokyo in 1926. This presentation highlighted Murphy's uncertainty whether "El Niño" was a "restricted coastal" phenomenon or a "surface movement of colossal extent." Dutch colonial scientists in Java soon provided the answer to this question. When the director of the Netherlands East Indies Meteorological Observatory returned to Batavia (now Jakarta) after attending the Tokyo meeting, he passed on Murphy's observations to his new colleague Hendrik Petrus Berlage, Jr. (1896-1968). Berlage had just taken

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56. T. Wayland Vaughan to W. W. Campbell, 10 Aug. 1926; Vaughan to F. R. Lillie, 10 Nov. 1927; Vaughan to W. S. Crosley, 16 Mar. 1927; Vaughan to Ralph J. Chandler, 23 Mar. 1926; Vaughan to R. G. Sproul, 7 Apr. 1926, Vaughan papers 1/23, 1/38, 1/29, 1/18-19. William E. Ritter and George F. McEwen to Melville Klauber, 9 Nov. 1918; Beecher [Sterue?] to Ritter, "List of Names of Persons to Whom Seasonal Forecasts Have Been Mailed," 16 Dec. 1918; Vilhelm Bjerknes to Vaughan, 30 Sept. 1924, SIO, Biographical Files, (AC 5) SIO Library, box 10/folder 346-347. Elizabeth N. Shor, "The Role of T. Wayland Vaughan in American Oceanography," in *Oceanography: The Past*, ed. M. Sears and D. Merriman (New York: Springer-Verlag, 1980), 127-137.

up the search for a practical way to use the Southern Oscillation, a quasi-cyclic variation in atmospheric pressure over the South Pacific, to make seasonal precipitation forecasts for what is now Indonesia. (The Southern Oscillation had first been identified earlier just a few years before by Gilbert Walker, a British colonial scientist running the Indian Meteorological Service who was trying to predict the Indian monsoon after the great famines of the late nineteenth century.) Murphy's work on the 1925 El Niño filled in a crucial piece of the puzzle. Berlage made the connection between Peruvian events and climate anomalies on the other side of the Pacific. He somehow obtained the Sociedad Geográfica de Lima's 1894 report of rainfall anomalies in Piura since 1791, and he used it to determined that they correlated almost exactly with a six- to seven-year cycle in the "east monsoon" he had been studying. He announced his results at the 1929 Pacific Science Congress held in Batavia to showcase Dutch colonial science in Southeast Asia. Berlage spent the rest of his career compiling data--most significantly, using Reimers's Puerto Chicama sea-surface temperatures--to hone his empirical understanding of the Southern Oscillation (fig. 8). Berlage made the direct connection between the Peruvian science done by employees of CAG and Gildemeister & Co. and observations made by colonial meteorlogical services on the other side of the Pacific. He established much of the empirical basis for our modern understanding of ENSO.[57]

57. Vaughan to Bowman, 11 June 1926, Vaughan papers 1/21; Murphy, "Oceanographic Work Originating in the New York Region during 1925-1926," in *Proceedings of the Third Pan-Pacific Science Congress, Tokyo, October 30th-November 11th 1926* (Tokyo: National Research Council of Japan, 1928), 1:219-220; *Committee on the Physical and Chemical Oceanography of the Pacific: Reports of the Chairman, T. Wayland Vaughan* (n.p., n.d.) [Tokyo, 1926], in George Francis McEwen Papers, (MC 21) SIO Library, box 8/folder 1, pp. 8-9, 19, 21-22; H. P. Berlage, Jr.,

In fact, Berlage's discovery almost immediately circled back to Peru. Gerhard Schott (1866-1961), the director of Deutsche Seewarte, the German national oceanographic observatory in Hamburg, and one of the most influential students of the Pacific Ocean, happened to be in attendance at the Batavia congress. He had already become interested in the 1925 Peruvian El Niño thanks, in part, to the report of a merchant seaman involved in compiling data for the German marine science establishment. During his trip home across the Pacific, Schott took a special detour to Peru explicitly to find out more about the El Niño phenomenon, where he made a special presentation to the Sociedad Geográfica de Lima explaining the broad significance of these events. In 1931, he authored a fundamental German-language study of anomalies in the Peru Current that posited the first detailed oceanographic explanation for El Niño. It was based on observations by German ships in the region as well as shore observations by

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"Arguments for the Existence of a Seven-Year Cycle in the Meteorological Elements of the Stations in or near the Pacific Ocean," in *Proceedings of the Fourth Pacific Science Congress, Java, May-June 1929* (Batavia: Bandoeng, 1930), 2A:11-16.

Berlage's other key publications on the Southern Oscillation include: "East-Monsoon Forecasting in Java," *Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia Verhandelingen* [*KMMOBV*] 20 (1927); idem, "Further Researches into the Possibility of Long-Range Forecasting in Netherlands India," *KMMOBV* 26 (1934); idem, "Fluctuations of the General Atmospheric Circulation of More Than One Year, Their Nature and Prognostic Value," *Koninklijk Nederlands Meteorologisch Instituut Mededelingen en Verhandelingen* [*KNMIMV*] (The Hague) 66 (1957); idem, "The Southern Oscillation and World Weather," *KNMIMV* 88 (1966), esp. 18. Cf. C. Braak, "Atmospheric Variations of Short and Long Duration in the Malay Archipelago and Neighbouring Regions, and the Possibility to Forecast Them," *KMMOBV* 5 (1919).

See also Pyenson, *Empire of Reason: Exact Sciences in Indonesia, 1840-1940* (Leiden: E. J. Brill, 1989), ch. 3; Glantz, *Currents of Change*, ch. 3; Grove, "The East India Company, the Australians and the El Niño," in *Ecology, Climate and Empire*, 125-141; Davis, *Late Victorian Holocausts*, ch. 7, esp. p. 230. Note that Davis misdates Berlage's discovery by almost 30 years, while Grove overlooks it completely.

Gildemeister & Co. and North Americans in Peru. CAG quickly translated and published it for Peruvian readers.[58]

Though it had important consequences for the future development of scientific understanding of Peru's marine environment, the 1925-1926 disaster did not act as a major agent of change in the historical context of the time. The guano birds and coastal agribusiness, for the most part, returned to normal soon after this event was over. The agroecological system linking marine production to export agriculture survived this crisis almost unscathed, thereby vindicating the policies of CAG's management.

Instead, this event is significant because it briefly revealed trends that would become important in the changed context of subsequent crises. It helps to explain why Peruvians looked to New York and Southern California to recruit future marine science experts. It foreshadows the direct influence so-called Peruvian events would have on environmental science and conservation elsewhere in the world--and reasons why such "peripheral" influences are so often ignored by historians. It also raises the question why the Peruvian guano industry (and fishing industry) suffered so much during future El Niño events. Finally, the response to the 1925-1926 El Niño shows the global nature of the connections between

58. Gerhard Schott, "Der Peru-Ström und seine nördlichen Nachbargebiete in normaler und anormaler Ausbildung," *Annalen der Hydrographie und Maritimen Meteorologie* 59 (1931), 161-169, 200-213, 240-252, trans. as "La corriente del Perú y sus límites norteños en condicionales normales y anormales," *BCAG* 9:3-4 (Mar.-Apr. 1933), 65-117; idem, "Conferencia del Profesor Gerhard Schott, del Observatorio Marítimo de Humburgo: La circulación general de los océanos," *BSGL* 49:3-4 (1932), 107-114; Franz Zorell, "La Corriente del Niño en 1925," *BSGL* 46:1-2 (Mar. 1929), 1-18, originally published as "Der Niño-Strom in Jahre 1925," *Annalen der Hydrographie und Maritimen Meteorologie* 56 (1928), 166-175.

government, business, and expertise during this era. Such linkages again came into play in the response to the sharp economic downturn of 1929.

Dealing with Crisis--The Great Depression

In some ways, Latin America became much more integrated into the global economy during the 1920s, thanks to the influence of defenders of the gold standard and central banking, the insatiable hunger of regimes like Leguía's Nueva Patria for debt financing and foreign investment, and increased demand in the industrial North for basic commodities produced in the South. (Economists call these trends "export-led growth.") In fact, the international discovery of the El Niño phenomenon is an important cultural product of this integration. On the other hand, the overwhelming success of scientific agriculture for certain crops, along with the construction of protectionist barriers, created unstable prices and steadily worsened the terms of trade for producers of staples like sugar and cotton.[59] Technocrats and their patrons hoped that the intervention of experts would encourage global economic integration and dampen the boom-bust cycles chronic to industrial capitalism. Instead, these oscillations became much worse. The vast capitalist edifice built by men like Kemmerer and Leguía came close to collapsing altogether during the Great Depression of the 1930s. CAG and the rest of Peru

59. For an introduction to these issues, see Thorp, "Latin America and the International Economy from the First World War to the World Depression," in *CHLA* (1994), vol. 6, pt. 1, 57-81; for a more exhaustive survey, see Enrique Cárdenas, José Antonio Ocampo, and Rosemary Thorp, eds., *The Export Age: The Latin American Economies in the Late Nineteenth and Early Twentieth Centuries*, vol. 1 of *An Economic History of Twentieth-Century Latin America* (New York: Palgrave, 2001).

faced a far greater crisis than they had during the 1925-1926 El Niño. Technocrats became the men of the hour as a consequence.

Even before the Great Crash of 1929, Peruvian agro-exporters responded to these pressures by increasing the amount of area they planted in cash crops. Like market farmers in many other parts of the world, they hoped to make up for sagging international prices and balance their accounts by exporting larger quantities. The laws of supply and demand doomed this response to fail during a long economic downturn, so the governments of a few countries dependent on commodity exports intervened to limit exports to prevent this, as in the case of Brazil's coffee valorization program. Chile took this strategy to an even further degree: From 1927-1931, as its nitrate sector was hurt more and more by competition from synthetic fertilizers, the technocratic government of Coronel Carlos Ibáñez appointed a cadre of engineers to key administrative posts all over the country in a futile attempt to rescue the Chile's economy and old oligarchic order from their downward slide.[60]

Of course, this was no ordinary downturn: this was the onset of the Great Depression.[61] The fortunes of cane and cotton growers plummeted from Cuba and

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60. On Brazilian coffee policy before and after 1929, see Topik, *The Political Economy of the Brazilian State, 1889-1930*, ch. 3; Celso Furtado, *The Economic Growth of Brazil: A Survey from Colonial to Modern Times*, trans. Ricardo W. de Aguiar and Eric Charles Drysdale (Berkeley and Los Angeles: University of California Press, 1963), 196-213. On Chile's technocratic turn, see Patricio Silva, "State, Public Technocracy and Politics in Chile, 1927-1941," *Bulletin of Latin American Research* 13:3 (1994), 281-297; idem, "Pablo Ramírez: A Political Technocrat Avant-la-Letter," in *The Politics of Expertise in Latin America*, 52-76.

61. On the global onset of the Great Depression and its regional effects in Latin America, see Dietmar Rothermund, *The Global Impact of the Great Depression, 1929-1939* (New York: Routledge, 1996), particularly his attention to rural, agrarian issues worldwide; Victor Bulmer-Thomas, "The Latin American Economies, 1929-39," in *CHLA* (1994), vol. 6, pt. 1, 463-535; Thorp, ed., *Latin America in the 1930s: The Role of the Periphery in World Crisis*, vol. 2 of *An*

Mauritius to Texas and Egypt. This had a direct impact on the agroecological system CAG presumed to manage. In Peru, the cotton market reached bottom in 1931; crop productivity dropped right along with it, since cotton growers were extremely dependent on guano purchases, which many could no longer afford. Looked at over the long term, the fortunes of Peruvian cane sugar exporters had been on a downward trend since the end of World War I, reaching a nadir in 1934. By this date, 14 of 42 sugar *ingenios* in operation in Peru in 1929 had closed their doors permanently, further concentrating this industry in the hands of a few. (Sugar cane productivity continued to decline steadily from 1931 to 1938 for a number of reasons, including decreased fertilizer purchases. The abrupt increase in sugar cane production during the late 1930s was due to the rapid adoption of a new, high-yielding cane hybrid.) As patterns of guano purchases make clear, smaller producers of cotton and grain around Lima, along the south-central coast, and near Arequipa were hit the hardest, while the biggest sugar planters of the north coast were best able to continue business as usual. The return of the El Niño phenomenon late in 1930 made these difficulties even worse.[62]

This economic blow shattered the social and political peace that Leguía had forcefully maintained during his oncenio. The Peruvian mining industry was hit much harder by this economic shock, leading to violent confrontations between workers, management, and the military in the highlands. José Payán's Banco del

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Economic History of Twentieth-Century Latin America; Charles P. Kindleberger, *The World in Depression, 1929-1939* (Berkeley and Los Angeles: University of California Press, 1973).

62. See app. 3, 5-6, 7 and fig. 3-7; Thorp and Bertram, *Peru, 1890-1977*, 172; Macera, "El guano y la agricultura peruana de exportación," 473-474.

Perú y Londres failed as a consequence of the Great Crash, and no one was willing to pick up its pieces because it had become a symbol of Leguía's faltering regime. A military junta led by Luis Sánchez Cerro (1890-1933), an upstart army major from Arequipa, finally deposed and imprisoned Leguía during the austral winter of 1930. An angry mob in Lima took its revenge on the homes of Leguía and his main collaborators. With Peru's old coastal oligarchy in disarray, Leguía's fall opened a brief window of opportunity for democracy in Peru. In 1931, Sánchez Cerro defeated Raúl Haya de la Torre, the charismatic leader of the Alianza Popular Revolucionaria Americana (APRA), in the first mass election in Peruvian history. An *aprista* assassin brought an end to Sánchez Cerro's presidency just over a year later. Congress asked General Oscar Benavides to serve out his term. After the election of 1936, Benavides refused to step down and hand over power to APRA. It proved impossible to install a popular democracy to rule the Peruvian state under the tense conditions of the 1930s.[63]

Similar unrest and authoritarian interventions affected most other Latin American countries during the early 1930s. Even though some critics blamed economic experts like Kemmerer for this catastrophe (the Peruvian Communist Party, for example, labeled him "the Yankee Hunger Maker"), Latin America's besieged rulers kept looking to "financial physicians" to save their faltering economies and political systems.[64] Latin Americans were not alone in embracing expertise. President Franklin D. Roosevelt installed his own "brain trust" to govern

63. Contreras and Cueto, *Historia del Perú contemporáneo*, 233-242; Mallon, *The Defense of Community in Peru's Central Highlands*, 239-243; Stein, *Populism in Peru*, passim.

64. Drake, *The Money Doctor in the Andes*, 228 [quote].

the United States after he took power in 1933 from Herbert Hoover. In its various manifestations, *tecnocracia* (Spanish, Portuguese), *technokratie* (German), *technocratie* (French, Dutch), *technocrazia* (Italian), *tekunokurashi* (Japanese), *technokracie* (Czech), *technokratija* (Latvian), et cetera, technocracy was the watchword of the Great Depression.[65]

Sometimes expert intervention worked, at least for political purposes. A visit by Kemmerer to Colombia in 1930 helped accomplish a peaceful transfer of power to the Liberal Party after 43 years of Conservative dominance. Leguía also requested Kemmerer's presence in Peru, but he was busy in Colombia and arrived too late to save Leguía. With prodding from New York bankers and the U.S. ambassador, who held out the empty promise of a new loan, Sánchez Cerro's military government welcomed a team of eight experts headed by Kemmerer to Peru to provide advice on economic policy. Like his Colombian counterpart, Sánchez Cerro desparately needed the political legitimacy such a ritual could provide to his regime.[66]

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65. The global range of 1930s literature on technocracy is striking. Nevertheless, the international nature of this movement has not received systematic attention from historians, except for Stefan Willeke, *Die Technokratiebewegung in Nordamerika und Deutschland zwishen den Weltkriegen: eine vergleichende Analyse* (New York: P. Lang, 1995). On the Technocracy movement in the United States, Canada, and France, see William E. Akin, *Technocracy and the American Dream: The Technocrat Movement, 1900-1941* (Berkeley and Los Angeles: University of California Press, 1977); Gerard Brun, *Technocrates et technocratie en France (1918-1945)* (Paris: Editions Albatros, 1985).

66. Drake, *The Money Doctor in the Andes*, esp. 63-75, 221-243. On Colombia's powerful technocratic propensity during this era, see Henderson, *Modernization in Colombia*, ch. 5; Murray, *Dreams of Development*, ch. 3; Safford, *The Ideal of the Practical*, 227-242; Donald S. Barnhart, "Colombian Transport and the Reforms of 1931: An Evaluation," *HAHR* 38:1 (Feb. 1958), 1-24; Richard E. Hartwig, *Roads to Reason: Transportation, Administration, and Rationality in Colombia* (Pittsburgh, PA: University of Pittsburgh Press, 1983), esp. 98-111.

Bail-out loans were never forthcoming. First Bolivia, then Peru (in March 1931, only two months after Kemmerer's visit!), then Chile, then Colombia, and many other Latin American states defaulted on their foreign loans, dropped the gold standard, and retreated from the orthodox, deflationary economic policies advocated by Kemmerer. But this happened belatedly. In fact, many historians blame economic orthodoxy for making the Great Depression so bad, for so long, in so many parts of the world. No Latin American country repudiated its foreign obligations, however, and most resumed servicing their debts in the 1950s. All Latin American states retained their central banks, the key innovation of this earlier generation of technocrats. In broad terms, the global capitalist system these experts presumed to manage survived this crisis, though it never returned to its old alignment.[67]

These violent shifts in the political and economic winds had a direct impact on CAG, and they reinforced, rather than weakened, CAG's technocratic tendencies. After Leguía's overthrow, CAG totally overturned its management. Ballén and his family had close ties to Leguía that made his position untenable under the new regime. Of course, sacking Ballén for his political connections violated the technocratic ideal. To remedy this, CAG's new board of directors named engineers both to replace Ballén as general manager and to take over as company president. It also promoted Lavalle to a top managerial post.

In 1931, CAG hired one of Peru's foremost young technicians and science educators, José Rafael de la Puente (1890-1934), to take Lavalle's old place as head

67. Drake, *The Money Doctor in the Andes*, passim, esp. pp. 16-17.

of CAG's Technical Section. De la Puente had been born into a *limeña* military family and trained as a mining engineer at the Escuela de Ingenieros, a legacy of Manuel Pardo's "practical republic" during the waning days of the Guano Age. De la Puente dramatically raised his political visibility in 1930 when he stepped in as director of the Escuela de Ingenieros during a major institutional crisis initiated by student demonstrations after Leguía's overthrow; he was given his position at CAG partly as a reward. After three years of service, CAG promoted him to general manager. CAG finally had a talented man at its head who perfectly fit the technocratic ideal--but then de la Puente died suddenly in a May 1934 accident. Ballén, despite his earlier dismissal, came back as interim chief, and stayed on until he retired in 1945 at age 70.[68]

As an institution, CAG made a valiant attempt to maintain its system of fertilizer supply and to preserve the fortunes of its patrons during this great global crisis. CAG slashed its prices. It also made arrangements to provide farmers with easy credit for fertilizer purchases. This lending pattern led directly to the establishment of the Banco Agrícola in 1931, an institution that markedly improved credit availability in rural Peru. CAG also helped the Peruvian state with its fiscal problems. Because local demand for guano was temporarily depressed, CAG had a large surplus that it could sell on overseas markets for a foreign exchange value worth ten to 15 times the bargain price it charged Peruvian farmers. In fact, 57

68. *MCAG* 22 (1931), xv-xvi; "Datos biográficos: José Rafael de la Puente," *BCAG* 10:5 (May 1934), 76-77; "Discurso del Vicepresidente del Directorio de la Compañía Sr. Carlos Larraburre y Correa, en el momento de injumarse los restos del Sr. Ingeniero Guillermo Talleri," *BCAG* 14:1 (Jan. 1938), 5.

percent of CAG's net income from 1930 to 1934 came from guano exports to the United States, Europe, Costa Rica, and Japan. Much of this income went straight to the government's coffers and the pocketbooks of stock-holding agro-exporters.[69]

At least for Peruvian cotton growers, the Great Depression did not last long. Ironically, their *success* during the mid-to-late 1930s led to the partial undoing of the agroecological system CAG had maintained for over two decades.

On the level of national accounts, cotton led the Peruvian economy back from the Great Depression. Peru's default and the systematic devaluation of the Peruvian sol actually made Peruvian exports more profitable, since it increased the local exchange value of foreign currency. Meanwhile, international cotton prices recovered rapidly as U.S. producers, especially in Texas, struggled with continued economic and social upheaval, crop pests, and climate extremes. Beginning in 1933, Peruvian farmers along the central and southern coast scrambled to profit from these favorable conditions by converting their lands to a monoculture of Tangüis cotton, often with capital borrowed from the new Banco Agrícola. Half a century after the El Niño floods of 1877-1878 practically destroyed Piura cotton production, farmers in that region started to export Pima cotton on a large scale with the help of several new irrigation projects. Cotton became Peru's biggest export. It has been estimated that half of the total arable land along the coast was planted in cotton and half of the coastal population depended on cotton for their living at the peak of the boom circa 1938. Guano consumption went up across the

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69. See app. 1, 4; *MCAG* 17 (1926), vi, xi; *MCAG* 18 (1927), ii, x; *MCAG* 22 (1931), xiv; *MCAG* 23 (1932), v, ix, 207; *MCAG* 24 (1933), vii.; *MCAG* 27 (1936), ix, xiv.

board in cotton-growing regions. In fact, so many farmers suddenly wanted to buy guano that this boom immediately created a shortfall in the guano supply.[70]

In his analysis of this emerging crisis, one of CAG's growing team of agronomists, Luis Gamarra Dulanto, raised the specter of Malthus: Guano had aided the progressive conquest of new lands, advances in agricultural technology, and the emergence of intensive cotton agriculture on the Peruvian coast. As a direct consequence, the production of crops had gone up "arithmetically," but success had caused demand for fertilizer to go up "geometrically." Even if his understanding of Malthus was more than a little confused, he rightly recognized that CAG simply had no way to raise guano production overnight to meet this new demand. Were there basic natural limits to this agroecological system? Observers continued to ask this question until the guano industry met its ultimate demise in the early 1970s.[71]

CAG's managers tried a number of stop-gap solutions in an attempt to maintain the fertilizer system they had so laboriously built. They immediately rationed guano distribution to cotton growers and other major purchasers. But by 1938, even though it produced a record guano harvest, CAG could only fill 50 percent of total requests. CAG leaned heavily on its cadre of experts to prevent hoarding and fraud. As Lavalle had done in 1914, a commission of agronomic engineers toured the Peruvian coast to ensure that guano was being used rationally.

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70. See app. 2-3, 6-7 and fig. 3, 5; Thorp and Bertram, *Peru, 1890-1977*, 173-177; *MCAG* 29 (1938), vii; Hocquenghem, *Para vencer la muerte: Piura y Tumbes*, 330-333. For a detailed, local-level account of this boom and its effects, see Peloso, *Peasants on Plantations*, ch. 6.

71. Gamarra, "El guano del Perú y sus perspectivas futuras en la economía del Perú," *BCAG* 11:10 (Oct. 1935), 483-484.

Thereafter, CAG required all farmers to fill out a 13-part form to accurately estimate their fertilizer requirements. These technicians thus reinforced CAG's technocratic control over coastal agriculture, although the system they oversaw was still subject to abuse by purchasers who misrepresented their crop choice. Meanwhile, CAG printed conservation instructions for guano use in the front of each *Boletín*; it stopped exporting guano; and it required all large purchasers to make an up-front deposit to guarantee their requests. As guano demand continued to rise, CAG arranged to sell nitrates from Chile and synthetic fertilizers from Europe and the United States at below-market prices. CAG remained devoted to its island rotation policy despite the pressure to maximize short-term production. Of its 25 most productive guano-producing territories, CAG only intensified its work significantly on Isla Santa between 1934 and 1939.[72]

As the hundreds of letters and dozens of newspaper articles reprinted in its yearly reports make clear, CAG's existence had always been controversial, and it became a lightning rod for criticism under these conditions. Peru's chief executive, General Oscar Benavides, appointed an independent expert to resolve this growing controversy. (He obviously remembered the role Henry Forbes had played during CAG's run-in with the Peruvian Corporation the last time he was in this position.) Benavides selected Carlos Alayza y Roel (b. 1878), a mining engineer who had built a successful political career acting as a mediator for labor conflicts at Peru's

72. See app. 4 and fig. 2-3; *MCAG* 26 (1935), v, 237, 244-245, 339; *MCAG* 27 (1936), vii, ix, xvi, 183; *MCAG* 29 (1938), vii, 240; *MCAG* 30 (1939), iv, vi-vii, 50-5; *MCAG* 33 (1942), iv; "Importante: Instrucciónes para la buena conservación y aprovechamiento del guano," *BCAG* 11:11 (Nov. 1935), 511; "Abonos: los aboneamientos peruanos y los fertilizantes de importación," *BCAG* 17:1 (Jan. 1941), 3-5; *ICAG*, 75; Macera, "El guano y la agricultura peruana de exportación," 479.

highland mines. Alayza personally visited all of the main guano islands and audited CAG's entire operations. In his 1936 report, Alayza endorsed CAG's rationing policy. Moreover, he concluded that CAG was capable of supplying even more guano at low prices if it invested in its productive infrastructure, reduced its remittance to the state budget, and stepped up its enforcement of conservation procedures. To make sure Alayza's recommendations were implemented, Benavides decreed his hiring as CAG's second-in-command and later his appointment to CAG's board of directors.[73]

CAG's managers had made a valiant effort to continue business as usual during this crisis. Now, Benavides's authoritarian support for the technocratic ideal enabled them to exercise a measure of independence from agribusiness. CAG jacked up the price it charged cotton and sugar cane exporters for guano, though it allowed cane growers to pay a lower price, thus revealing the sugar interest's continuing political influence. This new policy hurt marginal, cash-poor farmers the most, further encouraging concentration of ownership in Peru's coastal valleys. Food producers received the biggest discounts: a clear sign of growing concern that this export boom was threatening Peru's food security. Meanwhile, CAG's profits climbed to unprecedented heights. As usual, some of these were reinvested in irrigation projects designed to benefit farmers.[74]

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73. "Las funciones del Inspector de las islas guaneras," *BCAG* 11:11 (Nov. 1935), 556-557; Carlos Alayza Roel, "Informe del Personero del Fisco al Director General de Hacienda y oficio de la Gerencia sobre el mismo asunto," *BCAG* 12:5 (May 1936), 155-163; *Diccionario histórico y biográfico del Perú*, s.v. "Alayza y Roel, Carlos."

74. *MCAG* 27 (1936), 183; *MCAG* 29 (1938), ix; *MCAG* 30 (1939), 50-5.

By the late 1930s, despite CAG's occasional shortcomings, Alayza, Robert Cushman Murphy, and many others deemed its technocratic management of Peru's coastal environment a marvelous success. CAG's managers lorded over an efficient, productive system premised on the maintenance of an environment amenable to the guano birds' increase. The guanay, piquero, and their natural enemies--as well as the humans who extracted and used guano--were all seemingly domesticated. Despite the rumblings of the late 1930s, large-scale sugar and cotton producers overwhelmingly benefited from this agroecological system, both during periods of prosperity and penury. CAG funded a number of other development schemes, not to mention its main patrons: its stockholders, the Sociedad Nacional Agraria, and, above all, the Peruvian state. This was an enormous triumph for the technocratic ideal.

Peru's Lords of Guano enabled the dramatic expansion of scientific agriculture in Peru's coastal valleys. Input-intensive practices became "conventional," in the process. Now CAG had to deal with the shortfall between fertilizer demand and guano supply. Since Alayza, Francisco Ballén, and the rest of CAG's management had extra money available to throw at the problem, they looked to science for a definitive solution to Peru's fertilizer crisis. Perhaps further studies of Peru's marine environment would suggest new strategies for increasing guano production? With direct presidential authorization, in 1938, CAG looked to hire a foreign expert to study the guano birds. It acquired the services of one of the most important conservationists of the twentieth century.

Chapter 4

The Lords of the Guanay:

Professional Ornithology and the Guano Industry's Redirection

> There will be no true *Conservation* while this discipline is the patrimony of distinguished professors, outstanding academic circles, cultivated social nuclei, calloused institutions. In order to be effective, Conservation has to become the ABC of the man on the street.
>
> --Enrique Ávila (1954)

The emergence of professional ornithology in Peru after 1938 was a direct consequence of the decision by CAG's managers to resolve the crisis of guano supply by technocratic means. The proposals of Robert Coker and Henry Forbes had led to the remarkable recovery of the guano bird colonies and an almost fourteen-fold increase in the supply of nitrogen to Peruvian agriculture from the El Niño of 1911-1912 to the La Niña of 1938.[1] These scientists brilliantly solved Peru's initial "guano problem." But programs initiated by Francisco Ballén, José Antonio de Lavalle y García, and others had greatly expanded input-intensive agriculture in Peru, especially among farmers producing cotton for export. The natural increase of guano production simply could not keep up with the market forces driving up the number of farmers who wanted it. Then, an El Niño even more destructive than the event of 1925-1926 devastated Peru's marine environment and the guano birds from 1939 until 1941. CAG's managers again looked to scientists to solve this new guano-supply problem.

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1. See app. 3.

Peru had no home-grown expert with enough understanding of ornithology to plan and execute a scientific research project sufficient to suggest a definitive solution to this crisis of guano supply, so CAG again looked abroad for expertise. In 1939, it hired the U.S. ornithologist William Vogt. Vogt implemented a research program that was on the cutting edge of the sciences of ornithology, ethology, ecology, and wildlife management. He mentored Peru's first native-born professional ornithologist, Enrique Ávila, who continued Vogt's program and trained the next generation of professional marine-bird scientists in Peru. Ávila's experiences typify the trials experienced by students of humble origin who attempt to gain social prestige via education and technocratic careers in Latin America. Meanwhile, a new generation of managers inspired by Vogt's work developed policies that renewed the guano industry, while Peruvian state officials struggled to reorient the guano supply from export agriculture to other developmental concerns. In the process, CAG came to administer a different agroecological system.

Recruiting a Bird Expert

The Compañía Administradora del Guano looked to the United States for ornithological expertise because it already had a close connection to a leading U.S. ornithologist: CAG sent its initial request for assistance to Robert Cushman Murphy. After his work on the 1925 El Niño, he had become curator of oceanic birds and assistant director of the American Museum of Natural History in New York City. As author of the award-winning, definitive work on *Oceanic Birds of South America* (2 vol., 1936), Murphy was the world's undisputed authority on the marine birds of the southern Atlantic and Pacific Oceans. CAG wanted Murphy to come to Peru himself, but he was too busy with his duties as president of the Audubon Society, so he tabbed William Vogt (1902-1968), a native of Mineola, New York, for the job (illus. 23).[2]

Like so many North Americans during the early twentieth century, Vogt first developed his interest in nature during recreation away from the rapidly expanding urban centers of industrial North America. As a child, he grew up with his Anglo mother and step-father in what was then rural Long Island; they spent most summers in the wild Adirondacks. His family moved to Brooklyn in 1914; thereafter, the Boy Scouts provided him with the opportunity to escape the big city. He contracted polio during the great epidemic of 1916 while at Scout summer camp. His physical condition thereafter prevented him from becoming a professional forester, his ideal career. Later in life, his buddies admired him greatly for his stoicism as he trekked through the rough in search of his greatest love--birds. At the Manual Training High School of Brooklyn and what is now Bard College, Vogt mainly developed his interest in literature. After graduating from college in 1925, he worked as an insurance investigator--and was soon fired because of his disability--and then as an editor and drama critic for the gigantic New York publishing industry.[3]

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2. *MCAG* 29 (1938), xiv; *MCAG* 30 (1939), 64-65; *The National Cyclopaedia of American Biography* (New York: James T. White, 1942), s.v. "Murphy, Robert Cushman."

3. Autobiographical profile, "Some Notes on WV for Mr. Best to Use as He Chooses in Connection with a Possible Article," n.d., Vogt papers, box 5:1; *Who Was Who*, s.v. "Vogt, William."

Vogt's career as an ornithologist took off in the 1930s, and it illustrates the intimate connections between avocational bird-watching, conservation activism, and professional scientific research that typified North American ornithology during the mid-twentieth century. Vogt first got to know the famed birders Roger Tory Peterson, John Hopkinson Baker, and Robert Cushman Murphy at meetings of the Linnaean Society at the American Museum of Natural History and excursions with the Bronx County Bird Club. In December 1930, while Vogt and Peterson were counting ducks along the Hudson River, Vogt suggested that Peterson compile his bird drawings into a book. Vogt then used his connections to find a publisher for *A Field Guide to the Birds* (1934), the first of the celebrated Peterson Field Guide series. These vividly illustrated, easy-to-use field guides contributed enormously to the explosion of U.S. interest in birding after World War II--and to growing public concern for the fate of these wild creatures. Meanwhile, Vogt acquired his first experience in wildlife management as director of the Jones Beach State Bird Sanctuary on Long Island, a reserve attached to the famous rustic-styled state park built for auto-mobile New Yorkers by Robert Moses. (Vogt despised the changes the "bulldozer-subdivider Moses"--probably the most powerful urban technocrat of the twentieth century--wrought on his beloved Long Island.)[4]

4. "Some Notes on WV" [quote]; *Who Was Who*, s.v. "Vogt, William"; John C. Devlin and Grace Naismith, *The World of Roger Tory Peterson: An Authorized Biography* (New York: New York Times Books, 1977), 62-66; Frank Graham, Jr., *The Audubon Ark: A History of the National Audubon Society* (New York: Alfred A. Knopf, 1990), 133-134; Mark V. Barrow, Jr., *A Passion for Birds: American Ornithology after Audubon* (Princeton, NJ: Princeton University Press, 1998), ch. 7. For an exhaustive account of the God-like influence of Moses (Ph.D. in political science, Oxford, 1911, Columbia, 1913) on the physical landscape, class and racial segregation, and structures of

Except for an occasional graduate class, Vogt never acquired formal scientific training, still a common situation among U.S. ornithologists in the 1930s. (Murphy himself only had a master's degree from Columbia.) Instead, Vogt nurtured his scientific credentials in apprenticeship to scientists employed by the Ornithology Department of the American Museum of Natural History. In 1933, Vogt collaborated with Murphy on a study of the anomalous migration of little auks or dovekies (*Alle alle*) late in 1932; they concluded that peculiar meteorological conditions over the North Atlantic forced this offshore species to seek shelter on the Atlantic coast from Canada to Cuba. Besides forging their relationship and Vogt's links to the world of professional ornithology, this event was important because both Murphy and Vogt personally observed similar happenings in Peru related to the El Niño phenomenon: Murphy in 1925-1926 and Vogt in 1939-1941. Meanwhile, Vogt came into association with Ernst Mayr at the Museum. Mayr, who is best known as one of the main architects of the neo-Darwinian evolutionary synthesis, had made it his duty to raise the standards of ornithological research in the United States after his arrival from Germany in 1931. Through the Linnaean Society of New York (whose journal he edited), Mayr worked to establish mentoring relationships with up-and-coming young birders. In accord with Mayr's dictum that even amateur birders "should have a problem," Vogt took to observing the behavior and ecological relationships of a shorebird, the eastern willet (*Catoptrophorus semipalmatus*) and won the 1938 Linnaean Prize for

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power in the world's richest city, see Robert A. Caro, *The Power Broker: Robert Moses and the Fall of New York* (New York: Alfred A. Knopf, 1974).

Ornithological Research for his work. Vogt also played a major role in the organization of the Audubon Society's Breeding Bird Census (est. 1937) that, ever since, has brought together amateur and professional birders for the systematic gathering of scientific data. Vogt cut his teeth as a practicing scientist in close association with the vanguard for reform of ornithology in the United States.[5]

In 1934, the National Association of Audubon Societies purchased the journal *Bird-Lore* from Frank Chapman, the long-time head of the American Museum's Ornithology Department, and adopted it as its official organ. With Murphy's support, the investment banker John Baker had recently become executive director of the Association. Baker handpicked his friend Vogt to succeed Chapman as editor. Beginning with the January-February 1935 issue, Vogt worked with the illustrator Peterson to give the magazine a complete face-life, and he commissioned articles on a diversity of topics from such leading conservationists as Hugh Bennett and Aldo Leopold who gave the magazine a much more pessimistic tone befitting the Dust Bowl decade. These articles sometimes offered "no quarter" to sentimentality among rank-and-file birders. Later in life, Peterson recalled one notorious issue that was

> undeniably depressing. There was an essay by [the ecologist Paul] Errington about the suicidal tendencies of muskrats under population pressures; another described the difficulties of winter survival of quail; a

5. Murphy and Vogt, "The Dovekie Influx of 1932," *The Auk* 50 (July 1933), 325-349; Vogt, "Preliminary Notes on the Behavior and the Ecology of the Eastern Willet," *Proceedings of the Linnaean Society of New York* 49 (Oct. 1938), 8-42; Barrow, *A Passion for Birds*, 171, 179, 190-194, 259 n. 145. See also Vogt, "A Preliminary List of the Birds of Jones Beach, Long Island, NY," *Proceedings of the Linnaean Society of New York* 45, 46 (Apr. 1935).

> third dealt with the ecological effects of poisons--the entire issue reeked of death and destruction.[6]

Vogt himself wrote a series of editorials decrying the destruction of wetlands and use of poisons for insect control, years before Rachel Carson's *Silent Spring* (1962).[7]

In the pages of *Bird-Lore*, these authors first aired to a mass audience several of the ideas that became orthodoxy to Vogt and the later U.S. environmental movement. Murphy's comments regarding "posterity's world" epitomized the expanding worldview of the conservationist during the 1930s:

> Conservation in its broad sense is intimately concerned, of course, not merely with birds, flowers, and landscapes, but no less with power and transportation, agriculture, industry, health, fashion, advertising and other social habits, alterations and trends of every sort that affect the renewable or non-renewable natural resources of the earth.[8]

With these sort of associations, Vogt was taking an active role in the incipient metamorphisis of the turn-of-the century conservation movement into modern environmentalism.

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6. Quoted in Graham, *The Audubon Ark*, 144; see also Paul L. Errington, "No Quarter," *Bird-Lore* Jan.-Feb. 1938, 5-6; Douglas E. Wade, "Death Is Upon Them: The Record of a Weather-Killed Bob-White Covey," *Bird-Lore* Jan.-Feb. 1938, 7-10; Lee R. Dice, "Poison and Ecology," *Bird-Lore* Jan.-Feb. 1938, 12-17--a defense of the lowly coyote; H. H. Bennett, "Wild Life and Erosion Control," *Bird-Lore* Mar.-Apr. 1936, 115-121; Leopold, "Naturschutz in Germany," *Bird-Lore* Mar.-Apr. 1936, 102-111; idem, "Conservation Esthetic," *Bird-Lore* Mar.-Apr. 1938, 101-109.

7. For good examples of Vogt's conservation advocacy, see "Editorial," *Bird-Lore* Mar.-Apr. 1935, 127; "Editorial," *Bird-Lore* July-Aug. 1937, 296; "Editorial," *Bird-Lore* July-Aug. 1938, 273; Vogt, *Thirst on the Land: A Plea for Water Conservation for the Benefit of Man and Wildlife*, National Association of Audubon Societies Circular no. 32 (New York: National Audubon Society, 1937).

8. Murphy, "Posterity's World," *Bird-Lore* May-June 1938, 184-191, quote p. 188; Murphy wrote a monthly column as president of the National Association of Audubon Societies from 1937 to 1940.

Vogt's pessimism and zeal also could make him difficult to get along with. In 1938, he and several others tried to organize an office rebellion against the autocratic tendencies of his boss and one-time friend, Baker, but Vogt instead found himself in the hospital suffering from "nervous exhaustion" and jobless at the opportune time when CAG was looking for an ornithologist.[9]

Implementing a Research Program

From a provincial, myopic North American point of view, Peru was "his Elba," but Vogt was a godsend for Peruvian ornithological science. Few people in the world were more qualified to take on the tasks CAG gave him. As CAG ornithologist, he traveled from Isla Lobos de Tierra in the north to Isla Santa Rosa in the south, implemented several new research techniques, and brought with him perspectives that were at the cutting edge of scientific theory in the Northern Hemisphere. Vogt's understanding of intellectual currents in ecology, ethology, and evolution fundamentally shaped the way he perceived the guano birds and their environment. His role in the vanguard of U.S. conservationists, likewise, molded his views of the proper relationship between humans and the natural world. His different way of seeing nature inspired his new prescriptions for the Peruvians who profited from these birds.

The late 1920s and 1930s were a fertile period for innovation in ecological theory. At least in animal studies, they were marked by a turn away from

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9. Graham, *The Audubon Ark*, 117-118, 142-144; Margaret Morse Nice to Vogt, 9 Dec. 1937, Vogt papers, box 1:2.

descriptive studies of individual organisms in their environment (autecology) or entire natural communities (synecology) toward quantitative studies of population dynamics. Vogt's ideas and work in Peru reflected this transition. In his own words, Vogt came to Peru in 1939 "to help conserve the balance between species continually sought by Nature."[10] This perspective was the essential premise of Clemenstian successionalism, the dominant ecological paradigm of the 1930s, named for the U.S. plant ecologist Frederic Clements who emphasized the tendency of the species mixture of plant and animal communities to develop toward a stable, "climax" state. This "balance between species" was the foundational doctrine of Aldo Leopold's *Game Management* (1933), "the bible of the wildlife profession" that Vogt relied on heavily while designing his research on the guano islands.

Although Vogt did his best to complete a holistic study of the guano birds' natural community, he was not a prisoner to the steady-state assumptions that underlay community ecology. He was familiar with recent innovations in population ecology, particularly ongoing research on periodic fluctuations in the population of fur-bearing animals in Canada based on the historical records of the Hudson Bay Company. Vogt liberally employed the concepts of "biotic potential" and "environmental resistance" in his analysis of changes in the guano bird population. He knew it was possible to predict mathematically the future guano bird population if he could derive accurate measures of bird fecundity and mortality. To this end, Vogt tried to establish a statistical basis for his studies, but he had a poor mathematical background and little success. Without a doubt, Vogt

10. "Homenaje al Sr. William Vogt," *BCNPN* 1:1 (May 1944), 10.

derived his most important ecological principles from the English ecologist Charles Elton's *Animal Ecology* (1st ed., 1927), a work that overtly interpreted animal communities in economic terms. Vogt rigorously applied four of Elton's key concepts to his work: the food chain, appropriate food size, the pyramid of numbers, and the ecological niche, all of which were based on the crucial supposition that food is the basic determinant of the natural order.[11]

Vogt's awareness of new research relevant to the study of guano birds went beyond ecology. He was familiar with revolutionary work in the field of ethology, the study of the behavior of organisms in their natural environment. In 1935, Vogt and Gladwyn Kingsley Noble, the director of the American Museum's Department of Experimental Biology, completed a ground-breaking study on morphological sex recognition in wild birds at the Jones Beach Sanctuary. Vogt worked closely during the late 1930s with other leaders in the field. These included Mayr, Margaret Morse Nice (an unpaid "amateur" scientist--because of her social status

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11. Ref. for this section: Vogt journal, Isla Chincha Norte, 17 Mar. 1939, Vogt papers, box 3:1; Vogt, "Informe sobre las aves guaneras," 25; Charles Elton, "Periodic Fluctuations in the Numbers of Animals: Their Causes and Effects," *British Journal of Experimental Biology* 2 (1924), 119-163; idem, *Animal Ecology* (New York: Macmillan, 1927).

On the turn toward population ecology in animal studies, see Sharon Kingsland, *Modeling Nature: Episodes in the History of Population Ecology* (Chicago: University of Chicago Press, 1985). On Clementsian successionalism and its influence on the technocratic management of U.S. agriculture and grazing, see Worster, *Nature's Economy*, ch. 11, 12; Joel B. Hagen, "Clementsian Ecologists: The Internal Dynamics of a Research School," *Osiris* 8 (1993), 178-195; idem, "Organism and Environment: Frederic Clements's Vision of a Unified Physiological Ecology," in *The American Development of Biology*, ed. Ronald Rainger, Keith R. Benson, and Jane Maienschein (Philadelphia: University of Pennsylvania Press, 1988), 256-280; Ronald C. Tobey, *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895-1955* (Berkeley and Los Angeles: University of California Press, 1981), esp. 76-109, 191-222. On Leopold's *Game Management* and Elton's enormous influence on animal population studies, see Worster, *Nature's Economy*, 271-274, 294-301; Dennis Chitty, *Do Lemmings Commit Suicide? Beautiful Hypotheses and Ugly Facts* (New York: Oxford University Press, 1996); Peter Crowcroft, *Elton's Ecologists: A History of the Bureau of Animal Population* (Chicago: University of Chicago Press, 1991).

as a married woman), and Dutch-born ethologist Niko Tinbergen, all of whom were close associates of the German "father of ethology" Konrad Lorenz. Their theories regarding territory formation, which Vogt had begun to test during his investigation of willets, strongly influenced his work on the guano islands of Peru, and he explicity followed the "phenomenological" or descriptive method of research favored by these investigators during this period. Following Lorenz, Vogt rejected most behaviorist interpretations of guano bird behavior. Instead, he viewed the initiation and termination of behaviors as governed by inborn physiological thresholds initiated by sensory and biochemical "releaser" mechanisms. This played into his understanding of bird behavior as ultimately determined by material factors like the availability of food and nesting materials.[12]

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12. G. K. Noble and Vogt, "An Experimental Study of Sex Recognition in Birds," *The Auk* 52 (July 1935), 278-286; Vogt journal, Isla Chincha Norte, 6 Apr. 1941, Vogt papers, box 3:1; Vogt, "Informe sobre las aves guaneras," 47-50; Barrow, *A Passion for Birds*, 195-197; On the formation of ethology as a science see Niko Tinbergen, *The Herring Gull's World: A Study of the Social Behavior of Birds* (New York: Basic Books, 1953); idem, *Curious Naturalists* (New York: Basic Books, 1958), esp. ch. 3, which both focus on Tinbergen's own contribution; idem, "Ethology," in *Scientific Thought 1900-1960*, ed. R. Harré (Oxford: Clarendon Press, 1969), 238-268, which focuses on Lorenz and his legacy; Gregg Mitman and Richard W. Burkhardt, Jr., "Struggling for Identity: Animal Behavior in America, 1930-1945," in *The Expansion of American Biology*, ed. Keith R. Benson, Jane Maienschiein, and Ronald Rainger (New Brunswick: Rutgers University Press, 1991), 164-194, which focuses on Noble and Nice; and Burkhardt, "On the Emergence of Ethology as a Scientific Discipline," *Conspectus of History* 1:7 (1981), 62-81.

For an example of an important study also carried out using the "phenomenological" method, see Nice, "Studies in the Life History of the Song Sparrow I: A Population Study of the Song Sparrow," *Transactions of the Linnaean Society of New York* 4 (1937), 1-248; idem, "Studies in the Life History of the Song Sparrow II: The Behavior of the Song Sparrow and Other Passerines," *Transactions of the Linnaean Society of New York* 6 (1943), 1-329. Vogt was one of the select early readers of Nice's manuscript and arranged for Peterson to illustrate it; see Devlin and Naismith, *The World of Roger Tory Peterson*, 83-84. Tinbergen commented on Noble and Vogt's sex recognition study and their understanding of the "releasive value" of various stimuli in "The Behavior of the Snow Bunting in Spring," *Transactions of the Linnaean Society of New York* 5 (1939), 49-51.

Vogt on occasion formulated his interpretations in terms of the natural selection of genes. This indicated that he was familiar with the ongoing formation of the neo-Darwinian evolutionary synthesis in biology. But another aspect of orthodox evolutionary theory formed Vogt's conceptualization of Peru's coastal ecology. He presupposed that the entire community of species of the Peruvian coast was the evolutionary result of millennia of extremely gradual adaptation to local environmental conditions. He assumed (incorrectly) that the Peruvian marine environment had been basically unchanged for the last million years or so (though he did recognize its year-to-year variability). Each species was thus adapted to an extremely specific way of life, a unique ecological niche. Since this process was so slow, Vogt thought humans were likely to cause extinction whenever they change a species' environment in a fundamental way--as the guano industry had done for the potoyunco by eliminating the guano it needed to build nesting burrows. Evolution could not be used as a tool for ecological management by this logic. *Any* human manipulation of these ecological relationships was to be considered interference with natural processes. Therefore, Vogt believed the best way to manage the guano islands and to maximize their natural productivity was to recreate the pristine natural conditions that existed in centuries past, before humans started extracting guano.[13]

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13. Vogt, "Informe sobre las aves guaneras," 3-4, 35-37, 83. The literature on the formation of the neo-Darwinian evolutionary synthesis is large; particularly relevant studies include Vassiliki Betty Smocovitis, *Unifying Biology: The Evolutionary Synthesis and Evolutionary Biology* (Princeton, NJ: Princeton University Press, 1996); idem, "Unifying Biology: The Evolutionary Synthesis and Evolutionary Biology," *Journal of the History of Biology* 25:1 (Spring 1992), 1-65; James P. Collins, "*Evolutionary Ecology* and the Use of Natural Selection in Ecological Theory," *Journal of the History of Biology* 19:2 (Summer 1986), 257-288.

Upon his arrival at Isla Chincha Norte in January 1939, Vogt and his assistants immediately built a large burlap blind so they could closely observe the nesting behavior of the guano birds without risk of human disturbance (illus. 24). This became the site where much of Vogt's new scientific understanding of the guano birds was made. Blinds are a key part of the ornithologist's equipment because they establish a thin barrier between the observer and the observed. Vogt was surprised, at first, that guanayes would stampede from their nests on relatively undisturbed islands, even when he approached from a great distance. With the aid of observations by island guards, he came to recognize that this tendency was even greater when birds were raising their second brood of the breeding season--an observation of great importance for the timing of guano extraction. With this introduction, Vogt was equally surprised later to encounter colonies where he and his wife Juana Allraum Vogt could walk among the "stupidly tame" birds without causing any significant disturbance (illus. 25).

Like Murphy and his network of foreign observers, Vogt used several other techniques that extended his limited ability to observe the guano birds and their environment. To track nesting mortality and bird migration, he immediately started the first large-scale banding program in Peru. Vogt and his assistants banded over 39,000 birds in 1940. In order to work, this tactic required the participation of a

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More recent investigations of the populations of "Darwin's finches" on the Galapagos Islands by a pair of English population ecologists discovered serendipitously that the El Niño phenomenon makes it possible to observe the process of evolution by natural selection in the course of a couple seasons, rather than centuries or millennia as once thought. See Jonathan Weiner, *The Beak of the Finch: A Story of Evolution in Our Time* (New York: Alfred A. Knopf, 1994); B. Rosemary Grant and Peter R. Grant, *Evolutionary Dynamics of a Natural Population* (Princeton, NJ: Princeton University Press, 1989).

vast network of observers, most self-selected volunteers in a region with little bird-watching tradition. Vogt was quite pleased with the enthusiasm and accuracy with which the island guards compiled records of recovered bands in order to obtain a finder's fee. Dozens of other observers, some as far away as Colombia and southern Chile,also returned bands, making the project a spectacular success. On island after island, Vogt and his assistants made extensive measurements of local ambient and oceanic conditions using simple meteorological instruments. They measured the nesting densities of a number of colonies and made crude attempts at determining their statistical distribution. Vogt later introduced the use of aerial photographs, which he hoped to use with these density estimates to calculate colony size for entire islands--and eventually for the entire coast. He hoped, someday, that these observations and the new mathematical "laws" of population growth could be used to make precise demographic predictions. In 1955, at a time when the guano bird population was at its peak during the twentieth century, CAG and the Peruvian air force used these techniques to make the first good population estimate for the entire Peruvian coast. Of an estimated 33,280,000 birds, 81 percent were guanayes, 17 percent piqueros, and two percent alcatrazes.[14]

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14. Vogt journal, Isla Chincha Norte, 31 Jan. 1939, 1 Feb. 1939, Isla Asia, 6 Feb. 1939, Isla Tortugas, 11 Feb. 1939, Isla Chincha Norte, 23 Mar. 1939, 24 Apr. 1939, 25 Apr. 1939, Isla Santa Rosa, 5 May 1939, Isla Chincha Norte, 18 May 1939, Isla Macabí, 18 Feb. 1940, Vogt papers, box 3:1; "Nest Densities," manuscript, Vogt papers, box 3:3; "Resumen de la labor verificada en Ballestas, durante los días 24-31 de junio de 1941," manuscript, Vogt papers, box 3:3; Vogt, "Enumeración preliminar de algunos problemas relacionados con la producción del guano en el Perú," *BCAG* 15:7 (July 1939), 287-288; idem, "Aves guaneras: Estudios sobre su biología," *BCAG* 15:8 (Aug. 1939), 311-312; idem, "Informe anual del ornitólogo," *BCAG* 16:5 (May 1940), 145, 160; idem, "Aves guaneras," *BCAG* 17:4 (Apr. 1941), 161; idem, "Informe sobre las aves guaneras," 26; Gamarra, "Ensayo sobre la zoonomía de las aves guaneras del Perú," *BCCAG* 2 (1955), 117.

Vogt also made extensive, though less systematic observations of the other organisms that inhabited the environs of the bird colonies in an attempt to identify the ecological relationships that affected their welfare. When he and his assistants came anywhere near to the colonies, particularly when they sat for hours in the blind, they simply could not ignore the presence of lice and ticks. Like earlier Peruvian scientists, Vogt wondered how these parasites might impact the health of the colonies. A healthy bird carried quite a load of parasites. Might a lack of food increase the level of their attacks? Older fledglings certainly spent a great deal of effort to gain access to the ocean to wash themselves of these pests and cool themselves. Since he did not think it worth the effort to capture and kill large numbers of birds to quantify their parasite load, Vogt opted to use his own body as a scientific subject: he carefully noted the number of parasites that attacked him when he sat in the blind and tried to correlate these attacks to local climatic conditions. This self-observation provided the basis for many of Vogt's conclusions regarding the microclimate of the nesting colonies.[15]

In search of "natural" ways to manage the bird colonies, Vogt paid a great deal of attention to the predators of these parasites. In particular, he observed the behavior of eight different arachnid species and the *lagartija* and *saltojo* lizards (*Tropidurus peruvianus* and *Phillodactylus* sp.) that coexisted with the bird colonies. Vogt experimented with the construction of small shelters for the lizards so they could effectively regulate their body temperatures in areas that had been

15. Vogt, "Enumeración preliminar de algunos problemas," 293-296; idem, "Informe sobre las aves guaneras," 113-114.

completely cleared of rocks by guano workers in their drive to eliminate parasites. Even though he already doubted the effectiveness of killing predators, Vogt also tried lacing eggs with strychnine to eliminate the local vulture population. Finally, as he became more and more convinced that food supply was the key to the stability of the bird colonies, Vogt made systematic hauls and microscopic analyses of plankton, the primary producers of the marine environment, with the assistance of the U.S. planktonologist Mary Sears.[16]

But how should he interpret his observations? It was vital for Vogt to figure out exactly which factors led to the initiation, expansion, and abandonment of nesting colonies to enable CAG to manage them more effectively. Vogt's work was made much easier by the fact that male and female guanayes become subtly differentiated during mating season. Harking back to his work with Noble and foreshadowing Tinbergen's famous experiments with gulls, Vogt speculated that their green eyelids and red eye borders were centers of recognition. Vogt immediately recognized that the guano birds did not cooperate by sharing protection of egg clutches as do Australian emus, although he toyed briefly with the anthropomorphic idea that the guanayes organized themselves in military ranks, especially when feeding. Vogt soon came to the conclusion that each bird acted as a complete individualist except during its nesting relationship with a single mate. Vogt eventually formed the hypothesis that adult males defend nesting territories

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16. Vogt journal, Isla Chincha Norte, 5 Feb. 1939, Chucuito to Isla Don Martín, 10 Feb. 1939, Isla Macabí, 13 Feb. 1939, Isla Chichna Norte, 20 Oct. 1939, 31 Oct. 1939, 9 Nov. 1939, 11 Nov. 1939, Vogt papers, box 3:1; W. J. Gertsch to Vogt, 29 July 1943, Vogt papers, box 1:1; Vogt, "Las lagartijas y las aves guaneras," *BCAG* 15:9 (Sept. 1939), 346-348.

with a favorable microclimate, especially flat, open sites with exposure to cool southern winds and a smooth surface that discouraged the multiplication of parasites. Males then actively sought to attract females to these sites through specific calls, gestures, and the construction of small nest mounds. Late in 1939, he first recorded in his journal the observation that intense predation on the periphery of nesting colonies tended to make the periphery unstable. This observation probably would not have meant much to Vogt if not for his preformed notion that predators are integral to the "balance of nature." Vogt later noticed that other factors were involved in this peripheral instability, such as the tendency of chicks to wander from the nest and unpaired adult birds to fight over nesting materials.

Finally in 1941, Vogt made some basic generalizations from these observations, in effect, describing the life-cycle of a typical nesting colony each year: Colonizing guanayes first struggled to occupy the most ecologically desirable territory; a colony would then grow outward from this nucleus at a consistent density (which he measured precisely on several islands) and would become more stable as the colony grew, since chicks at the center were likely to be forced back to the nest by their neighbors and because the adult birds at the center were more likely to defend their prime territories. The periphery of the colony was less stable, not simply because of predation, but because the birds were less advanced in the breeding cycle, less invested in their chicks, less devoted to their nests as a consequence, and, therefore, more likely to leave the nests when food was scarce. In Vogt's understanding, much like a sheep dog or wolf with a flock of sheep, predators helped keep the colony intact by picking off these stragglers; predation also helped to prevent overpopulation. The fact that Vogt came to no conclusions regarding the competitive advantage presented by these behaviors was a clear indication that he belonged to the era before the neo-Darwinian synthesis in biology.[17]

Vogt also noted some marked behavioral differences between the three main species of guano birds. The piqueros were more territorial and less gregarious than the guanayes, although not to the extent of their close relatives, the camanayes--which he deemed to be economically useless as producers of guano. The piqueros also tolerated a much broader range of nesting conditions, including cliffs, and ate a broader range of fish, although not to the extent of the alcatrazes which could nest successfully in deep crevices and even on the hot northern island Lobos de Tierra. In short, the different guano birds occupied quite different ecological niches and were not in competition with each other for resources in a significant way.[18] All of these observations had profound significance for the management of the bird colonies.

Vogt's final generalizations regarding territoriality were strongly influenced by his chance observation of a protracted "ecological depression on the Peruvian coast." The field sciences have always been constrained by a fundamental uncertainty: Are the conditions observed at a particular time and place "normal"

17. Vogt journal, Isla Chincha Norte, 5 Feb. 1939, 10 Aug. 1939, 15 Nov. 1939, 23 Nov. 1939, Isla Chincha Norte, 4 Apr. 1941, 12 Oct. 1941, Vogt papers, box 3:1; Vogt, "Informe sobre las aves guaneras," 42-43, 47-50, 53-54.

18. Vogt, "Informe sobre las aves guaneras," 90-91, 96, 98-99.

enough that they can be used to constitute genuine, *general* knowledge of an organism or the environment?

A strong El Niño event blasted Peru almost continuously from 1939 to 1941 just as the rest of the world was finally leaving the Great Depression behind and entering the Second World War. The persistence of this environmental shift "radically modified" the ecological relationships of the Peruvian littoral to an extent comparable to the more extreme but shorter-lived El Niño events of 1982-1983 and 1997-1998.[19]

Sitting in his blind on Isla Chincha Norte, Vogt shared the palpable discomfort of the guano bird colonies as the air temperature rose, particularly when the north wind blew, to a high temperature of 26 degrees Celsius (79 degrees Fahrenheit) in the shade in March 1941, and up to 41 degrees Celsius (106 degrees Fahrenheit) in the sun--far above normal for this cool maritime environment. Many older chicks began a dangerous search for water to drink and cool off in; this led thousands to plunge like lemmings over cliffs to their deaths. Although Vogt never interpreted his observations explicitly in such terms at this point in his career, this was exactly the sort of behavior that initially led Charles Elton to his interest in animal population cycles--and others (including Vogt) to the belief that overpopulation "naturally" leads to high rates of suicide.[20] Some adult guanayes stayed to shield their chicks from the sun, but eventually 90 percent abandoned their nests. All nesting piqueros under Vogt's observation left their eggs and

19. Vogt, "Una depresión ecológica en la costa peruana," *BCAG* 16:10 (Oct. 1940), 328.

20. On the scientific basis for the popular image of suicidal animals, see Chitty, *Do Lemmings Commit Sucide?*, esp. 210 n. 17.

chicks to certain death. Not all animals suffered from these changed conditions: condors, vultures, skuas, and flies (*Sarcophaga* sp.) had a field day on all this carrion. Meanwhile, blue-footed boobies arrived like "Cassandra's voices of death" as far south as Isla Santa Rosa, 1,000 miles from their normal range.

These anomalies threatened to ruin Vogt's entire research project--not to mention their impact on guano production. But this El Niño provided other scientific opportunties. It gave Vogt the chance to observe the behavior of a new pelican colony on Isla Chincha Norte. Helpful observers from hundreds of miles away began to return leg bands from migrating guano birds, as far north as Buenaventura, Colombia, and as far south as the Isla de Chiloé in southern Chile. These returns indicated that most guano birds migrated south to Chilean waters to wait out El Niño events. But many never returned to their home range. So many birds died at Iquique that this northern Chilean city had to hire trucks for their removal. Physicians there were kind enough to send a few back to Vogt for examination.[21]

Why had these parents abandoned their young? The heat could not be the only answer, because it would not explain how the few remaining birds successfully recruited young and why so many birds that left soon died. Following Elton's lead, Vogt suspected that lack of food was the answer. This inspired his interest in plankton, the first link of the "food chain" that led to the guano birds.

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21. Vogt journal, Isla Chincha Norte, 20 Nov. 1940, 23 Nov. 1940, 1 Mar. 1941, Antofagasta, Chile, 21 Jan. 1942, Vogt papers, box 3:1; Vogt, "Una depresión ecológica en la costa peruana," 311, 316, 328-329; idem, "Aves guaneras," 127-138, 143-144; idem, "Informe sobre las aves guaneras," 5, 59, 93.

Using the language of Clementsian successionalisim, Vogt ultimately concluded from his microscopic analyses that an "etenophore-salp climax" community of plankton typical of warm, tropical waters had replaced a much more productive and nutritious "radiolarian-copepod climax" typical of cold waters. This signified a sharp decline in primary production at the base of the "pyramid of numbers" and a catastrophe for the animals living at its apex that depended on their abundance for sustenance. (According to this basic Eltonian concept, a population of predators [the guano birds] requires a much larger population of primary consumers [the anchoveta] and a vast population of primary producers [phytoplankton] in order to subsist.) Vogt found abundant qualitative signs of starvation in the guano birds that did not fly away: he recovered vegetable matter from the stomachs of several moribund birds he dissected (both chicks and adults), and he saw many an adult return from feeding only to find an aggressive swarm of hungry chicks barring the way to the nest--leading the besieged parent to regurgitate a small amount of precious food to rid itself of these beggars. The din of feeding calls from hungry chicks lasted longer and longer--until it ended altogether with their massive deaths. George Leove of W. R. Grace & Co., another U.S. expatriate, confirmed that he had observed many emaciated birds during the 1925 cataclysm at Isla Lobos de Tierra.[22]

22. Vogt journal, Isla Pescadores, 13 Mar. 1939, Isla Chincha Norte, 30 Dec. 1940, Vogt papers, box 3:1; Vogt, "Informe sobre las aves guaneras," 60-64, 66, 69-72. For a more detailed introduction to the pyramid of numbers and its relation to energy flow within an ecosystem, see Ricklefs, *Ecology*, 174-176, 189-209.

But what had happened to their principal food source, the anchoveta? This question was much more difficult to answer empirically. At least everyone agreed that schools of fish were much less common at the surface and seemed to be out of sight and out of reach of the guano birds during their daily quests for food. According to Elton's pyramid of numbers, if plankton (the base) and guano birds (the apex) had displayed a sharp change in kind and numbers during this El Niño event, then the anchoveta (the middle) must have declined in numbers, as well.[23]

With strong prodding from his Peruvian colleagues, who respected the tradition of epidemiological research that Lavalle had established, Vogt did not totally rule out disease as a factor in this population crisis. For this part of his studies, he relied on the expertise of the well-developed community of physicians and hygienists in the region. Director Telémaco Battistini Sánchez and pathologist Quentin M. Geimán of the Peruvian Instituto Nacional de Higíene y Salud Pública personally travelled to Isla Chincha Norte to take tissue samples, determine the parasite load of birds in various states of health, and dissect corpses. Marshall Hertig, also of the Instituto Nacional, did an extended study of ticks to determine their life cycle and possible role as disease vectors. Together, they concluded that even healthy guano birds carry an extensive load of parasites besides the obvious ticks and lice: nematodes, tapeworms in the intestines, flagellates in the cloaca. They detected no noticeable organisms in the birds' blood, although that did not rule out ectoparasites as vectors of disease (such as viruses). They concluded that aspergillosis caused some bird deaths, confirming Lavalle's earlier work, but they

23. Vogt, "Informe sobre las aves guaneras," 66, 72-75.

encountered few cases, especially compared to the number of obvious cases of malnutrition. Along the coast of Tarapacá, where many of the guano birds had migrated, the Iquique physician J. García Suárez reported the appearance of external symptoms of "bird cholera" among dead and dying birds. Neither Chilean nor Peruvian scientists could confirm this bacteriologically, even among birds returning from the south to central Peru that showed similar symptoms. Many observers also noted the appearance of "*pata pálida*" (palid foot) among moribund birds. Vogt related this visible illness to anemia, although his hematology experiments were inconclusive. Disease certainly caused many deaths, Vogt explained to his superiors, but the evidence overwhelmingly indicated that food, not disease, was the root ecological cause of this population crisis.[24]

Based on all these observations, Vogt took this conclusion one step farther: He declared that the availability of anchoveta fundamentally limited the size of the guano bird population and the growth of the Peruvian guano industry. As we shall see in later chapters, this theoretical conclusion led Vogt into a nasty debate with his Peruvian colleagues that had major significance for the future development of Peru's fishing industry.

24. Vogt journal, Isla Chincha Norte, 18 Mar. 1939, 2 Apr. 1939, Vogt papers, box 3:1; Vogt report to Ballén, 16 May 1941, Vogt papers, box 3:2; Vogt, "Informe anual del ornitólogo," 151-152; idem, "Informe sobre las aves guaneras," 4, 22, 76-77, 79, 113-114. On the establishment of the Institute of Hygiene, see Cueto, *Excelencia científica en la periferia*, ch. 4.

Vogt's Recommendations

Vogt was not ready to admit that the carnage caused by this El Niño event indicated that the guano birds live in a constant, chaotic struggle with their environment. Instead, when making his policy recommendations he fell back on the Clementsian idea that biological communities tend to exist in cyclic equilibrium unless they are disturbed by humans. Guano birds could travel only a limited distance away from their nests in a day, so breeding failure was inevitable during El Niño events when their principal food, the anchoveta, was difficult to find. Elton's pyramid of numbers simply collapsed for the birds. Vogt insisted that these events were cyclic, not abnormal, happening every seven years or so. They served to prevent what he termed an "irruption" (progressive overpopulation) among the guano birds that would lead to even greater ecological disruption. Based on his limited observations of successful breeding and the past experience of the Peruvian guano industry, Vogt reasoned that the guano birds were remarkably fecund and would recover rapidly from an "ecological depression," just as the global economy always recovered from periodic economic downturns, even the Great Depression. Vogt concluded, furthermore, that massive death from disease was unlikely in a population in balance with its environment. In fact, he thought parasites were beneficial to the guano bird population as a whole, since they probably helped kill off birds with more dangerous infections.[25]

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25. Vogt, "Enumeración preliminar," 296; idem, "Una depresión ecológica en la costa peruana," 324; idem, "Informe sobre las aves guaneras," 22, 84-86, 88-89.

These observations had tremendous implications for scientific management of the guano birds and the development of input-intensive Peruvian agriculture based on guano. The population of guano birds depended on the supply of anchoveta; thus, guano production would plateau when both fish and birds attained their "climax" populations, and then crash again during the next El Niño event. Moreover, *any* exploitation of the anchoveta would put the guano bird population at risk of collapse.[26] Vogt's general message was clear: beyond a certain level, Peruvian farmers would have to look somewhere other than Peru's marine environment for concentrated fertilizer.

Yet these natural limits to the growth of guano production did not mean humans could not alter the existing environment to favor the guano birds in some ways. Vogt reasoned that the guano islands had been altered from their primoridial state when their ancient deposits were removed during the nineteenth century, so there was no harm in further alterations, particularly if they were done to replicate the pristine past. After studying the microclimate of the bird colonies, Vogt confirmed Lavalle's 1918 conclusion that guanayes, at least, preferred to nest in areas exposed to the prevailing winds. With this in mind, Vogt proposed that CAG use explosives to flatten the topography on more crowded islands to open new areas to the wind and to fill crevices. He hoped this would give them a semblance of the "aerodynamic" quality of the dome-like guano deposits he supposed existed in ages past. (In fact, by flattening the surface of some guano islands, human

26. Vogt, "Aves guaneras," 127-138; idem, "Informe sobre las aves guaneras," 109, 111, 118-120.

guano extraction actually made them more attractive to the guano birds, especially in the case of Isla Macabí; see illus. 2.) Vogt hoped that World War II might turn out to be a boon for such a project, since the end of hostilities would likely produce a sudden glut of cheap munitions.

Some CAG employees suggested that CAG should exterminate the piquero and perhaps even the alcatraz populations to rid the guanayes of competition for food and nesting space, especially since the guanayes produced a superior grade of guano. Vogt strongly objected to this notion, arguing that the three main guano birds occupied distinctly different niches in the local ecology. The alcatrazes, for example, were much less affected by El Niño events and produced significant quantities of guano when most of the guanayes had flown to Chile. In fact, Vogt thought CAG could manipulate these ecological differences: much more guano could be harvested from the piqueros by taking full advantage of their propensity to nest on cliffs. All CAG needed to do was hang nesting platforms over the cliffs. Not only would they increase the area available for nesting, but they could be raised after the chicks fledged in order to harvest the guano. Vogt had already demonstrated their potiential by experimentation, although he admitted they might not be economical because of the expense of wood and steel cable in Peru. (Vogt thought Peruvian industrialization would eventually remove this barrier. As we shall see in the next chapter, by the end of the 1940s, Vogt became convinced that industrialization was impossible for most of Latin America, including Peru.)

Finally, Vogt proposed the construction of safety ramps that would help young birds reach the water to bathe, structures akin to the fish ladders that helped spawning salmon get over dams. This action would help control parasites during “normal” years and reduce the number of accidental deaths during hot El Niño conditions.[27]

Despite his apparent enthusiasm for environmental alteration on the guano islands, Vogt criticized many of CAG’s older island hygiene policies. In some ways, he thought CAG had made the islands too clean. He noted that all the predators of bird parasites required shelter to regulate their body temperatures, but rock and guano removal had eliminated almost all surface shelter on many islands. To make matters worse, guano workers routinely killed the saltojo lizard in the belief (he thought unfounded) that they were poisonous. This had to be stopped, Vogt contended, and CAG needed to construct hundreds of lizard shelters to remedy the harm already done. Island surface cleaning also removed feathers and other material the birds needed to build nests. This led to increased competition and fighting between the birds for scarce nest material, the lack of which probably increased chick mortality. He thought CAG should leave this material behind.

In some ways, however, Vogt thought the guano islands were not clean enough. Like so many North American scientists in the tropics--including Murphy during his visit to the guano islands 20 years before--Vogt was obsessed with the uncleanliness of *human* excrement. The guano workers routinely defecated in the open air, he noted with disgust, and their feces provided a food source for flies and

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27. Ref. for this section: Vogt journal, Isla Chincha Norte, 21 Mar. 1939, Isla Lobos de Tierra, 14 Aug. 1939, Vogt papers, box 3:1; Vogt, “Informe anual del ornitólogo,” 145-168; idem, “Informe sobre las aves guaneras,” 39-41, 90-91, 96, 98-99, 122-123, 125-126. Cf. Lavalle, “Estudio sobre los factores que influyen sobre la distribución de los nidos,” 207-213; Duffy, Hays, and Plenge, “The Conservation Status of Peruvian Seabirds,” 251-252.

dung beetles which distracted the lizards from the birds' parasites. Human dung also fed rats which posed a threat to both humans and the guano birds. Vogt implored his superiors to install clean, comfortable latrines near work sites and perhaps introduce ferrets (all male to prevent any unwanted reproduction) to eliminate the rats. Vogt thought poison-laced grain would not work because the rats had an alternative food source and easily developed resistance to poisons--thus revealing, in incipient form, the sort of attitude toward poisons that became so important during the later DDT controversy in the United States.[28]

Vogt further admonished CAG for failing to eliminate chickens and other fowl from the habitations of its island workers. He agreed with Luis Gamarra that these birds potentially carried diseases of Old World origin to which the guano birds had no immunity. Pet and feral cats also needed to be eliminated since they preyed on the lizards. He thought CAG should stop wasting its resources on gulls and vultures which "naturally" helped to prevent guano bird overpopulation, in his view. Nevertheless, he shared Murphy's view that the Andean condor posed a genuine threat to the colonies. But he thought these "majestic" birds should only be killed after they had been observed preying on a colony. Otherwise, Vogt feared, these national symbols might suffer the fate of the California condor, which was nearly extinct. In sum, CAG needed to return the environment of the guano islands to as "pristine" a condition as possible, even if this required even greater

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28. On scientific attitudes in the United States toward human excrement and poisons, see Anderson, "Excremental Colonialism"; Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring* (Cambridge, UK: Cambridge University Press, 2001).

alteration of the islands to make up for other human changes of their ecology. Paradoxically, Vogt did not blanch at suggesting the use of fire to "disinfect" the nesting areas after each harvest to eliminate parasites.[29]

What was the broader meaning of these recommendations? Vogt undeniably recognized that humans had the capacity to destroy the natural ecological balance of the Peruvian littoral as, he noted, they had destroyed the U.S. southern Plains and created the Dust Bowl. In contrast to Coker and Forbes who emphasized the direct threat humans posed toward the guano birds alone, Vogt chose to emphasize the more subtle dangers posed by human alteration of the guano islands' ecological community. He thought CAG had done a good job protecting the guano birds, but now the *total* environment of the guano birds needed human vigilance, if the guano birds were to be fully protected. This meant that the entire ecology of the guano birds needed investigation in all of its complexities, a gargantuan task. The anchoveta, the guano birds' primary food source and the proximate cause for the disruption of guano production during El Niño years, needed special attention. Therefore, Peru had to increase its investment in the technocratic management of its marine environment by a significant sum. Such a declaration was in keeping with concurrent proposals in the United States

29. Sources for this section: Vogt, "Las lagartijas y las aves guaneras," 346-348; idem, "Informe anual del ornitólogo," 150, 158-159; idem, "Aves guaneras," 165, 167; idem, "Informe sobre las aves guaneras," 40-41, 81-82, 112-113, 115-118, 121, 123, 125; Murphy, "Informe sobre el viaje de estudios realizado por el Dr. R. Cushman Murphy en el año 1920," *BCAG* 30:2 (Feb. 1954), 16-20.

for ecologists, agronomists, and soil scientists to supervise the recovery of the grasslands and agriculture of the southern Great Plains.[30]

Training a Successor

Vogt was not the man to oversee this expansion. By the time he began work on his final report, Vogt had worn out his welcome in Peru in a fight with CAG's other experts over the scientific basis for his recommendations and plans to exploit Peru's anchoveta fishery. In December 1941, Francisco Ballén informed Vogt that CAG's board of directors had decided to terminate his contract "despite the importance of [his] studies." As a conciliation, they gave Vogt permission to use his data in any way he saw fit once he returned to the United States. But they did not give up on the idea that CAG should employ a professional ornithologist: they promised to hire Vogt's assistant to continue his research if Vogt was able to obtain a scholarship for him to study in the United States.[31]

In September 1940, after he encountered him during a vacation to Arequipa, Vogt had hired Enrique Ávila, a native of the Lake Titicaca region, to assist him during his second full season observing birds at Isla Chincha Norte. "Hank," as Vogt called him, had decent English skills and some scientific training, although Vogt was appalled at their inadequacy in places, particularly Ávila's antiquated, state-published textbook *Zoología peruana*. He appreciated Ávila's ability to learn

30. Vogt, "Informe sobre las aves guaneras," 118-120; Worster, *Dust Bowl: The Southern Plains in the 1930s* (New York: Oxford University Press, 1979), pt. 5; Tobey, *Saving the Prairies*, 191-222.

31. See introduction; Ballén to Vogt, 18 Dec. 1941, Vogt papers, box 1:1. Regarding Vogt's relationship with other CAG technocrats, see ch. 6.

quickly, however, and gave him the responsibility to record offshore ocean temperatures so they could follow the local development of the El Niño phenomenon. Ávila stayed on as Vogt's assistant until Vogt's termination and even translated Vogt's reports into Spanish for use by CAG officials.[32]

As we learned in the introduction, Ávila was acutely aware of his inferior social status in Peru. He recognized, even more than Vogt did, the opportunity for social elevation that the technocratic ideal promised for a man with his background.

In 1942, Vogt used his connections to arrange for Ávila to study at the University of Wisconsin with his friend Aldo Leopold (1887-1948). Vogt could not have provided Ávila with a more qualified mentor. Leopold was the definition of the conservation technocrat and had done as much as anyone to expand the purview of nature management in the United States. Although one of his biographers claims that Leopold "was not by nature an engineer," he certainly was by nurture.[33] After obtaining a master's degree in 1909 from the Yale Forest School, the first professional program in forestry in the United States, Leopold worked variously as an administrator for Gifford Pinchot's U.S. Forest Service in the U.S. Borderlands and as a wildlife researcher in the upper Midwest. In 1933, he took a position as the University of Wisconsin's new professor of game management in its Department of Agricultural Economics. That same year, he

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32. Vogt journal, Lima, Sept. 1940, Isla Chincha Norte, 7 Nov. 1940, Vogt papers, box 3:1; Vogt, "Informe sobre las aves guaneras," 4.

33. Susan L. Flader, *Thinking Like a Mountain: Aldo Leopold and the Evolution of an Ecological Attitude toward Deer, Wolves, and Forests* (Columbia: University of Missouri Press, 1974), 172.

promised "control over nature" through "co-ordination of science and use" to those who followed the guidelines of his new textbook *Game Management*.

Leopold is better-known today for his philosophical streak. He prefaced this declaration of technocratic optimism in *Game Management* with a caution:

> We of the industrial age boast of our control over nature. Plant or animal, star or atom, wind or river--there is no force in earth or sky which we will not shortly harness to build "the good life" for ourselves. But what is the good life? Is all this glut of power to be used for only bread-and-butter ends? Man cannot live by bread, or Fords, alone. Are we too poor in purse or spirit to apply some of it to keep the land pleasant to see, and good to live in?[34]

Leopold took this question to heart and became a major political activist for the preservation of undeveloped wilderness areas. Meanwhile, he began to formulate his famed land ethic, a philosophical rule that would govern humans' relationship with their natural environment:

> Quit thinking about decent land-use as solely an economic problem. Examine each question in terms of what is ethically and esthetically right, as well as what is economically expedient. A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.

This prophet of the Age of Ecology worked to instill these principles in his Peruvian disciple. As we shall see in the next chapter, their relationship helped to reinforce Vogt's already profound attachment to Leopold.[35]

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34. Leopold, *Game Management* (New York: Charles Scribner's Sons, 1933), vii.

35. Leopold, *A Sand County Almanac*, 224-225. There are a multitude of studies of Aldo Leopold's life, thought, and importance to the modern enviromental movement; see Flader, *Thinking Like a Mountain*; Worster, *Nature's Economy*, 271-274, 284-290; Curt Meine, *Aldo Leopold: His Life and Work* (Madison: University of Wisconsin Press, 1988); Max Oelschlaeger, "Aldo Leopold and the Age of Ecology," ch. 7 in *The Idea of Wilderness: From Prehistory to the Age of Ecology* (New Haven: Yale University Press, 1991); Roderick Nash, "Aldo Leopold:

Ávila had a tough time completing his studies, but finish he did. In 1945, Ávila returned to Peru with a master's degree and a five-year contract to take over Vogt's former duties as CAG ornithologist. In fact, Ávila had an academic degree equal to or better than his two mentors in an age when a doctorate was still more the exception than the rule among field scientists anywhere in the Americas. Because of the El Niño of 1939-1941, CAG was in deep financial trouble and political turmoil for most of the 1940s. The fact that CAG hired Ávila at all is a testament to its devotion to the technocratic ideal.

Ávila struggled to establish an ambitious bird research program. His overall goal was to reduce the fluctuation of the guano bird population. Ideally, he hoped to continue Vogt's studies of the birds' external environment and ecology and combine these with new studies of their anatomy and physiology. But Ávila ran into constant barriers in his bird research, some economic, some political. CAG's directorate only reluctantly agreed to pay for a fraction of the equipment he requested for an ornithology lab. Bird banding had gone on hiatus after Vogt's departure; Ávila wanted to band 80,000 birds over four years, but had trouble acquiring the US$9,000 needed to purchase bands. Even after he acquired some bands, he had trouble obtaining reliable transport to the guano islands to do the actual work, or to do timely scientific investigations of any kind. Ávila did eventually band 20,000 birds in 1950, and CAG banded 58,000 more in 1956. In

Prophet," ch. 11 in *Wilderness and the American Mind*, 3d ed. (New Haven: Yale University Press, 1982).

accord with local scientific interests, Ávila migrated to the well-established study of guano bird parasites and epidemiology.[36]

Ávila's training and degree only provided him with a small measure of prestige at CAG, much less than he expected. Vogt had tried to warn Ávila that his colleagues might not automatically bow to his expertise: "You will have a much higher scientific standard than many of the people with whom you will be associated," Vogt cautioned. "Some of them will recognize this and, consciously or unconsciously, resent it and tend to drag you down if they have the chance. This is the inevitable situation facing a pioneer," Vogt added, referring to his own troubled experience at CAG. "It is unfortunate that a scientist should have to consider such things, but it is inescapable in the United States, and even more so in Latin America."

Vogt may have been correct, but the pattern of Ávila's experience suggest that other forms of discrimination were a factor. For example, when all of the "bigwigs and *técnicos*" at CAG received a cost-of-living increase in their salaries in

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36. Ávila to Vogt, 15 May 1945, 23 July 1945, 17 Sept. 1945, 20 June 1947, 15 Feb. 1949, Vogt to Ávila, 19 May 1945, Vogt papers, boxes 1:1, 3; Ávila, "Informe sobre el plan a seguir en el estudio de las aves guaneras," *BCAG* 21:7 (July 1945), 229-232; *MCAG* 40 (1949), ix. Ávila's parasite and epidemiology studies include, "Enfermedades mas corrientes entre las aves silvestres," 21:4 (Apr. 1945), 87-[?]; idem, "Sobre la efectividad de 'Gamexana' en la lucha contra las garrapatas en las aves guaneras," *BCAG* 22 (1946), 261-[?]; idem, "Sobre la diftero viruela [fowl pox] en los guanayes," manuscript, 16 Sept. 1949, Vogt papers, box 1:1; idem, "El epitelioma contagioso en el guanay," *BCCAG* 1:1 (Sept. 1953), 43-50. Studies on the same subect by other CAG employees include Rafael La Rosa Llosa and Teodoro Ramos Saco, "Informe sobre la mortandad de las aves guaneras," *MCAG* 30 (1949), cxxx-cxxxiv; Juana María Coha, "Informe sobre parasitología de las aves guaneras," *BCAG* 25:9 (Sept. 1949), 265; idem, "Investigación preliminar al estudio de tremátode en los riñones del guanay *Phalacrocorax bougainvillei* [sic]," *BCAG* 25:11-12 (Nov.-Dec. 1949), 295-302; Blanca Rojas Escajadillo, "Descripción preliminar de *Syngamus sp*. encontrado en el guanay (*Phalacrocorax bougainvillii*)," *BCCAG* 1:2 (Sept. 1954), 93-97.

1946 and again in 1947, Ávila was overlooked. He complained to Vogt that he was forced to send his wife and daughter back to live with their family in Puno because his S/.900 a month salary (US$138) simply would not cover their living expenses when his paycheck was losing more than 20 percent of its real value every year due to inflation. Ávila received less than half the pay of his scientific peer at CAG, the German oceanographer Erwin Schweigger, though his salary certainly qualified as a middle-class income in Peru. Ávila also failed to obtain patronage for his brother Néstor at CAG. He confided to Vogt that things might have been different if he declared membership in the APRA party, implying that his superiors' personnel decisions were biased by political partisanship. (According to his widow, Ávila was both apolitical and an atheist.) Ávila's racial identity and provincial origin did not help his situation any, nor, as we shall see in chapter 6, did his involvement in a bitter scientific debate with his peers over the growth of the anchoveta fishery in Peru.[37]

But Ávila was not satisfied to simply sit back and take these slights. He was no fool, and recognized that Peruvian politics, even in a technocratic institution like CAG, operated on the basis of patronage not merit. First, he appealed to his own scientific patrons for help. Robert Cushman Murphy promised to put in a good word for Ávila "to prevent his bosses in Lima from doing a number of things which are dead wrong" ecologically. Murphy spoke in Ávila's favor to his old friend Enrique Dibos Dammert, a prominent Peruvian agribusinessman friendly to

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37. Vogt to Ávila, 8 Oct. 1945, Ávila to Vogt, 24 Apr. 1946, 17 Sept. 1947, 23 Oct. 1947, Vogt papers, boxes 1:1, 1:3; interview with Basilia Díaz Viuda de Ávila and Ingrid Ávila Díaz, Lima, Peru, 13 June 2001.

conservationism who had recently been appointed to CAG's board of directors. When this did not work as intended, Ávila contemplated taking a job with the Sociedad Chilena de Fertilizantes--Chile's analogue to CAG--and even submitted his resignation. This strategy worked: his superiors promised to improve Ávila's working conditions and provide him with greater institutional support for his bird research.

Fortunately, the growing guano bird population provided the funds CAG needed to deliver on this promise. As part of a broad strategy to improve its scientific apparatus during the late 1940s and early 1950s, CAG established a permanent marine biology research station on Isla Don Martín and placed it under Ávila's control. Once entrenched in this position, Ávila went to work on a series of scientific studies and trained Peru's next guano bird expert, his assistant Rómulo Jordán Sotelo. Jordán eventually took marine bird research to a new level and trained another generation of Peruvian bird experts at the Instituto del Mar del Perú.[38]

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38. Murphy to Vogt, 15 Nov. 1946, Vogt to Murphy, 2 Dec. 1946, Ávila to Vogt, 17 Sept. 1947, 12 Apr. 1948, 26 Apr. 1948, 6 Apr. 1949, Ávila to Señores Directores de la CAG, 12 Apr. 1948, Vogt papers, boxes 1:1, 1:2, 1:4; *BCCAG* 1:1 (1953), cover. On the extensive land holdings of the Dibos Dammert family, see Malpica, *Los dueños del Perú*, 95-96.

Important ornithological studies by Rómulo Jordán and his disciples include, Jordán "El fenómeno de las regurgitaciones en el guanay (*Ph. boungainvillii*) y un método para estimar la ingestión diaria," *BCAG* 35:4 (1959), 23-40; idem, "Emigraciones y mortandad de las aves en el invierno y otoño de 1963," *Informe del IREMAR* 27 (1964); Jordán and Humberto Fuentes, "Resultados de los censos gráficos de aves guaneras efectuados durante el ciclo reproductivo 1962/1963," *Informe del IREMAR* 22 (1964); idem, "Las poblaciones de aves guaneras y su situación actual," *Inf.Inst.Mar Perú* 10 (Apr. 1966); Humberto Tovar S., "Areas de reproducción y distribución de las aves marinas en el litoral peruano," *Boletín del Instituto del Mar del Perú* (La Punta, Callao) 1:10 (1968); idem, "Las poblaciónes de aves guaneras en los ciclos reproductivos de 1969/70 a 1973/74," *Inf.Inst.Mar Perú* 45 (1978); Tovar, Guillén, and Nakama, "Monthly Population Size of Three Bird Species off Peru, 1953 to 1982."

Ávila was not the only person struggling to make a career as a professional ornithologist during these years. As other institutions tied to Peru's fishing industry began to hire scientists, the science faculty of the Universidad Nacional Mayor de San Marcos in Lima came to recognize the need for a local academic training program in marine science. Following CAG's lead, it hired a foreign expert, the German marine biologist Hans-Wilhelm Koepcke, for the job. In 1950, the German ornithologist Maria Miculicz-Radecki (1924-1971) took up residence in Peru after finishing her doctorate at the University of Kiel. She almost immediately married Koepcke (to whom she was probably already engaged), and they worked together for two decades at the university's Museo de Historia Natural "Javier Prado" as researchers and as mentors to a new generation of Peruvian biologists. Even though she had credentials equal to her husband, she was never granted a professorship before she died tragically in a plane crash in the course of her tropical bird research.[39]

By the time Ávila finally consolidated his position at CAG in the mid-1950s, he had become noticeably dissatisfied with the narrow elitism that went along with the technocratic ideal in Peru. In fact, he began to see this elitism as a major barrier, not only to his career and the progress of science, but to environmental protection in Peru: "There will be no true *Conservation* while this discipline is the patrimony of distinguished professors, outstanding academic

39. *Diccionario histórico y biográfico del Perú,* s.v. "Koepcke Miculicz-Radecki, María Emilia Ana [sic]"; Maria Koepcke, *The Birds of the Department of Lima, Peru*, trans. Erma J. Fisk (Wynnewood, PA: Livingston Publishing, 1970); originally published as *Las aves del Departamento de Lima* (Lima, 1964); Vegas Vélez, "La investigación oceanográfica en el Perú desde Humboldt a nuestros días," 148.

circles, cultivated social nuclei, calloused institutions." Like Vogt and Leopold, Ávila came to believe that the "material conquest" being directed by the developmental experts of his day would be seen as "ephemeral" or even "illusory" by "future societies." In his view, the Peruvian populace needed to be properly educated so they could tell the difference proper technocratic direction and impractical developmental nostrums: "In order to be effective, Conservation has to become the ABC of the man on the street."[40] As we shall see in the next chapter, Ávila had many reasons to be unhappy with Peru's elitist conservation movement.

In stark contrast to his mentors and much of Peru's scientific elite, Ávila was all too aware of the unmet needs of those "poor in purse" in his own society. To use Leopold's words, Peru lacked both "bread and Fords." How could a poor country like Peru continue its development while showing respect for the "impoverished earth" (*esquilmada planeta*)? This was the central dilemma that faced the new cohort of Peruvian marine scientists Ávila founded. For his part, Ávila thought only "an advanced ecological ethic," premised on the imperative that each generation should leave "an equally giving, equally productive, equally *healthy* earth" to its offspring, would provide a solution to this modern dilemma. Echoing the Mexican intellectual José Vasconcelos's statements on the Cosmic Race, Ávila believed it was Latin America's historical duty to follow the dictates of "contemporary ecology" if it was to justify itself as "the New Continent and Promised Land in World History."[41]

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40. Ávila's emphasis; Ávila, "Etica en marcha," *BCAG* 30:5 (May 1954), 22-23.
41. Ibid., Ávila's emphasis; Leopold, *Game Management*, vii.

Opening New Horizons

Vogt's guano bird research had little impact on scientific understanding in the rest of the world, even though it spoke to a number of major concerns in the fields of ornithology, ecology, and ethology. Vogt simply neglected to publish anything of note on these subjects for English-speaking scientists upon his return to the United States. He became preoccupied with what he thought were much more pressing concerns. In Peru, however, Vogt's work had a major impact on conservation science. His studies eventually helped propel Peru's guano industry to new levels of success during the 1950s.

But in the short term, nothing Vogt discovered could have helped CAG avoid the crisis of the early 1940s. Under the onslaught of the El Niño phenomenon and with the outbreak of World War II, the old agroecological system that linked guano production to the export of agricultural staples completely fell apart. These external shocks caused agricultural demand for guano to fall significantly, though not nearly enough to regain parity with the guano supply, much less to resolve pent-up demand. Moreover, El Niño acted differently this time around. From 1939-1941, it worsened for three consecutive nesting seasons, rather than the usual one or two. It returned again in force in 1943. Only the strongest adult guanayes and piqueros could cope with these conditions, and they failed to recruit a vigorous year-class of offspring until 1944. Guano production and sales plummeted, along with CAG's profits, bottoming out at 67,537 metric tons sold in 1943, the lowest figure since 1922-1923. This only met one-fourth of Peruvian national demand.[42]

Thanks to a series of political shifts, export agribusiness completely lost its privileged access to the guano supply during this ecological depression. CAG therefore lost its main bastion of political support with far-reaching consequences. But CAG's technocratic redirection saved it from extinction for the time being.

In 1939, Manuel Prado y Urgarteche (1889-1967) replaced General Benavides as Peru's chief executive. His less-than-democratic election represented the return of civilian government to Peru after Sánchez Cerro's assassination in 1933. Prado was the first president of Peru with genuine scientific credentials. He was an expert in hydraulic engineering and held a doctorate in civil engineering from the Escuela de Ingenieros (1910), where he wrote his thesis on pluviometrics, the study of precipitation and runoff measurement, an ancillary science of meteorology. At least initially, Prado's career followed a pattern typical of the early-twentieth-century Peruvian technocrats we have seen: He briefly worked as a mathematics professor at the Universidad de San Marcos, then served as inspector of works for the Lima municipal council, before beginning an undistinguished parliamentary career that led to his exile during Leguía's dictatorship.

Prado's ascent to the heights of political power was only marginally based on his expertise. He was from one of Peru's most prominent banking families whose rise was deeply rooted in the schemes of the Aristocratic Republic. His brother Jorge, a military officer, was General Benavides's right-hand man. Thanks

42. See app. 2-4, and fig. 2, 7.

to these connections, as well as his scientific credentials, Manuel was named director of the Banco Central de Reserva in the aftermath of Peru's default on its foreign loans. He oversaw the systematic abandonment of the orthodox monetary policies advocated by "the money doctor of the Andes," Edwin Kemmerer. Such acts helped Peru out of the Depression. Several years later, when a trial balloon indicated Jorge was untenable as a presidential candidate, Benavides handpicked Manuel as his successor. Manuel Prado enthusiastically adopted the persona of the engineer as president, and like Leguía, he is remembered as one of the *gran constructores* of modern Peru.[43]

In this spirit, Prado made the agronomic engineer Carlos Moreyra Paz Soldán (b. 1898) one of his closest aides, first as Minister of Development and Public Works during his first term in office (1939-1945) and then as vice president during his second term (1956-1962). Moreyra had worked with the agronomist Gerardo Klinge as a sugar estate manager and presided over the Sociedad Nacional Agraria. He had even closer ties to the Prados' financial empire, including a stint as director of the Banco Popular. But what really solidified his place among Peru's ruling elite was the development of his family's Hacienda San Isidro into one of Lima's richest suburbs. By attaining these high governmental positions, Prado and

43. Felipe Portocarrero Suárez, *El Imperio Prado, 1890-1970* (Lima: Universidad del Pacífico, Centro de Investigaciones, 1995), 81-89, 115-123, 158-159; Gilbert, *The Oligarchy and the Old Regime*, 281-283; Pike, *The Modern History of Peru*, 276-281; Thorp and Bertram, *Peru, 1890-1977*, 35; Bertram, "Peru, 1930-60," 419-420, 422-424; Cotler, *Clases, estado y nación*, 253-260; Baltazar Caravedo Molinari, *Burguesía e industria en el Perú (1933-1945)* (Lima: Instituto de Estudios Peruanos, 1976), ch. 5, 6. On Prado's accomplishments as builder of Peru's modern infrastructure, see *Peru: Obra de gobierno del presidente de la República Dr. Manuel Prado, 1939-1945* (Buenos Aires: Guillermo Kraft, 1945).

Moreyra opened new horizons for the technically trained--at least those who belonged to Peru's leading families.[44]

With regard to guano and national agriculture, Prado's administration initially tried to maintain the status quo of the late 1930s. As table 6 shows, the lion's share of guano continued to go to cotton and sugar planters, though they had to pay extra to get it.

But Prado's government gradually took a populist turn. Many historians have interpreted this as a recognition of the rising political influence of the urban middle class and working-class supporters of Haya's persecuted APRA party. Others see it as a pragmatic (even cynical) response to the conditions of a world at war explicitly intended to prevent urban unrest and co-opt APRA support. Since so much of coastal Peru's arable land was devoted to export crops, its coastal population was highly dependent on food imports, especially wheat and rice. The severe inflation of food prices during World War II distorted Peru's international balance of trade and hurt wage-earning Peruvians badly. In March 1940, Prado's government began controlling food prices at the cost of creating shortages. This paved the way for more state interventions in Peru's agricultural economy, including a series of decrees limiting the amount of coastal property that could be planted in export crops. In June 1943, as part of this broader policy, CAG gave food producers absolute priority in guano purchases in an attempt to stimulate domestic food production. By law, export-crop growers had to find other sources

44. *Diccionario histórico y biográfico del Perú*, s.v. "Moreyra Paz Soldán, Carlos"; *La obra de los ingenieros en el progreso del Perú* (Lima) 2 (1931), s.v. "Moreyra Paz Soldán, Carlos"; Malpica, *Los dueños del Perú*, 90.

of fertilizer. These were hard to come by, of course, since much of the world's nitrogen production was headed for explosives manufacture. In the short term, these policies had little effect, at least on consumer prices: According to CAG, the cost of living in Peru continued to increase by 233 percent and the price of imports by 261 percent from 1943-1948. As Enrique Ávila discovered, wage increases seldom kept pace, even though the Peruvian government was creating more and more public sector jobs to oversee and enforce these changes, for example, in its new Ministry of Agriculture (est. 1943).[45]

Prado and his successors wanted to use guano to encourage directed agricultural development and diversification. To a significant extent, they succeeded, at least over the long term. As table 6 shows, Prado's distribution policy reinforced a trend begun during Benavides's tenure that enabled small purchasers to consume a far greater proportion of CAG's production. For the rest of its existence, CAG encouraged the sale of fertilizer to small producers by offering them lower prices and priority access. In the process, these small purchasers became integrated into the system of input-intensive agriculture. Nevertheless, small purchasers only bought more guano than large purchasers during one year of CAG's entire history, 1943. Peruvian smallholders had many things working against them as they struggled to compete with modern agribusiness, including government price controls designed to benefit urban consumers at their expense. These forces led increasing numbers of rural peasants

45. *MCAG* 36 (1945), iv; *MCAG* 40 (1949), lii-liii; Thorp and Bertram, *Peru, 1890-1977*, 173, 177-179, 199-201.

to leave the land for the *barriadas* (shanty-towns) that began to envelop Lima and other Peruvian cities after 1950.[46]

CAG's guano distribution policy was much more successful at encouraging agribusiness to cultivate food crops and forage for dairy cattle on a large scale. Irrigated rice became one of the principal products of Lambayeque and the rapidly developing Piura- and Jequetepeque-valley regions. (Gildemeister & Co. owned huge tracts of land in the latter.) Lima-area farmers converted much of their property to the cultivation of grain, forage, and other food crops--if they did not pave it under altogether for urban developement. In the late 1950s, CAG finally achieved a long-term goal by convincing grain and potato planters in the Sierra,

46. Key works for understanding trends in peasant agriculture, rural proletarianization, and the rural exodus to Lima and other cities after 1940 include Joan Martínez Alier, *Haciendas, Plantations, and Collective Farms: Agrarian Class Societies, Cuba and Peru* (London: F. Cass, 1977); idem, *Los huacchilleros del Peru: Dos estudios de formaciones sociales agrarias* (Paris: Ruedo Ibérico, 1973); studies by José Matos Mar, such as *Yanaconaje y reforma agraria en el Perú: El caso del valle de Chancay* (Lima: Instituto de Estudios Peruanos, 1976); and Manuel Burga, *De la encomienda a la hacienda capitalista: El Valle de Jequetepeque del siglo XVI al XX* (Lima: Instituto de Estudios Peruanos, 1976). The virtual closure of the Archivo del Fuero Agrario after it was moved to the overwhelmed Archivo General de la Nación has made it difficult to pursue such studies in recent decades, though see Karl S. Zimmerer's fieldwork-based *Changing Fortunes: Biodiversity and Peasant Livelihood in the Peruvian Andes* (Berkeley and Los Angeles: University of California Press, 1996). Cf. Martínez Alier, "Ecology and the Poor: A Neglected Dimension of Latin American History," *JLAS* 23 (1991), 621-639.

On these trends more generally and for comparable regions, see Robert McC. Netting, *Smallholders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture* (Stanford, CA: Stanford University Press, 1993); Enrique C. Ochoa, *Feeding Mexico: The Political Uses of Food since 1910* (Wilmington, DE: Scholarly Resources, 2000); Lawrence S. Grossman, *The Political Ecology of Bananas: Contract Farming, Peasants, and Agrarian Change in the Eastern Caribbean* (Chapel Hill: University of North Carolina Press, 1998); Jack Temple Kirby, *Rural Worlds Lost: The American South, 1920-60* (Baton Rouge: Louisiana State University Press, 1987). Older, still influential studies include Ester Boserup, *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure* (Chicago: Aldine, 1965); Jeffery M. Paige, *Agrarian Revolution: Social Movements and Export Agriculture in the Underdeveloped World* (New York: Free Press, 1978).

especially around Huancayo, to adopt input-intensive agricultural practices. Such shifts are reflected in the regional distribution of guano in Peru.[47]

In sum, these policies achieved some of their populist intent. They broadened the distribution of guano by region, crop, and property size, though they still provided the greatest benefits to a new class of agricultural lords dedicated to the provision of food to Peru's burgeoning urban areas. But in terms of the total area dedicated to export agriculture along the Peruvian coast, these policies convinced few farmers to convert their lands to food production. Guano never came close to making Peru self-sufficient in food production.

Meanwhile, political conflict over these policies came close to destroying any pretensions CAG might have had to autonomy--a vital ingredient, at least theoretically, to true technocratic governance.

After a complicated series of political machinations, partly inspired by the triumph of "democratic" forces in World War II, Manuel Prado decided to step aside at the end of his presidential term. He scheduled elections for June 1945 and his favored candidate, José Luis Bustamante y Rivero, a law professor from Arequipa, won a clear majority of Peru's limited electorate with vital support from the legalized APRA party, which gained control of Congress. This seemingly peaceful and democratic transfer of power, the first at the executive level since the 1910s, was hardly tranquil where CAG was concerned.

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47. See app. 7; Macera, "El guano y la agricultura peruana de exportación," 442, 445; Thorp and Bertram, *Peru, 1890-1977*, passim.

Old-guard agro-exporters did not submit freely to these populist policies. They owned a majority of private shares in CAG, and they used CAG's board of directors to rally their forces against Prado's restrictive guano distribution policy. Agro-exporters stood to lose money, not only from their lack of access to cheap fertilizer at a time when fertilizer imports were difficult and expensive to obtain, but also because Prado's policies sold CAG's scarce product at the lowest possible price, thus eroding their dividends even further. At its annual meeting early in 1945, the board elected a new president, agronomist Gerardo Klinge. His immense scientific prestige notwithstanding, Klinge was the complete opposite of the image of the impartial technocrat. He had been a leading partisan of the Partido Nacional Agrario, an ultra-conservative front for Peruvian agro-exporters that had taken an unbending stance in favor of free trade and vocally opposed Prado's election in 1939. Klinge made sure that cotton and sugar cane planters were able to resume their consumption of limited amounts of guano. Other partisans expressed extreme dissatisfaction with CAG's management. Some even suggested dissolving the Sección Técnica to reduce CAG's overhead and increase its profitability. Francisco Ballén, sensing the change in the political winds, announced his retirement as general manager in July 1945 after 33 years of service.

CAG's old-guard directorate initially appointed Ernesto Diez Canseco Yáñez (b. 1907) to replace Ballén. He had the proper technical credentials: a degree in mining engineering with a speciality in industrial hygiene and years of experience as a manager in Peru's northern oil fields and highland mines. He had the added prestige of having recently completed a course of study at Harvard

University funded by the Rockefeller Foundation. Like Prado and Moreyra, and for that matter, Lavalle and Ballén, family connections cleared the way for his promotion. Diez Canseco Yáñez's father, Ernesto Diez Canseco Masías-- a one-time mining engineer with long experience at Cerro de Pasco--happened to be president of the Peruvian Senate. Everyone knew Diez Canseco Yáñez got this job as a cronyist political favor.

When Bustamante's government took power in August 1945 after trouncing his conservative rivals at the polls, it began a complete house cleaning at CAG. Bustamante summarily booted out General Benavides's old client-technocrat, Carlos Alayza, as the government's representative on CAG's board of directors and replaced him with the agronomic engineer Carlos Llosa Belaúnde. Klinge and four other board members resigned before Bustamante could force their exit. Diez Canseco Yáñez followed them out the door when the newly elected Congress announced an investigation of CAG's management. A veteran manager, the agronomist Rómulo E. Lanatta (who had been originally hired in the midst of the crisis following Leguía's overthrow in 1930), took over in the interim. An emergency shareholders' meeting elected an almost entirely new board of directors. Six of ten posts were filled by men with engineering degrees, including the presidency by José Barreda Bustamante and the vice-presidency by Robert Cushman Murphy's old friend Enrique Dibos Dammert (both of whom were agro-exporters of a different political stripe.) Dibos succeeded Barreda as board president in 1947 and 1948. Meanwhile, three present or former CAG technicians were rumored to be under consideration for Ballén's old position: Lavalle, Gamarra, and Lanatta. But the new board promoted the president's man, Carlos Llosa, to the post.[48]

This new group of managers thus obtained their positions primarily for their political allegiances, rather than for their technical qualifications. Carlos Llosa Belaúnde (illus. 26), yet another product of Peru's Escuela Nacional de Agricultura, presided over CAG from 1945 to 1954. Llosa's administrative skills immediately won the confidence of his superiors and most of CAG's remaining technocratic corps. Yet considering the intense scrutiny he faced during the political polarization of these years, it is nearly miraculous he survived in this position.

Even before Bustamante took office, several of Peru's leading agro-exporters had been plotting against him and his *aprista* allies. They despised his continued interventions in the agricultural economy. For example, in 1947 Bustamante and APRA forced through a major, pro-labor reform in coastal sharecropping (*yanaconizaje*) that eliminated many of the advantages held by large cotton producers. Agro-exporters had their revenge. In 1948, as Bustamante's government proved unable to resolve an accelerating economic crisis and unwilling to put down working-class unrest, they convinced the Peruvian military to replace Bustamante's faltering government with a right-wing dictatorship devoted to free trade. Besides losing his political patron, Llosa had to face intense criticism from

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48. Ref. for this section: Ávila to Vogt, 23 July 1945, 17 Sept. 1945, 16 Oct. 1945, Vogt papers, box 1:1; *Diccionario biográfico del Perú*, ed. Escuelas Americanas (Lima: Imprenta Torres Aguirre, 1944), s.v. "Diez-Canseco Masías, Ernesto," "Diez-Canseco Yáñez, Ernesto"; "Homenaje al nuevo sub-gerente Sr. Dr. Rómulo E. Lanatta," *BCAG* 16:5 (1940), 141-144; *MCAG* 37 (1946), x-xi; Pike, *The Modern History of Peru*, 273-274, 279-281; Contreras and Cueto, *Historia del Perú contemporáneo*, 268-271.

another expert, Rómulo Lanatta, who doubted Llosa's devotion to CAG's conservation policies and fiscal probity.[49]

Llosa was able to survive because he and the rest of CAG's technicians achieved overwhelming success at redirecting CAG's system of guano production and distribution to serve several masters. Their actions stunningly vindicated the ideal of environmental management by experts, at least where the guano industry's fortunes were concerned. Llosa's staying power is again testimony to the ability of the technocratic ideal to provide grounds for agreement between opposing factions.

Under Llosa, CAG did not forget agro-exporters. Despite President Bustamante's continued devotion to Prado's diversification policies, CAG allowed cotton and sugar cane planters to retain the access to guano they had gained in 1945. As a payback for the vocal support it got from powerful agro-exporters, the military junta that took power in 1948 instructed CAG to triple the price of guano, ostensibly to stabilize CAG's finances. This made guano too expensive for many small producers and freed up some (though not all) of the supply for agro-exporters eager to profit from the pent-up international demand for sugar and cotton after the war. (Despite the declining price of Chilean nitrates and synthetics produced by the Haber-Bosch process, imported fertilizers were still more expensive.) CAG's stockholders reaped enormous dividends.

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49. Ávila to Vogt, 12 Dec. 1945, Vogt papers, box 1:1; *MCAG* 41 (1950), xvii-xviii, lxxxii; Lanatta, *Informe*, esp. 7-8; cf. CAG, *Informe que el directorio presenta al Señor Ministro de Hacienda sobre las actividades de la Compañía en los ultimos cinco años* (Lima: Imprenta Gil, 1948); Contreras and Cueto, *Historia del Perú contemporáneo*, 271-274, 281-283.

Such manipulation of the guano supply could do nothing to remedy the basic problem: there simply was not enough guano to go around in Peru. CAG could not even supply half of total Peruvian demand for nitrogen fertilizer. CAG again went into the fertilizer import business to help ease the pain of this transition to synthetic fertilizers. In February 1946, Bustamante's government had given CAG permission to import and sell duty-free nitrates and synthetic fertilizers to commercial farmers, although CAG was not allowed to establish a distribution monopoly. That year, CAG imported and sold 11,966 metric tons of nitrates from Chile to large producers and 6,606 metric tons to smallholders. By 1958, CAG still sold 29,305 of the 766,656 metric tons of fertilizer imported nationwide. Under Llosa, CAG also looked to improve the services it offered to "scientific" farmers in Peru. In 1951, a German company completed a new industrial plant for CAG in Callao that could mix guano *rico* and *pobre*, imported nitrates, and other chemicals in set proportions. This enabled CAG to market a full line of fertilizers chemically balanced for use on different crops. Peruvian cane and cotton planters never again purchased the majority of guano (Prado's diversification policy was never totally undone), but this powerful economic interest continued to receive a valuable service from CAG during the late-1940s and 1950s.[50]

The main reason CAG prospered during these years, however, had to do with its management of Peru's marine ecology. Under Llosa's watch, crews of

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50. See table 6 and app. 3; *MCAG* 37, (1946), iv-v; *MCAG* 38 (1947), i-ii, vi, xix; *MCAG* 39 (1948), viii; *MCAG* 42 (1951), vii; *MCAG* 50 (1959), x, anexos; Thyrele Robertson, *The Peruvian Fertilizer Industry, Present Situation and Future Prospects*, Iowa-Peru Program Economic Study, no. 4 (Lima, May 1968), esp. 101.

workers "conditioned" the islands for the guano birds in line with the 1942 Vogt report. Almost immediately after he took over as general manager, Llosa instructed Enrique Ávila to do a survey of each island to identify locations amenable to "surface regularization" with explosives. Much of the stone produced by these landscape alterations was then used to build containment walls on the islands. In accord with Vogt's recommendations, these were designed to reduce losses by preventing hot, thirsty chicks from falling to their deaths in search of water and by discouraging adult birds from launching themselves into the air from the edge of cliffs. (Vogt had observed that birds tend to defecate at take off.) CAG workers built over 31 kilometers of walls of this type by 1949, remnants of which are immediately apparent on the guano islands today. As noted in chapter 3, CAG initiated a major campaign against the condor population of Isla La Vieja in 1946, and it soon became CAG's single largest guano-producing territory. During the late 1940s when CAG was flush with money, Llosa arranged the purchase of loading machinery and several new ships so CAG could more rapidly transport guano away from the islands. Llosa rationalized this expense (which was harshly criticized by Lanatta) with the argument that CAG could regularize its island rotation schedule and leave the bird colonies in peace for a longer period each year, since loading and transport slowed guano exploitation more than any other factor. CAG put off indefinitely, however, Vogt's suggestion to build cliff platforms for the piqueros, much less shelters for the lizards, and it completely ignored his advice to stop indiscriminate shooting of other predatory birds, despite Ávila's protests.[51]

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51. Ávila to Vogt, 25 Nov. 1945, 12 Dec. 1945, 12 Apr. 1948, Vogt papers, box 1:1;

CAG's managers did not follow Vogt's counsel to the letter. Instead, they took several of his observations of bird behavior and developed their own ways to take advantage of them. The most important policy change adopted by CAG after 1945, by far, was an extension of two of Vogt's main findings: 1) that food and competition for nesting space were the basic factors limiting the total size of the breeding population, and 2) that most birds migrated south during El Niño years when warm surface water flowed in from the north.

During his first year as general manager, Llosa became obsessed with circumventing the cyclic "ecological depressions" caused by El Niño. He seized on the observation that not all guano birds flew to Chile during the 1939-1941 crisis: many hung around coastal points in southern Peru. What kept them from establishing breeding colonies in the south during El Niño years? The answer was seemingly obvious: there were no suitable islands. But what prevented successful nesting on the mainland? Llosa reasoned that the wild fox or *zorro* (*Dusycyon sechurae*), rats, feral cats, and other predators prevented them from establishing viable colonies on coastal points, even though there was sufficient anchoveta in adjacent seas. He came up with a brilliant solution: CAG would create artificial "islands" along the southern coast by building walls to isolate coastal points of land already frequented by roosting guano birds. Llosa hoped these would provide a breeding refuge during El Niño years and perhaps prevent the guanayes from

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MCAG 38 (1947), i-v; *MCAG* 39 (1948), vii; *MCAG* 40 (1949), vi-vii. Again, this scheduling was not as strict nor as careful as CAG claimed it to be; see Lanatta, *Informe*, 25-26.

"wasting" so much of their excrement over Chile. (All available evidence indicates Llosa came up with this idea on his own.)

CAG workers completed construction of walls isolating Puntas Tres Hermanas, Lomas, and Coles in 1948 (illus. 31). In fact, CAG did not have to wait for another big El Niño for this experiment to bear fruit: birds almost immediately colonized Punta Coles. This unexpected success led to the decision to isolate points along a stretch of the north-central coast where there were no islands in order to promote "even exploitation of the sea surface" by the guano birds. As this policy continued to prove its worth, CAG completed isolation walls around 14 mainland points by 1961. CAG also conditioned the surface of these coastal points and tried to reduce their vulnerability to contraband guano and egg extraction. It increased the number of manned guard stations to a peak of 24 in 1955, although its real spending on its guardian staff and stations by the late 1950s was less than one-third of what it had been during the late 1930s.[52]

These isolation walls allowed the guano birds to surpass their former breeding limits. Guano production reached new heights during the 1950s thanks to dramatic production increases from these artifical guano islands. Some rapidly joined the ranks of Peru's most lucrative guano-producing territories. In 1945,

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52. These walls were situated (in order of construction) on Puntas Tres Hermanas, Lomas, Coles, Atico, Litera, Culebras, San Juan, Colorado, Salinas, Malabrigo, La Chira, Pampa Redonda, La Grama, and Lomitas; see map 1. Each *Memoria* lists all operating guard stations and their operating cost; *MCAG* 38 (1947), i-ii, v-vi; *MCAG* 39 (1948), vii; *MCAG* 40 (1949), v-vi; *MCAG* 44 (1953), iv; *MCAG* 45 (1954), v; *MCAG* 46 (1955), vi; *MCAG* 47 (1956), vi, xvii; *MCAG* 48 (1957), vi; *MCAG* 49 (1958), xvii-xviii; *MCAG* 52 (1961), xi; Murphy, *El guano y la pesca de anchoveta: Informe oficial al Supremo Gobierno* (Lima: CAG, 1954), 23-24; idem, "Peru Profits from Sea Fowl," *National Geographic Magazine* Mar. 1959, 401, 404-405, 408-409; Gamarra, "Ensayo sobre la zoonomía de las aves guaneras," 113-116; Tovar, Guillén, and Nakama, "Monthly Population Size of Three Guano Bird Species off Peru," 213-214.

CAG removed less than two percent of its guano from coastal points. In 1956, coastal points supplied nearly 30 percent of total guano production. In that year, CAG extracted an all-time record of 332,223 metric tons of fresh guano *rico* at an all-time record concentration of 15.21 percent nitrogen by weight. If only for a season, CAG produced more guano--and significantly more nitrogen--than was mined in an average year during the Guano Age! By this measure alone, the Compañía Administradora del Guano was an immense triumph for the principle of sustained-yield conservation.[53]

Carlos Llosa gave full credit to "long and patient scientific studies" for the record guano harvests of these years.[54] These production increases demonstrated the worth of Vogt's science in the most dramatic way possible. It is worth underscoring that Llosa, Ávila, and the rest of CAG's managers arrived at these policies not by following Vogt's specific recommendations for environmental management, but by creatively applying his general scientific observations. This showed the value of placing technically competent individuals, not only in research and advisory positions, but also in positions of power.

The institutionalization of professional ornithology at CAG had given its technocrats new tools with which to "domesticate" the guano birds and their breeding territory. This enabled CAG to increase the supply of guano to agro-exporters, though not to the levels of the 1930s. It also allowed CAG to continue encouraging the adoption of input-intensive practices by other farmers--both large

53. See app. 1, 8; "Anexos: Gráfico no. 2," *MCAG* 54 (1963).
54. *MCAG* 42 (1951), 71-72.

and small--in new parts of the country, especially grain producers. Both right- and left-wing partisans had reason to be pleased, if not fully satisfied, since CAG never again came close to supplying Peru's entire demand for concentrated fertilizer. The choice of William Vogt was pivotal for the continued development of the guano industry and the technocratic ideal in Peru.

Through Vogt, CAG's triumph also inspired widespread enthusiasm for environmental management by experts that reached far beyond Peru's borders. Similar to Jean Baptiste Boussingault's brief encounter with the Peruvian guano trade over a century before, which led to his life-long fascination with the fertilizing powers of nitrogen compounds, Vogt's intense experience with Peru's guano birds during the disastrous El Niño of 1939-1941 made him obsessed with the relationship between population, subsistence, and environmental change. His Peruvian sojourn was hardly a career detour. It put this Lord of the Guanay on a trajectory to become one of the main architects of modern environmentalism.

Chapter 5

The Road to Survival:

William Vogt and Environmentalism in the Americas

Your prophecies on Mexican agriculture at the end of the next 100 years have produced quite a national commotion.
'Guano,' my dear Doctor, 'guano' is the word.
--Carlos Benítez to William Vogt (1946)

Many things are at stake in the history of environmentalism. Long before the identity politics of recent years, creating a sense of *belonging* has been one of the fundamental motivations for writing history. Belonging is tied up with who deserves credit for triumphs and failures in the past, as well as who deserves influence within the halls of power in the present. The history of guano-bird conservation in Peru belongs at the core of the history of environmentalism, since, as this chapter will show, Peru's experiment had a powerful, reciprocal influence on environmentalism in the rest of the Americas during the mid-twentieth century.

It is still common wisdom that the modern environmental movement was born in the United States and Western Europe during the twentieth century as a revolt against the excesses of industrialization. The first generation of self-identified environmental historians ratified this belief with histories of the passing of the frontier, of the invention of National Parks, of the preservation of wilderness, of the drive to protect "beauty, health, and permanence." Indeed, William Vogt's initial interest in conservation was inspired by the threat that urban civilization posed toward wild birds. More recently, historians have written new accounts that have expanded environmentalism to a plurality of movements. This trend has been pushed especially by critics of "environmental racism," the tendency of policies designed to protect (or hurt) the environment to privilege the interests of affluent, professional, white (sub)urbanites and to discriminate against poor, working-class people of color, especially those living near sources of industrial pollution.

Richard Grove, a historian of European "green imperialism," has pushed back by centuries the date when modern environmentalism got its start. Grove turned completely on its head the notion that environmentalism was initially a response to industrialism: instead, he argues, environmentalism has its origins in the first-hand encounter of European scientists, technicians, and physicians with "tropical island Edens" dessicated by the forces of colonialism and the plantation complex. In short, modern environmentalism was born on the colonial "periphery" of the imperial world system between the sixteenth and mid-nineteenth centuries. Most recently, a historian of "global environmentalism" reasserts the old notion that environmentalism--now in two phases (1750-1945, 1962-present)--fundamentally represents a rejection of northern industrialism. Between these two periods, an "age of ecological innocence" supposedly intervened when environmental ideas failed to alter the course of the great Age of Development.[1]

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1. On these points, see Ramachandra Guha's recent survey, *Environmentalism: A Global History* (New York: Longman, 2000); Richard Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600-1860* (Cambridge, UK: Cambridge University Press, 1995); Robert Gottlieb, *Forcing the Spring: The Transformation of the American Environmental Movement* (Washington, DC: Island Press, 1993); Anna Bramwell, *Ecology in the 20th Century: A History* (New Haven, CT: Yale University Press, 1989); Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985* (Cambridge, UK: Cambridge University Press, 1987); David Pepper, *The Roots of Modern Environmentalism* (London: Croom Helm, 1984); Roderick Nash, *Wilderness and the American Mind*, 3d ed. (New Haven, CT: Yale University Press, 1982). This short list necessarily omits many important, though less-seminal essays and books. One recent work attempts to extend Grove's conclusions to more recent North American imperialism in the Pacific Basin: Gary Kroll,

This brief recitation is necessary to demonstrate how important the "Peruvian" events described in this work are for our understanding of this global history. We only need to look back to the 1940s to discover an instance when events on the periphery of the industrial world powerfully influenced the history of environmentalism. One of the major fixtures of modern environmental thought is the belief that many (if not most) of the world's problems are a consequence of the exploding human population--or worse, that the world stands on the verge of an apocalypse because of progressive overpopulation. It is only a slight exaggeration to say that such "neo-Malthusian" ideas got their start when the North American conservationist William Vogt witnessed the collapse of Peru's guano bird population due to a subsistence crisis caused by the El Niño of 1939-1941. (Note that this trend stemmed from Vogt's encounter with a *successful* environmental management project overseas, rather than the degradation emphasized by Grove.) A few years later, Vogt's visit to El Salvador, the most densely populated country in the Americas, fully convinced him that overpopulation doomed most of the Latin American "continent" to eternal poverty, strife, and environmental catastrophe.[2] At least for Vogt, this was no age of ecological innocence.

In fact, Vogt's experience in Peru fundamentally changed the course of his career and by extension the trajectory of environmentalism in the Americas. Even before he left Peru, Vogt's engagement with CAG contributed to the organization

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"Exploration in the *Mare Incognita*: Natural History and Conservation in Early-Twentieth Century America" (Ph.D. diss., University of Oklahoma, 2000).

2. On Vogt's conception of Latin America as a unified ecological and cultural region, see "A Continent Slides to Ruin," *Harper's Magazine* June 1948, 481-489; cf. Martin E.Lewis and Kärin E. Wigen, *The Myth of Continents: A Critique of Metageography* (Berkeley and Los Angeles: Univeristy of California Press, 1997).

of the Comité Nacional de Protección a la Naturaleza (National Committee for the Protection of Nature), an elitist group of professionals who hoped to use its shared prestige to influence the course of economic development in Peru. Such activities made Vogt an ideal candidate to head a new conservation office within the Pan-American Union. Vogt used this office to spread his ideas to other Latin American countries, especially Mexico and Chile. To a striking extent (illustrated by this chapter's epigraph), guano remained a focus of Vogt's post-CAG activities. This reveals not only CAG's international notoriety, but also its influence on Vogt's understanding of the ecological relationship between the fertility and integrity of the soil, the health and productivity of the land, and human prosperity.

When he returned permanently to the United States, Vogt's professional experience in Latin America equipped him to play a key role in the emergence of the environmental movement in his homeland, both as a popular author and as an outspoken advocate of birth and population control. His seminal 1948 book *Road to Survival* was a manifesto advocating a new human relationship to the environment. It displayed Vogt's continued allegiance to the technocratic ideal. At least initially, Vogt had much more impact on environmentalism than his now better-known colleague Aldo Leopold. But it is difficult to separate their involvement since they were such close friends and collaborators, particularly when it came to their shared interest in animal "irruptions," the publication of Leopold's *A Sand County Almanac*--and, as we have already seen, the career of their young disciple Enrique Ávila. Together, Vogt, Leopold, and a small group of U.S. conservation *professionals* created an important part of the ideological framework of later environmentalists. (Note that Vogt, like many conservationists, often crossed the amateur-professional divide during the course of his career.)[3]

The broader reception of Vogt's ideas was, of course, an important part of this process and one over which he had little control. The horrors unleashed by World War II and the growing potential for nuclear holocaust made many readers receptive to Vogt's apocalyptic rhetoric. At the same time, a widespread desire to reject these horrors and attribute them to totalitarian extremism led most people to dismiss Vogt as an anti-progressive fatalist. In the reception of Vogt's book, one sees the opening of an international, optimist vs. pessimist divide over the issue of economic development. This had its analog in Vogt's 1930s experience as editor of *Bird-Lore*, his conflict within CAG's scientific cadre, and the development of the Peruvian fishing industry (subjects of chapters 6-8). People tended to read what they wanted in *Road to Survival*. I am no different, my pretensions to historical objectivity notwithstanding. My singular reading of this important book has a purpose: it is intended to place it in the context of Vogt's Peruvian and Latin

3. Historians have long debated whether the U.S. conservation movement had its strongest root in professionalism or amateur reformism--and whether a conflict between these two traditions led to the destruction of important natural areas, such as the Hetch Hetchy Valley in California, to make way for technological progress. Samuel Hays, in *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920* (Cambridge, MA: Harvard Univeristy Press, 1959), wrote the classic study of U.S. conservationism as a movement of technocratically inclined professionals such as U.S. Forest Service chief Gifford Pinchot. Stephen Fox, in contrast, argues in *The American Conservation Movement: John Muir and His Legacy* (Madison: University of Wisconsin Press, 1981) that a vocal group of amateurs led by John Muir formed the base of American conservationism. Of course, these two perspectives are not mutually exclusive. Note that Hays later concluded that "technical professionals" diverted the U.S. environmental movement from most of its more radical aims after 1970, in *Beauty, Health, and Permananence*, ch. 12, esp. pp. 419-422.

American experience and pursue an alternative reading emphasizing Vogt's anti-capitalist, anti-imperialist, and technocratic notions.

Some of Vogt's ideas will seem abhorrent to present-day readers, as they did to his contemporaries, particularly his assertion that progress in public health and medicine is undesirable, even dangerous, since it encourages population growth by decreasing the death rate. Vogt freely associated with eugenicists, who welcomed the demise of "less fit" (i.e., less educated, less prosperous, less WASPy) humans. In their hands, the population explosion became the new "yellow peril." Such fears profoundly influenced both population control policies and crop-breeding research supported by the Rockefeller family during the 1950s. It is well-known that the latter led to the development of high-yielding grain varieties that formed the basis for the so-called Green Revolution--a major case in which environmental ideas influenced the course of world development during this supposed "age of ecological innocence."

As we shall see in chapter 8, Vogt's population thinking turned around and affected the course of events in Peru, when defenders of Peru's new fishing industry cynically claimed they were reducing world hunger. Even more remarkably, Vogt influenced the writing of environmental history, particularly the so-called Berkeley School of historical demography which almost single-handedly convinced us that the indigenous population of the Americas was very large before 1500, and that the forces of what we now call "ecological imperialism" helped Europeans along in their conquest of the globe. As much as Aldo Leopold, Vogt deserves the title "prophet" of the Age of Ecology and credit for initiating an environmental movement that was geographically, if not socially, broad-based.[4]

The Comité Nacional de Protección a la Naturaleza

The continued development of a conservation movement in Peru was a direct extension of Peru's guano experiment. During his tenure as CAG ornithologist, Vogt acted as a catalyst for the establishment of what was probably the first Peruvian society established solely for conservation advocacy. This organization is significant because it displays links between conservation movements in the Americas, especially the importance of technocrats to these groups. Most significantly, this society's failings reveal important barriers that face environmentalisms premised on the interests of a select few.[5]

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4. On Vogt's importance to the U.S. environmental movement, see Gottlieb, *Forcing the Spring*, 36-37; Fox, *The American Conservation Movement*, 306-313; Worster, *Nature's Economy*, 352. Cf. Max Oelschlaeger, "Aldo Leopold and the Age of Ecology," ch. 7 in *The Idea of Wilderness: From Prehistory to the Age of Ecology* (New Haven: Yale University Press, 1991); Nash, "Aldo Leopold: Prophet," ch. 11 in *Wilderness and the American Mind*. Vogt is unjustly ignored in several other prominent histories. On the transition from a professional-dominated conservation movement to a popular environmental movement, see Hays, "From Conservation to Environment: Environmental Politics in the United States since World War II," in *Out of the Woods: Essays in Environmental History*, ed. Char Miller and Hal Rothman (Pittsburgh, PA: University of Pittsburgh Press, 1997), 101-126.

5. The shortcomings of elitist, technocratic, gender-biased, even racist conservation movements is becoming a leitmotif of environmental histories of the colonial and postcolonial worlds. See Dean, *With Broadax and Firebrand*, esp. 241-242, 257-264, 361-363; Simonian, *Defending the Land of the Jaguar*; Melissa Leach and Cathy Green, "Gender and Environmental History: From Representation of Women and Nature to Gender Analysis of Ecology and Politics," *Environment and History* 3:3 (Oct. 1997), 343-370; John M. MacKenzie, ed., *Imperialism and the Natural World* (Manchester, UK: Manchester University Press, 1990); Ramachandra Guha, *The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya* (Berkeley and Los Angeles: University of California Press, 1989); Anker, *Imperial Ecology*; Drayton, *Nature's Government*; Beinart, "Introduction: The Politics of Colonial Conservation"; McCracken, "Experts and Expertise in Colonial Malawi."

In April 1940, Vogt and CAG's general manager Francisco Ballén invited a distinguished group of Peruvian scientists and professionals to meet with one of Vogt's old colleagues, T. Gilbert Pearson. Pearson had been one of the founding officers of the National Association of Audubon Societies in 1905 and later became its domineering president. After he was deposed by John Hopkinson Baker in 1933 (which led directly to Vogt's hiring as editor of *Bird-Lore*), Pearson devoted his time to international bird protection from a small office at Audubon headquarters in New York. Since September 1939, he had been traveling around South America distributing conservation and ornithology literature, setting up societies on the model of the International Committee for the Conservation of Birds, and organizing support for an international "convention for the protection of the fauna, flora, and natural beauty of the Americas." His interest in the fate of "North American migratory birds" in South America was the primary motivation for his trip south, however. To quote Texas nature writer John Graves, Pearson sweated himself "where the Eskimo curlew went."[6]

During this meeting at the swank Hotel Bolívar in central Lima, 25 Peruvian notables founded the Comité Nacional de Protección a la Naturaleza to conserve not only birds, but also "animals, plant species, and beautiful scenery" in Peru, as well as to promote the welfare of "culture, science, and the economy of our country today, and even more for generations to come." Echoing the economic

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6. See epigraph of this work, p. v; John Graves, *Goodbye to a River* (New York: Alfred A. Knopf, 1960), 159. The extinct Eskimo curlew (*Numenius borealis*) once ranged from Arctic Canada to Patagonia. Its last confirmed sitings were in 1962 in Texas and 1963 in Barbados. David Allen Sibley, *National Audubon Society: The Sibley Guide to Birds* (New York: Alfred A. Knopf, 2000), 14; Roger Tory Peterson, *A Field Guide to the Birds of Texas and Adjacent States* (Boston: Houghton Mifflin, 1963), 98-99, 278.

nationalism that led to the foundation of CAG, its members vowed to fight against the wrongful enrichment of exploitative foreigners who threatened to destroy "our national patrimony." (This implicitly blamed outsiders for Peru's environmental plight and conveniently overlooked that foreign-owned agribusiness had benefited most from guano bird conservation.) The Comité Nacional hoped to form a state-supported political society similar to the powerful Sociedad Nacional Agraria that would have direct influence over natural resource use through the Ministerio de Fomento. Besides this political function, the Comité Nacional aimed to study environmental problems, gather and diffuse information, and "instill in youth a love for Nature, exalting its aesthetic, scientific, and industrial values." Its members took up a number of causes advocated by Vogt and other North American conservationists, but as their rhetoric makes clear, they continued to promote rapid economic development.[7]

This Peruvian organization was not established in a vacuum. It was part of a nascent movement throughout Latin America linked to the U.S. conservation movement. It is analogous to movements in other world regions under the influence of Europe's imperial powers, such as the Netherlands Indies Society for the Protection of Nature (est. 1912). Mexico, under the leadership of hydraulic engineer Miguel Ángel de Quevedo, "the apostle of the tree," had already established the first Latin American conservation organization on the model of the

7. *BCNPN* 1:1 (1944), 1-2, 5-6, 8-9; "Comments by T. Gilbert Pearson, Chairman of the Pan-American Section of the International Committee for Bird Preservation and Chairman of the United States Section," 1942 [?], Vogt papers, box 3:3; Graham, *The Audubon Ark*, 46-47, 117; Pearson, "Birding Below the Line," *Bird-Lore* July-Aug. 1940, 315-322.

International Committee for the Conservation of Birds in 1931, followed by Argentina in 1937. Pearson's tour of nine of ten Hispanic republics in South America was a big success: Paraguay, Chile, Bolivia, and Colombia founded similar societies within six months of Peru, followed by Brazil in 1942. The list of directors of these associations reads like a who's-who list of important scientists and scientific organizations, an indication of the intimate connection between expertise and conservationism in Latin America.[8]

The membership of Peru's Comité Nacional was no exception (illus. 32). Its original members included German botanist Augusto Weberbauer who ran the Parque Zoológico y Botánico, one of the most important sites where the Lima populace had contact with "wild" nature, and biogeographer Javier Pulgar Vidal who authored the most influential text ever published on Peruvian ecology *Las ocho regiones naturales del Perú* (1st ed., 1941). Five founding members had ties to the guano industry and agribusiness, including CAG agronomist Luis Gamarra. Young fishery technician Enrique del Solar, recently returned from training in Japan, also attended this initial meeting. Other important scientists who later joined the Comité Nacional included the great student of altitudinal physiology Carlos Monge, CAG general manager Carlos Llosa, and CAG oceanographer Erwin Schweigger. Only one woman, the jurist and women's activist Luz Jarrín de Peñaloza, associated with the Comité Nacional over the years; she was never granted official membership, however, an honor given only to her husband. Even

8. *BCNPN* 1:1 (1944), 176-190; "Comments by T. Gilbert Pearson"; Simonian, *Defending the Land of the Jaguar*, 81; Boomgaard, "Oriental Nature, Its Friends and Its Enemies: Conservation of Nature in Late-Colonial Indonesia, 1889-1949."

though this organization did not have explicit technocratic powers, such individuals gave the Comité Nacional a masculine aura of technocratic authority.[9]

Carlos A. Barreda y Ramos (b. 1890) presided over the Comité Nacional for 30 years. Like Enrique Ávila, Barreda was a native of the highland city of Puno, and he was an enthusiastic agent of agricultural modernization in the Sierra. After earning an agronomy degree from the Escuela Nacional de Agricultura y Veterinaria in 1919, Barreda returned home to teach at the state secondary school in Puno and to manage various livestock haciendas. In 1930, he was appointed the director of a model farm near the highland city of Abancay, and then was elected senator for the Department of Puno in 1939. As senator, Barreda advocated a number of soil conservation projects. He authored laws that established the Ministerio de Agricultura and a national center for domestication of the vicuña. He also published conservation propaganda, including an influential 1940 pamplet on national parks in Peru. Barreda epitomized the importance of agricultural concerns in the Peruvian conservation movement, an interest he shared with Vogt, his colleagues at CAG, and conservationists throughout the Americas.[10]

Another North American played a major role on the Comité Nacional. His example illustrates, yet again, the importance of technocrats to Peruvian

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9. *BCNPN* 1:1 (1944), 1, 2, 176-190; *BCNPN* 7 (1950), 2-3; *BCNPN* 20 (1965-1970), 65-69, 118; "Miembros del Comité Geofísico Peruano," n.d., SIO Subject Files box 8/folder 10. On Monge and for prosopographical information on scientists in Peru, see Cueto, *Excelencia científica en la periferia*; idem, "Andean Biology in Peru: Scientific Styles in the Periphery."

10. *BCNPN* 1:1 (1944), 31; *BCNPN* 20 (1965-1970), 26, 44-48, 68; *Diccionario biográfico del Perú*, s.v. "Barreda Y Ramos, Carlos A." Cf. Vogt, "Un peligro futuro para el Perú," *BCNPN* 1:1 (1944), 144-152; Gamarra, "El abonamiento de las tierras"; idem, "La erosión de los suelos un problema nacional," *BCAG* 23:9 (Sept. 1947), 141-147; Worster, *Dust Bowl*; Tobey, *Saving the Prairies*; Simonian, *Defending the Land of the Jaguar*.

conservation and the immense prestige a foreign expert could attain in Peru. Albert A. Giesecke (1883-1968) obtained a degree in economics from the Wharton School of Commerce and Finance at the University of Pennsylvania, the first professional business school in the United States, before completing a Ph.D. in political science at Cornell in 1908. He was a direct product of the movement toward the "scientific" study of business, politics, and society in U.S. universities, the "knowledge factories" that produced a new class of management professionals to govern the world.[11] In 1909, the same year Ballén was appointed CAG's general manager because of his foreign business experience, a Peruvian envoy recruited Giesecke to establish a business faculty at the Colegio Nacional de Guadalupe, a prestigious state secondary school supported by the guano industry. Giesecke later took over rectorship of the Universidad de San Antonio Abad and served 12 years as *alcalde* (mayor) of Cuzco Province. In 1923, he was en route to the University of Pennsylvania to resume his career as a political scientist, but President Augusto Leguía tempted him to remain in Peru by offering a top administrative post in the Ministry of Public Education, where he stayed until Leguía's overthrow in 1930. He remained in Peru for 34 additional years as a U.S. embassy offical. Giesecke's career attests to the direct influence U.S. experts had over the affairs of the Peruvian state during this era.[12]

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11. See Noble, *America by Design*; Chandler, *The Visible Hand*, esp. 464-468.

12. *BCNPN* 20 (1965-1970), 58-64; *Diccionario histórico y biográfico del Perú,* s.v. "Giesecke, Alberto"; Jorge Basadre, *Peruanos del siglo 20* (Lima: Ediciones Rikchay Perú, 1981), 65.

There may be no figure who has been more important for the promotion of cultural tourism in Peru than Giesecke. His devotion to "the protection of nature" was a natural extension of his interest in archaeology and tourism. Though it is often overlooked, cultural preservation has been integral to the national parks movement in many countries. In fact, national parks and monuments were first established in the United States partly to make up for its comparative lack of urban cultural treasures.[13]

In 1911-1912, Giesecke helped organize logistics for the U.S. expedition that discovered the lost ancient city of Machu Picchu. As Cuzco's *alcalde*, he saw to the construction of a paved highway connecting Cuzco's main plaza to the megalithic hill fortress of Sacsayhuaman. Later, he personally supervised the construction of a highway to the important Pachacamac ruin south of Lima, as well as its excavation and restoration. In 1948, he helped inaugurate a tourist road that climbed from the Urubamba River up to the ruins of Machu Picchu itself. Under his influence, the Comité Nacional lobbied for the establishment of Pachacamac National Park in 1950, the first in Peru, and for the protection of forested areas along Peruvian highways. Such advocacy reflects the once widespread belief that highway construction and automobile tourism would promote, rather than hurt, rural conservation.[14] Paracas National Park and Marine Reserve, which today

13. There is an immense literature on national parks and monuments in the United States; see esp. Alfred Runte, *The National Parks: The American Experience*, 2d ed. (Lincoln: University of Nebraska Press, 1987); Hal Rothman, *America's National Monuments: The Politics of Preservation* (Urbana: University of Illinois Press, 1989; reprint, Lawrence: University Press of Kansas, 1994). On the cultural importance of anthropology in Mexico, see Tenorio-Trillo, *Mexico at the World's Fairs*; on national parks in Mexico, see Simonian, *Defending the Land of the Jaguar*.

14. See Gregory T. Cushman, "Environmental Therapy for Soil and Social Erosion: Landscape Architecture and Depression-Era Highway Construction in Texas," in *Environmentalism*

protects several of the main guano islands and the Bahía de Independencia, was originally founded in the 1960s to preserve remnants of the Paracas culture, an ancient fisher people famous for their intricate tapestries. Meanwhile, Giesecke supervised the purchase of indigenous artifacts that today are at the core of Peru's system of state archaeological museums, including the famous collection of sugar planter Víctor Larco Herrera, one of the Lords of Guano's primary beneficiaries. The growth of tourism to these sites has turned out to be crucial to recent efforts to preserve Peru's natural heritage through ecotourism. This is the Comité Nacional's most important legacy to environmental preservation in Peru.[15]

But the Comité Nacional's earliest political victory illustrates the limits of the legalist approach to conservation. Carlos Barreda authored a law that completely banned the hunting and export of three Andean fur-bearing mammals: the camelids vicuña (*Lama vicugna*) and guanaco (*Lama guanacoe*), and the rodent chinchilla (*Chinchilla laniger*). It was passed by the Peruvian Congress and signed into law by President Manuel Prado in June 1940. With a view toward saving these animals from extinction, the Comité Nacional convinced Peru to join the Convention on Nature Protection and Wild Life Preservation in the Western

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in Landscape Architecture, ed. Michel Conan (Washington, DC: Dumbarton Oaks Research Library and Collection, 2000), 45-70; Linda Flint McClelland, *Building the National Parks: Historic Landscape Design and Construction* (Baltimore, MD: Johns Hopkins University Press, 1997) esp. ch. 5-6.

15. *BCNPN* 1:1 (1944), 21, 23, 34; *BCNPN* 6 (1949), 43; *BCNPN* 20 (1965-1970), 58-64; *Diccionario histórico y biográfico del Perú,* s.v. "Giesecke, Alberto"; César Morales Arnao, "Los parques nacionales en el Perú," *BCNPN* 20 (1965-1970), 128-130; Bonta, "A Peruvian Safari." Cf. Felipe Injoque Espinoza and Gustavo Suárez de Freitas, "Problems in the Enforcement of a Strict National Park Policy in the Case of Peru," in *National Parks without People?: The South American Experience*, ed. Stephan Amend and Thora Amend, trans. Lilian de Croce and Christopher Canaday (Quito, Ecuador: IUCN/Parques Nacionales y Construcción Ambiental, 1995), esp. 323-327.

Hemisphere, the so-called Washington Convention. On 12 October 1940, Peru, Ecuador, and Venezuela were the first of 11 South American states to sign this influential international agreement. Neither law did much to protect these valuable creatures since they established no means for enforcement, much less for dealing with the social and economic conditions that motivated their relentless hunting.[16]

The fate of these animals sheds light on why CAG was so successful as an animal conservation project and why the Comité Nacional's advocacy rarely accomplished much. The chinchilla almost certainly became extinct in the wild in Peru years before these laws were even passed. It was eventually reintroduced to Peru as a semi-domesticated object of commerce thanks to captive breeding in the United States. Today, a few scattered wild populations survive only in the remote highlands of Bolivia and Chile. The vicuña, meanwhile, continued to decline in numbers until the late 1960s. Its eventual recovery had practically nothing to with the Comité Nacional, but it had everything to do with technocratic management. A wealthy Peruvian diplomat, Felipe Benavides Barreda (1917-1991), convinced upper-class Brits--by far the largest consumers of wool harvested from poached vicuña skins--to do something about the vicuña's plight. The U.K. government funded a two-year field investigation by zoologist Ian Grimwood. He developed a plan whereby armed local peasants would manage a national reserve under the supervision of government forestry service officials. In 1966, Peru established the

16. "Comments by T. Gilbert Pearson"; "Estado de la conservación en el Perú según la Misión Francesa," *BCNPN* 15 (1957), 37-38; Wilfredo Pérez Ruiz, *La saga de la vicuña* (Lima: CONCYTEC, 1994), 114-146; Stephan Amend and Thora Amend, "Balance Sheet: Inhabitants in National Parks--An Unsolvable Contradiction?" in *National Parks without People?*, 451.

6,000 hectare Reserva Nacional de Pampa Galeras to protect a wild population of 6,500 vicuñas in the southern highlands. Premised on local involvement, it was a remarkable success. Such projects unifying the interests of different social groups and nationalities appear to have saved the vicuña and guanaco from extinction.[17]

It is safe to say that the Comité Nacional achieved little in most of its attempts to protect Peruvian nature. Its experience with the Santa Lucía forest near Ica was typical. In the mid-1940s, the Beneficiencia de Ica (a local government welfare organization) put a 68-hectare plot of extremely rare coastal riparian forest up for sale at a time when the local cotton industry was in turmoil, urban prices were high, and demand for public welfare benefits was great. This grove represented one of the last old-growth stands of the threatened *algarrobo* or carob tree (*Prosopis alba*) in central Peru. The members of the Comité Nacional hoped to save this forest from the historical fate of most trees along the arid Peruvian coast: sale to a charcoal company. To this end, they offered to purchase the Santa Lucía forest and made a well-publicized visitation to promote its preservation as a national park. But their pocketbooks were too small and their dreams too grand. Instead of becoming Peru's first national park, the Santa Lucía forest was reduced to charcoal for urban resale. The Comité Nacional only delayed its fate. As Enrique Ávila aptly pointed out to his patron Vogt, the Comité Nacional during its early years devoted itself almost entirely to "enthusiastic talk" and little action.

17. *BCNPN* 20 (1965-1970), 30-32; William L. Franklin, "High, Wild World of the Vicuña," *National Geographic Magazine* Jan. 1973, 77-91; Pérez, *La saga de la vicuña*, passim; *Diccionario histórico y biográfico del Perú,* s.v. "Benavides Barreda, Felipe"; *Encyclopaedia Britannica*, 2000 ed., s.v. "chinchilla," "vicuña."

Years later, Carlos Barreda himself could convey little more than an overwhelming sense of loss in his organizational memoir.[18]

These proponents of "protection of nature" in Peru, quite simply, could not make themselves heard above the din of modernization advocacy in Peru. They were up against powerful forces devoted to the cause of rapid economic growth. For example, in a last-ditch effort to protest the destruction of the guano birds, Barreda and a remnant of the Comité Nacional tried to organize a conference chaired by Robert Cushman Murphy on the "Conservation, Exploitation, and Development of the Renewable Natural Resources of the Sea" in 1967. But this scheme came to nought, largely because its organizers wanted to focus on "one negative aspect" of marine development when progress-minded *políticos* were fixated on the positive task of creating industrial jobs, infrastructure, and wealth in the Peruvian fishing industry.[19]

Not all of the Comité Nacional's shortcomings can be blamed on their opposition. True to its roots in development-oriented scientific organizations, the Comité's tepid criticism of a few projects stood in stark contrast to its members' overwhelming general support for national development. As I will note in the conclusion, today's proponents of "sustainable development" face similar dilemmas. But the Comité Nacional's major problem was institutional. Its history,

18. Ávila to Vogt, 17 Sept. 1945, Barreda to Vogt, 12 Oct. 1946, Vogt papers, box 1:1; *BCNPN* 20 (1965-1970), 26-43, esp. 29-30; Hilton-Taylor, ed., *2000 IUCN Red List of Threatened Species* [cited 6 Aug. 2001], available from http://www.redlist.org/search/details.php?species=33953.

19. Barreda and Benjamín Almanza Ocampo to Schaefer, 26 May 1967; Barreda to Milner Bailey Schaefer, 30 June 1967; Schaefer to Barreda, 6 June 1967; Carlos Otero Lora to Almanza, 5 July 1967, UC-IMR Records 4/184.

CAG's success notwithstanding, betrays one of the central weaknesses of technocracy as a model for political organization: its frequent lack of a political base and inability to inspire popular backing. Although the Comité Nacional's members accurately gauged the nature of politics in Peru when they formed this society--particularly the linkage between the personalist exercise of power, centralist organization, and social standing--they cut off many possibilities for organizational growth, particularly as Peruvian politics evolved a more populist style in the years leading up to the military revolution of 1968.

The Comité Nacional was elitist by definition. As a "committee," its membership was limited to 25 notables who presumed to represent the interests of prominent scientific and governing institutions, all with their headquarters in Lima. Other associates were mere "correspondents." Its membership, likewise, was almost entirely composed of prominent scientists *living in Lima* who figured their expertise, professional and social prestige would gain them political influence regarding conservation policy. Early on, the Comité Nacional formed a mission to Iquitos, Peru's Amazonian metropolis, and convinced local notables to form a subordinate Subcommittee for the Protection of Nature in 1943. Prominent citizens in other cities less isolated from Lima's overweening centralism rejected any liaison with the Comité Nacional. (The Sociedad Geográfica de Lima, from which these organizing tactics were derived, had much greater success at attracting regional "corresponding" members and forming local societies.) Even in the capital, the leaders of the Comité Nacional hesitated to admit new devotees to their ranks who did not fit their social mold. After returning from his studies with Aldo

Leopold, Ávila expressed an interest in joining. Giesecke rejected his overture with the reply that membership was "severely restricted." Ávila got the message: it was restricted to "certain Peruvian Big-shots" unsullied by his humble origin. As a remedy, Ávila used a tried-and-true political tactic: he appealed to his patron Vogt who wrote to Barreda directly with the request that his client be admitted to membership. Ávila's highland compatriot heeded Vogt's appeal, and Ávila contributed however marginally to the activities of the Comité Nacional over the next 25 years. The Comité Nacional quite literally had difficulty reproducing itself: it rarely opened new slots unless an old member died.[20]

The leaders of the Comité Nacional had visions of a popular conservation movement, led by Peruvian youth, but their project could hardly have been less populist. Barreda loved to blame the failures of the Comité Nacional on the failings of common Peruvians. They lacked his "high civic concept," much less any "popular education that generalizes the love of nature and affectionate repect for animal life." The popular threat to wild nature, therefore, needed "police vigilance and control." Barreda's idealization of proper recreation betrayed a disdain for plebian culture that cynically ignored the everyday demands of survival for most Peruvians. In his view, sport hunting, rural tourism, and "contemplation of living nature" give "spiritual satisfaction to the modern man who tires of the daily burdens of urban life" and allow him to "return to the simple, primitive life lived by our ancestors." He thought "true national parks" in Peru should be

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20. *BCNPN* 1:1 (1944), 9, 89-90, 186-188; Ávila to Vogt, 19 Dec. 1946, Vogt to Ávila, 25 Nov. 1946, Vogt papers, box 1:1

centrally organized playgrounds for the leisure class with "comfortable hotels and restaurants for the rest and lodging of tourists . . . who should be guided . . . by expert forest guards." In his zeal for the greening of rainless Lima, Barreda despised the use of open public space for fairs and *fútbol* and favored their conversion to closed forests and contemplative gardens.[21]

Perhaps the Comité Nacional deserves some credit for action on this last count. Led by the beautification advocate Francisco Ruiz Alarco, one of the Comité Nacional's few original members without a professional degree, its members undoubtedly achieved their most tangible "success" through their promotion of zoos, botanical gardens, and municipal parks in Lima. But most green spaces in Lima have been designed to protect their thirsty lawns and tropical plants from trampling by the urban horde, not for popular access. For example, the central object of Barreda's scorn regarding popular land use, the Campo de Marte, is no longer a military marching ground, nor is it the site of plebian recreation. Instead, it is one of the largest green expanses in central Lima today, fenced off from adjacent neighborhoods except for a small, relatively inaccessible gate on the Avenida de Peruanidad. This paved parade ground and park provides a landscape for Peru's modern, mechanized military to brandish its might each July during Fiestas Patrias, Peru's independence celebration. Many other "accessible" green spaces are walled off in a different way: they are located in affluent neighborhoods miles away from the dwellings of the majority of Lima's population or surrounded by dangerous urban thoroughfares. In this way, Lima mirrors the elitism of its first

21. *BCNPN* 20 (1965-1970), 26, 30, 35-38.

society of conservation advocates. It is little wonder the Comité Nacional inspired no popular following--it was hardly national in its representation. But this failure was not inevitable: *limeños* have risen up en masse on several occasions to demand environmental protection, most notably to protest air and water pollution caused by the fishmeal boom of the early 1960s. The Comité Nacional shows the limits of the technocratic model of environmental conservation--the central theme of the remaining chapters.

Spreading the Gospel of Guano to Mexico and Chile

Defenders of the Peruvian guano industry as a model of conservation-based development had better luck obtaining a new following outside of Peru. No one was more successful in this endeavor than William Vogt.

When CAG's directorate decided to terminate Vogt's contract in December 1941, they did not sink Vogt's career as a scientific consultant in Latin America. Earlier that month, Japan had bombed the headquarters of the U.S. Pacific fleet at Pearl Harbor. Suddenly, Vogt's experience in Peru made him a valuable source of intelligence on Pacific South America to the U.S. wartime government. (Recall that immigrants like the Fujimoris and Nikumatsu Okada had built a large Japanese community in coastal Peru, which the United States saw as a direct threat to the Panama Canal.) The U.S. Committee for Inter-American Cultural and Artistic Relations gave Vogt a small grant ostensibly to investigate the climatology of the Chilean coast. During his brief tour of Chile, Vogt questioned local fishermen, Chilean scientists, and U.S. expatriates about the migration of Peru's guano birds and *anchoveta* during the 1939-1941 El Niño event--but Vogt was actually working as a spy for the G-2 intelligence branch of the U.S. Army. The U.S. War Department debriefed him on his return to the United States later in 1942. Since he was physically unfit for military duty, Vogt migrated to the Office of the Coordinator of Inter-American Affairs where he worked under Nelson Rockefeeler as associate director of its Division of Science and Education. His foreign service and reputation as a conservationist made him an ideal choice in 1943 to head the Conservation Section of the Pan-American Union (in 1948, renamed the Organization of American States).[22]

In this position, Vogt's career as an international conservation advocate went into high gear. To an amazing extent, Vogt's affairs during his tenure as Pan-American conservation chief were concerned with guano. CAG's achievements were widely known, and officials in other countries looked to replicate Peru's success.

By this date, Peru was not the only country that operated a guano industry based on the conservation of marine birds. Beginning in the early 1890s, the government of Cape Colony in southern Africa initiated annual guano extraction under a regime designed to protect island nesting colonies of three species: the Cape gannet or málaga (*Morus capensis*), jackass penguin (*Spheniscus demersus*), and Cape cormorant or Trek duiker (*Phalacrocorax capensis*), all species analogous to Peru's guano birds. Until the final collapse of the Benguela Current

22. *Current Biography* (New York: H. W. Wilson, 1953), s.v. "Vogt, William"; Curriculum Vitae, ca. 1964, Vogt papers, overview folder; *Américas* Mar. 1949, back cover.

sardine fishery in the 1970s, these islands consistently produced several thousand metric tons of guano a year, making them the leading source of nitrogenous fertilizer for South African agriculture during the first half of the twentieth century. Beginning in 1931, the South African government initiated the construction of large, offshore nesting platforms along the northern coast of Namibia; these continue to produce significant quantities of fertilizer. I know of no direct connection between the Peruvian and South African guano industries. This appears to be a case of technological convergence between these distant but ecologically similar regions.[23]

Mexico also had a guano industry with a long history that extended into the realm of manure science. The first non-European student to study at Justus von Liebig's famous teaching laboratory at the University of Giessen came from Mexico, not the United States. Liebig's famous 1840 book on agricultural chemistry, which contributed so much to the guano rush of the mid-nineteenth century, found a ready audience among Mexican scientists.[24]

Mexico had rich guano deposits of its own. Beginning in 1857, private concerns extracted substantial quantities of guano from both ancient deposits and

23. P. B. Best, R. J. M. Crawford, and R. P. Van Der Elst, "Top Predators in Southern Africa's Marine Ecosystems," in *A Century of Marine Science in South Africa*, ed. A. I. L. Payne and J. R. E. Lutjeharms, *Transactions of the Royal Society of South Africa* 52:1 (1997), 177-225; K. L. Cochrane, D. S. Butterworth, and A. I. L. Payne, "South Africa's Offshore Living Marine Resources: The Scientific Basis for Management of the Fisheries," in *A Century of Marine Science in South Africa*, 149-176; Johnsgard, *Cormorants, Darters, and Pelicans of the World*, 243-247; Wines, *Fertilizer in America*, 54-55; Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 134-157; Watson, "The Guano Islands of Southwestern Africa," 631-641.

24. Liebig, *Química aplicada a la agricultura* (Mexico City: Imprenta de Juan Navarro, 1850), "translated from the latest English edition, for the Semanario de Agricultura." Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans*, app. 2; Liebig's influence is discussed in ch. 1-2.

living bird colonies in the Baja California region and exported it to the agricultural empires of California, even as far away as Hamburg. In 1938, the Mexican state prohibited all private extraction and set up a state corporation of its own, Guanos y Fertilizantes de México, to manage this natural resource for national consumption. Over the next decade, this Mexican version of CAG collected approximately 1,000 metric tons of guano *rico* (averaging nine percent nitrogen by weight) per year from five bird species, all close relatives of the guano birds of Peru. Along the Pacific coast of Baja California, this company extracted a rather poor product mixed with large quantities of extraneous material from colonies of Brandt's cormorant or *sargento guanero* (*Phalacrocorax penicillatus*), the double-crested cormorant or *cuervo marino* (*P. auritus*), and brown pelican or *alcatraz* (*Pelecanus occidentalis californicus*). Guanos y Fertilizantes de México extracted its best product inside the Gulf of California from a single, dense colony of the brown booby or *bobo vientre blanco* (*Sula leucogaster*) and from a mixed colony of brown and blue-footed boobies (*S. nebouxi*). Mexico's latter-day guano extractors ignored a colony of elegant terns (*Sterna elegans*) and Heermann's gulls (*Larus heermanni*) on Isla Rasa that at one time produced large quantities of phosphate rich, guano *pobre*--probably because decades of egg collecting had reduced this population to a fraction of its former numbers.[25]

25. Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 122-132; Johnsgard, *Cormorants, Darters, and Pelicans of the World*, 172-179, 201-208, 387-397; Thomas Bowen, *Unknown Island: Seri Indians, Europeans, and San Estéban Island in the Gulf of California* (Albuquerque: University of New Mexico Press, 2000), 122-137; Steve N. G. Howell and Sophie Webb, *A Guide to the Birds of Mexico and Northern Central America* (New York: Oxford University Press, 1995), 123-124, 128-129, 292-293, 305-306.

In 1944, the director general of Guanos y Fertilizantes de México, Dr. Carlos H. Benítez, began promoting the idea that the Mexican guano industry could be improved by transplanting guano birds from Peru to the arid Baja coast. Geographers had long contended that the California and Peru Current environments are mirror images of one another, and Benítez hoped that the Brandt's cormorant might be replaced with its close relative the guanay. He figured that the much more gregarious and productive guanay would "know better what to do" with offshore shoals of the California sardine. If this did not work, Benítez hoped to replace Mexico's brown and blue boobies with the piquero. As hare-brained as this scheme might seem to us today, it fit with conservation orthodoxy at the time which enthusiastically advocated the transplant of alien trees like the eucalyptus, ground-cover plants like kudzu, game fish like the brown trout, and other species to improve the "natural" productivity of environments around the world.[26]

Peru's network of experts soon got involved. In 1944, CAG agronomist Luis Gamarra traveled to Mexico to examine the situation, although he did not bring guanay eggs as the Mexicans had requested, since his boss Francisco Ballén was suspicious of the entire project. Benítez also consulted Vogt and Ávila regarding the situation, for he was not foolish enough to think his project would succeed without expert direction. Vogt drew up a plan for ornithological research, and Guanos y Fertilizantes de México hired biologist Bibiano H. Osorio Tafall to

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26. Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 122-132; Lanatta, *Informe*, 37-39. The Australian eucalyptus was the most obvious case of an imported species transforming the landscape in much of Latin America during this period, especially in the Andes; see Robin W. Doughty, *The Eucalyptus: A Natural and Commercial History of the Gum Tree* (Baltimore, MD: Johns Hopkins University Press, 2000).

complete a study of Brandt's cormorant and its ecology. One by one, all the experts involved with this project came out against the plan to introduce the Peruvian guano birds to Baja California. Ballén came out against it almost immediately; he did not want to share even a single bird with Mexico at a time when Peruvian guano production was at a two-decade low. This led Benítez to label him "*un loco de la casa*." With the Peruvian option looking doubtful for the moment, Vogt offered to approach Chilean authorities to arrange the export of guanayes from northern Chile to Mexico.

Ballén's retirement in July 1945 gave the plan to transplant Peruvian birds a new lease on life. At the request of Peru's new Minister of Finance, a contract was prepared to provide Mexico with 100,000 guanay eggs, 100,000 piquero eggs, and 25,000 pairs of both birds each year for 29 years. Vogt and Gamarra returned to Mexico late in 1945 to study this new plan, but they together concluded that the much-less-productive waters off Baja California could not produce much guano--at most 3,000 metric tons per year, and only a few hundred profitably--even if the introduction plan succeeded. Vogt offered to wager Benítez "a hundred to one odds that any attempts to establish the guanay on the west coast of Mexico will be a failure." Osorio confided to Robert Cushman Murphy that he, too, thought the plan was impracticable, but he could not say so publicly since his job depended on the continuation of this research. Murphy anonymously transmitted Osorio's critique of the project, citing recent studies of the California sardine indicating that the maximum upwelling of the California Current was much more dispersed than the Humboldt Current and could never support such great concentrations of bird life.

Murphy's long experience as a student of marine birds led him to raise a more troubling question: Why had the Peruvian birds never colonized this region on their own over the eons if the environment was so suitable for them? But even with powerful experts on his side, Ávila was still hesitant to oppose the project publicly in his final report because it had "quite a few political strings attached to it." As Murphy had done for Osorio, Vogt passed on Ávila's negative opinions to CAG's new managers. These junior Latin American scientists felt too vulnerable to divulge their "unbiased opinions" to their superiors--their jobs and economic survival were at stake. Avila and Osorio's power as Lords of Guano had tightly circumscribed limits.[27]

As a consequence, project boosters could dismiss the criticism of "foreign" scientists and present these Latin American "nationals" as sharing their optimism. Seemingly no amount of expert criticism would snuff the enthusiasm of one Mexican booster. José Carlos Arenas traveled all the way to Peru to promote his grandiose plan to purchase US$600,000 worth of boats, tractors, and bulldozers to collect the wealth of excrement Peruvian birds would eventually provide to Mexico. Rather than trust the opinion of U.S. scientists, Arenas detected an imperialist conspiracy: he boldly dismissed Vogt as "a sentimentalist nature lover who wants to confuse Latin American conservationists for the sole pupose of saving the industrial interests" of the sagging California sardine industry. Arenas

27. *MCAG* 36 (1945), 47-48; *MCAG* 36 (1946), xi; Lanatta, *Informe*, 37-39; Carlos H. Benítez to Vogt, 20 Mar. 1944, 4 July 1945, 12 Jan. 1946; Vogt to Benítez, 4 Apr. 1944, 2 Jan. 1946, 18 Feb. 1946; B. H. Osorio Tafall to Vogt, 26 May 1945; Ávila to Vogt, 12 Dec. 1945, 6 June 1946, 2 July 1946; Vogt to Ávila, 28 Dec. 1945, Vogt papers, box 1:1-3.

thought it practicable to airlift thousands of eggs from Peru to Mexico and then surreptitiously switch the eggs of *P. penicillatus* with those of *P. bougainvillii*, thereby tricking the former to raise changlings. Peruvians eventually decided to err on the side of caution: CAG listened to Vogt and rejected the proposal. Even though, ecologically speaking, this looks like the right call to us today, this technocratic decision was not necessarily good for the scientific management of Mexico's marine resources. It put Osorio's job in severe jeopardy. But Vogt respected the patron-client relationship he had established with Osorio and tried to obtain other positions for him, in addition to providing him with scientific books and equipment. In a pattern that was repeated by Peru's first native-born professional ornithologists, Osorio sought to solve this problem by becoming an advocate--and scientist--for the development of Mexico's fishery resources. But his career reached a dead end in Mexico, and he emigrated to work for the nascent Chilean fishing industry in the early 1950s.[28]

Vogt's second mission to Chile was also premised on guano's promise. Chile operated a small guano industry in the 1940s. Every four years, it typically extracted a little over 3,000 metric tons from bird colonies off the coast of its far northern provinces Arica and Tarapacá (territories it had won from Peru during the War of the Pacific). Late in 1944 while Mexico was negotiating with Peru, the Chilean Corporación de Fomento (CORFO)--an extremely important technocratic

28. Ávila to Vogt, 12 Dec. 1945, 30 Apr. 1946; Vogt to Ávila, 28 Dec. 1945; Vogt to Osorio, 14 Jan. 1946, Vogt papers, boxes 1:1, 3-4; *MCAG* 38 (1947), xv; Osorio, "El destino marítimo de México," *Revista de economía* (Mexico City) 10:8 (Aug. 1947); Cary, "Report #12--September 19, 1953," 24 Sept. 1953, American Tunaboat Association Records, SIO Library, box 28/folder 1.

institution in its own right--sent a request to the Inter-American Development Commission to obtain the services of Vogt.[29] CORFO engineers wanted Vogt to show them how to organize better their own guano industry to increase its output for Chilean national agriculture. But Vogt obtained little local cooperation during his guano study: Chilean officials would not provide him with data regarding past guano collection nor even the most basic information on Chilean fisheries. Vogt had to rely on transportation provided by the U.S. Embassy as he did a whirlwind environmental survey of Chile's north coast. Chilean officials probably suspected, with good cause, that Vogt was acting as a spy for U.S. military and fishing interests. Despite these problems obtaining information, Vogt felt confident enough to conclude that Chile could establish a guano industry based on the conservation techniques developed over the years by CAG that would produce around 5,000 metric tons per year. In response, the Chilean state formed the Sociedad Chilena de Fertilizantes to implement Vogt's recommendations. By 1945, there were three technocratic organizations in Latin America devoted to sustained-yield production of guano. In the 1950s, Chile copied CAG's policy of building artificial breeding islands by walling-off coastal points along its far northern coast.[30]

29. On the establishment of CORFO and its role in the rise of technocrats to state power in Chile, see Silva, "State, Public Technocracy and Politics in Chile, 1927-1941."

30. Vogt, "Informe sobre las aves guaneras," 85-86; "Chile's Guano Production Developed under U.S. Expert," *Foreign Commerce Weekly* 16 Dec. 1944, Vogt papers, clippings from Latin American newspapers, 1940s, fol. 1, p. 3r; Vogt, *Más guano blanco: Posibles recursos de la costa desértica chilena* (Santiago de Chile: Sociedad Chilena de Fertilizantes, 1945); Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 95-112; Murphy, "Peru Profits from Sea Fowl," 407; Vogt to José L. Colom, 28 Mar. 1945; Vogt to Ávila, 26 Sept. 1947, Vogt papers, box 1:3.

Like his experience with CAG and the Comité Nacional de Protección a la Naturaleza in Peru, Vogt's consultation with the guano industries of Mexico and Chile opened the door for organizing activity in other realms of conservation. During his mission to Mexico in 1944, Vogt met with some "top-notch Mexicans" to reorganize and broaden the goals of the Comité Nacional para la Protección de Aves Silvestres established in 1931 by Miguel Ángel de Quevedo, Mexico's foremost conservationist of the early twentieth century. During his mission to Chile in 1945, Vogt convened a meeting of scientific notables who reorganized their own national committee as the Comisión de Protección a la Naturaleza. Its goals reflected those of Peru's Comité Nacional, and this meeting led directly to the establishment of Cape Horn National Park, a reserve protecting 2,000 square kilometers of rugged coast and icy wasteland at the southern tip of the Americas. Taking over where Gilbert Pearson left off, Vogt inspired the organization of national sections of the International Committee for Bird Preservation in Guatemala and Venezuela in the mid-1940s.[31]

As he had in Peru, Vogt collaborated most closely in these endeavors with local scientists, technocrats, and educators. In Mexico, Vogt teamed up with Enrique Beltrán (b. 1903) on a series of projects. During the first phase of his career, Beltrán had been an advocate for the rational development of Mexico's marine resources. To this end, he obtained a degree in marine biology from

31. Vogt, *Progress Report* (n.p.: Pan American Section of the International Committee for Bird Preservation, 1 Jan. 1946), Vogt papers, box 3:3; Vogt to Aldo Leopold, 1 Mar. 1944, Vogt papers, box 1:4; "Se realizan estudios para formar una Comisión de Protección a la Naturaleza," *El Mercurio* (Santiago de Chile) 4 Mar. 1945, Vogt papers, clippings from Latin American newspapers, 1940s, fol. 1, p. 3v; Simonian, *Defending the Land of the Jaguar*, 81, 248 n. 51.

Mexico's national university. In the 1920s, he led two government expeditions to establish a marine biology research center on the Gulf of Mexico, but post-revolutionary instability led to their abrupt interruption and forced Beltrán to abandon this career path. With the help of a scholarship from the Guggenheim Foundation, Beltrán completed a Ph.D. in protozoan zoology at Columbia University in New York in 1933. President Lázaro Cárdenas then appointed Beltrán as the first director of Mexico's Instituto Biotécnico, a short-lived state agency charged with the administration of all investigations related to natural resource management. Beltrán later worked as a developer of state science curricula for Cárdenas's government, a position of some importance in the cultural politics of the time, before he joined Mexico's new institute for the study of tropical diseases, an institution near the top of Mexico's scientific hierarchy. Vogt and Beltrán focused on conservation propaganda during Vogt's missions to Mexico. Most notably, they collaborated on a series of broadcasts on the Universidad Nacional Autónoma de México's XEXX radio station in 1944 that presented "brief essays on the ecology of conservation." These provided the basis for Beltrán's best-known book *Los recurosos naturales de México y su conservación* (1946), a secondary-school conservation manual. Significantly for Vogt's future influence, about this time, Beltrán adopted the philosophy that population is the root cause of environmental problems. In 1952, he went on to found the Instituto Mexicano de Recursos Naturales Renovables (IMERNAR). It quickly evolved into one of Mexico's premier conservation organizations. Like Peru's Comité Nacional de Protección a la Naturaleza, IMERNAR's most visible and influential accomplishment, its long series of annual "round table" meetings of experts, was eminently technocratic in orientation. As much as Quevedo, Beltrán's career makes evident the central role of scientists serving as environmental managers in the Mexican conservation movement.[32]

Mexico's attempts to install a conservation technocracy suffered from divisions and weaknesses similar to Peru's experiment. Technocrats in Mexico became embroiled in intense disagreements over the issue of development. Vogt, for example, became involved in a public debate with Adolfo Orive Alba, Mexico's irrigation commissioner, over the value of large dams in the battle against soil erosion. Orive objected vociferously to Vogt's contention that Mexico was geographically ill-suited to industrialization and that dams needlessly drowned rich farmland. Orive won the political side of the debate with his promises of cheap electricity and regular water supplies for every Mexican. In keeping with the revolutionary rhetoric of the Mexican state, Orive and Beltrán both expressed sensitivity toward the rights of poor Mexicans to use national resources--though Beltrán thought their use should be under the firm guidance of ecologists. Today's Mexican environmentalists have attracted little popular support despite such

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32. Enrique Beltrán, *Los recursos naturales de México y su conservación*, introduction by William Vogt (Mexico City: Secretaria de Educación Pública, 1946), esp. viii; idem, "Cuarenta años de conservacionismo mexicano," in *El conservacionismo mexicano* (Mexico City: Instituto Mexicano de Recursos Naturales Renovables, 1966), 21-52; Simonian, *Defending the Land of the Jaguar*, 125-127, 129-130, 133-140; Vogt, *Progress Report* (n.p.: Pan American Section of the International Committee for Bird Preservation, 1 Jan. 1946), Vogt papers, box 3:3. See also Vogt, *El hombre y la tierra* (Mexico City: Secretaria de Educación Pública, 1944); Beltrán, *El hombre y su ambiente: Ensayo sobre el Valle de México* (Mexico City: Tezontle, 1958), an environmental history of the lake basin containing Mexico City from the pre-Hispanic period to the 1950s. On the key political importance of educational projects during the Cárdenas era, see Mary Kay Vaughan, *Cultural Politics in Revolution: Teachers, Peasants, and Schools in Mexico* (Tucson: University of Arizona Press, 1997).

populist appeals and Beltrán's dedication to conservation education.[33] This shortcoming is understandable when one recognizes the technocratic elitism lying at the root of both the Mexican and Peruvian environmental movements.

The Environmentalist Manifesto

While Vogt spread the gospel of guano to Chile and Mexico, he began to map out a general solution to the globe's environmental problems. His duties as Pan-American conservation chief provided him with an ideal opportunity to expand his horizons. During the mid-1940s he completed conservation surveys of Mexico, Guatemala, Chile, Venezuela, El Salvador, and Costa Rica. Vogt had come a long way from his days sitting in a blind among Peru's guano birds, but he remained fixated on the relationship between population, subsistence, and environmental crisis. His survey reports all emphasized the threat of overpopulation, the progressive deterioration of agricultural land, and the human misery that inevitably followed in their wake.[34] This turn toward the study of human populations far beyond the boundaries of his native land was of epochal significance for the future development of the environmental movement in the United States.

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33. Simonian, *Defending the Land of the Jaguar*, 120-121, 203-221.

34. Vogt, *Progress Report* (n.p.: Pan American Section of the International Committee for Bird Preservation, 1 Jan. 1946), Vogt papers, box 3:3. This phase of Vogt's career deserves much further study; see his various reports published in Spanish and English editions: Vogt, *La población de Costa Rica y sus recursos naturales* (Washington, DC: Unión Panamericana, 1946); idem, *La población de El Salvador y sus recursos naturales* (Washington, DC: Unión Panamericana, 1946); idem, *La población de Venezuela y sus recursos naturales* (Washington, DC: Unión Panamericana, 1946). See also Maureen A. McCormick, "Cold War Conservation: International Science, National Resources, and Reproductive Limits" (Ph.D. diss., University of Oklahoma, in progress).

As witness to the Malthusian decline of Peru's guano birds during the 1939-1941 El Niño, Vogt became highly attuned to the importance of food to human well-being. This concern developed into an obsession during his tenure as a conservation administrator for the Americas, and his obsession found its public expression in Vogt's 1948 book *Road to Survival*.[35] Vogt's jeremiad was perhaps *the* most influential environmentalist book published in the United States during the years leading up to Rachel Carson's *Silent Spring*. He dropped the "population bomb" thesis 20 years before biologist Paul R. Ehrlich and the Club of Rome, the experts who tend to get credit for drawing the world's attention to the ecological dangers of population growth. (Ehrlich, in fact, read Vogt's book and took its conclusions to heart while he was still a young college student; Ehrlich appropriated the phrase "population bomb" from a pamphlet first published in 1954 by Vogt's disciple Hugh Moore.) The contents of Vogt's book, particularly its commentary on scientific management of natural resources, reflect the fundamental influence of Vogt's experience in Peru and Latin America. Through Vogt's rather haughty, ethnocentric conceptualization, events in Latin America had a decisive impact on the development of environmental thought at a crucial stage in United States history when its long-established conservation movement was in the midst of metamorphosing into a full-fledged environmental movement.[36]

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35. Vogt, *Road to Survival* (New York: William Sloane, 1948).

36. See Paul R. Ehrlich, *The Population Bomb* (New York: Ballantine, 1968); Donella H. Meadows, et al., *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books, 1972); Mauricio Shoijet, "*Limits to Growth* and the Rise of Catastrophism," *Environmental History* 4:4 (Oct. 1999), 515-530; Hays, "From Conservation to Environment."

Road to Survival was a manifesto "to regain ecological freedom for our civilization." It was based on a twin premise: "We live in one world in an ecological-environmental sense," Vogt reasoned, expressing the globalist ideology that had recently given birth to the United Nations and his own Pan-American experience. "Environmental resistance" or "carrying capacity" put a "practical ceiling" on all human endeavors, Vogt argued, applying the principle that had guided his study of the guano birds and announcing his opposition to the undiluted technological optimism of post-war progressives like Vannevar Bush, the architect of the National Science Foundation. This dual premise was based on Vogt's idealization of a world in "ecological equilibrium" where destructive competition was minimized and productivity maximized. The "Earth's golden mean" was that of a democratic society, which "survives through a system of checks and balances." From this background, Vogt proceeded to paint a grim picture of our probable future explicitly designed to vindicate the avatar of "the dismal science," the English political economist Thomas Robert Malthus (1766-1834).[37]

Vogt's first target was "that sacred cow, free enterprise." Echoing many of his intellectual colleagues in the United States formed by the experience of the Great Depression and the Age of Reform that preceded it, Vogt had little but scorn for free-market capitalism, though he hesitated to take clear sides in the emerging Cold War. "The good of the individual, and even of groups, must be sacrificed for the general good," Vogt pleaded. Western cattlemen typified America's "ecological Fifth Column" and were at the top of Vogt's blacklist: "The

37. Vogt, *Road to Survival*, 14-15, 22, 63, 68, 72, 86, 88-89, 284.

freebooting, rugged individualist . . . we must now recognize, where his activities destroy resources, as the Enemy of the People he has become." Considering his activities in Latin America, it is no surprise that Vogt concluded that government intervention, perhaps even government ownership, was needed to increase democratic access to natural resources. But he was no fan of the Soviet "police state" (nor Latin American military states, for that matter) which he viewed as deceived by the same nineteenth-century progressivism that had given rise to the sins of modern capitalism.[38]

Vogt was haunted by the specter of the recent world war, and he desperately wanted to prevent the seemingly inevitable "atomic or bacterial warfare" of a World War III. Echoing the rhetoric of the eugenicist who founded the Washington-based Population Reference Bureau, Guy Burch, he faulted nationalist expansionism typified by Hitler's *Lebensraum* idea for recent hostilities. But Vogt laid ultimate blame for this great tragedy at the feet of the industrial West which he thought had senselessly encouraged population growth and global competition for resources through imperial conquest in the decades leading up to the war. Countries with limited natural resources such as Japan were not the only villains of World War II:

> The culpabilty of Japan in seeking this way out of her Malthusian dilemma is a culpability shared by most of the nations that have been self-righteously preaching democracy. We grabbed enormous territories from Mexico, and under Theodore Roosevelt we unblushingly did to Colombia [by establishing the Panama Canal Zone] what Russia would now like to do to Turkey [in the Bosporus strait]. The chief justification for our present

38. Ibid., 15, 136, 143-144, 228-234, 285.

> attitude seems to be that we did our grabbing several decades ago. We did not have the very eminent excuse of such population pressure as confronted Japan.

In its colonial rule of India, the "contented parasite" Great Britain had done even more harm than the United States. Through its industrial and sanitary policies, it removed the checks of "disease, famine, and fighting" and allowed Indians, for whom "sex play is the national sport," to go "their accustomed way, breeding with the irresponsibility of codfish." This then put pressure on the United States to open its doors to immigration "to reduce the pressure caused by untrammeled copulation." As a consequence, the United States stood to see its own living standard fall in order "to raise that of the backward billion of Asia." Late twentieth-century nativism among North American and European environmentalists has followed similar reasoning--not to mention some Latin American anti-imperialist rhetoric.[39]

It is quite remarkable, in fact, how many latter-day environmentalist shibboleths Vogt expressed in this 1948 book, many of which eventually found their way into environmental historiography: nature as pristine before humans became "civilized," the "goat-god" and ax as destroyers of ancient Mediterranean civilization, sheep as the "devourers of men," erosion as "the cancer of the land," endangered species and predators as integral to the "balance of nature," the dams of the Tennessee Valley Authority (TVA) as "cross-purpose" rather than "multi-purpose," "good roads" as the highways to environmental destruction, China as the

39. Ibid., 216-217, 225-223; see Guy Irving Burch and Elmer Pendell, *Population Roads to Peace and War* (Washington, DC: Population Reference Bureau, 1945), revised and reissued for a mass market under the title *Human Breeding and Survival: Population Roads to Peace or War* (New York: Penguin Books, 1947).

land of starvation, Africa as a "dying land" condemned by desertification. Most significantly, Vogt, like Leopold and Ávila, foresaw that ecological "revolution" would occur only after "a profound change of fundamental ideas" led humans to discard "our elementalistic Aristotelean heritage." Of course, Vogt was not the first nor the most eloquent to enunciate these ideas, but he did bring them to bear on a compelling and immensely influential argument.[40]

At the core of Vogt's book was an explicit comparison between the United States and Latin America. This was the supposed empirical foundation of his analysis, acquired by experience. Picking up on a metaphor long used by proponents of tropical medicince and eugenics, Vogt contrasted North America's tremendous fortune with Latin America as a tubercular patient.[41]

This fortune, however, was built on spoilage. "Our forefathers . . . were one of the most destructive groups of human beings that have ever raped the earth." Citing early environmental historian Avery Craven, Vogt concluded that this fortune was built on soil mining for the production of plantation crops, followed by parasitic industrial development. Furthermore, the Americas (as a whole) had succored Europe's vast ecological hunger by exporting American cultivars like the potato and then importing vast numbers of Europe's human castoffs who had been brought up on this largesse and then orphaned. Quoting eugenicist P. K. Whelpton in the *Journal of Heredity*, Vogt concluded, "The United States is *now* overpopulated from the standpoint of per capita economic welfare," at least in

40. Vogt, *Road to Survival*, 19, 38-39, 94, 99, 120, 131, 142-143, 204, 219, 240.
41. Ibid., xiv.

terms of what Vogt called “The American Standard of Living.” Its immense natural inheritance notwithstanding, the United States needed to reduce its population to 100 million if it was to survive. (Vogt scrupulously avoided any mention of the true inspiration for this statement: Whelpton’s desire to produce a “better population” by cutting off immigration and encouraging the reproduction of “native white women” and “the more able, intelligent and farsighted portion of the population.”)[42]

Latin America was in far worse condition. “All Latin American countries except three or four are overpopulated. . . . Biological bankruptcy hangs over their heads like a shaking avalanche.” (In other words, it was folly to keep following the positivist slogan “to govern is to populate” coined by the Argentine Juan Bautista Alberdi in 1853.) Vogt diagnosed Latin America’s regional illness as traceable to four basic causes: First, in polar opposition to regional progressives, Vogt concluded that the land simply did not have sufficient fertility (“carrying capacity”) to produce wealth over the long term without depleting Latin America’s “ecological capital.” (In Vogt’s thinking, like that of the eighteenth-century French physiocrats, all value was derived ultimately from the soil.) Second, Vogt declared that a “cultural lag” inherited from sixteenth-century Spain and nineteenth-century France held back Latin America’s political development, particularly the region’s domination by large landowners and the corruption entailed by the “spoils system”

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42. Whelpton and Vogt’s emphasis; ibid., 59-6, 114-116, 146; P. K. Whelpton, “Population Policy for the United States,” *Journal of Heredity* 30:9 (Sept. 1939), 402, 405-406. Cf. Avery O. Craven, *Soil Exhaustion as a Factor in the Agricultural History of Virginia and Maryland, 1606-1860* (Urbana: University of Illinois Press, 1925).

that ruled its centralized governments. (Significantly for future development of this discourse, a negative evaluation of Roman Catholicism did not figure into this formulation.) Third, this region's "primitive New World folkways" were a barrier to progress. For example, the communal *ejido* was not a viable solution to Mexico's land reform problem simply because it doled out land in too-small quantities to communities of peasant farmers--who also lacked the knowledge to produce enough for their own subsistence while conserving the productivity of their minuscule holdings. The "scientific vacuum" that created this situation, however, was not due to "lack of intelligence or ability" among even the poorest, as Vogt's more racist peers might have argued; rather, it was due to a fundamental lack of economic resources related to causes one and two above. Fourth, "the 'American standard of living' . . . has sent all classes [in Latin America] awhoring after strange gods." In Vogt's prognosis, industrialization was simply impossible in most Latin American countries. Nearly all lacked exploitable natural resources (particularly energy, since Vogt dogmatically rejected hydroelectricity) and had small internal markets (impoverished by the basic lack of arable land). Vogt especially criticized the contradictory effect of high protectionist tariffs promoted by some economists because they tended to enrich only a few import-substituting industrialists while drastically raising the cost of living for the masses. Only Argentina, Brazil, and perhaps the Dominican Republic, which had "protected itself against the Haitian hordes," seemed to be in a position to escape from this vicious cycle, Vogt concluded--although if he had actually toured these countries, perhaps he would have condemned all of Latin America to destruction. Vogt largely blamed the United States for this ominous situation: as in Asia's ongoing conflicts, the U.S. policy of "dollar diplomacy" promised to have "violent repercussions" in the near future in Latin America. As in the United States, the fundamental cause for all of these problems was ballooning population.[43]

Peru, at least, was not so bad off in Vogt's schema thanks to its guano industry. Like Robert Coker and Robert Cushman Murphy before him, Vogt unequivocally praised CAG to his North American audience. "Were it not for guano, Peru would indeed be in a sorry state," with its coastal agricultural productivity soon falling to nothing. But "with guano they have few equals"--in sharp contrast to Chile whose "greatest natural asset is its high death rate." As a civil service organization, the Compañía Administradora del Guano

> set an example not only for the Americas but for the entire world. Were natural resources generally managed as intelligently as the Peruvians have--in this century--managed their guano, the future of the human race could be regarded with considerably more optimism.

Peru's guano ecology served as an object lesson for the rest of the world in other ways. Vogt noted with approval that the *lagartija* lizard *Tropidurus peruvianus* eats its own young to control its population. It is clear from such comments that Vogt's conception of animal behavior, especially among the guano birds, strongly influenced his ideas regarding human conflict. In *Road to Survival*, Vogt repeated his assertion that increased competition among guano birds for living space on

43. Vogt, *Road to Survival*, 75, 152-153, 161-162, 165-166, 168, 191. Regarding the ideology of "to govern is to populate" and eventual acceptance of the "fertility out of control" thesis in Latin America, see Nicolás Sánchez-Albornoz, *The Population of Latin America: A History*, trans. W. A. R. Richardson (Berkeley and Los Angeles: University of California Press, 1974), 151-153, 207-218.

coastal islands, especially when food was scarce, led to the break-up of breeding colonies, created millions of "ecological refugees," and served as a powerful natural form of population control. He described almost an identical scenario for humankind during World War II. This reveals one of Vogt's fundamental presuppositions: human beings are a part of nature; therefore, the ecological relationships that govern animal populations must also be the norm for human populations. Unless we experience a fundamental change in outlook, Vogt fervently believed, material necessity would bring human civilization to a great crash that paled before the economic downturn of the 1930s and the ecological depression of the guano birds. Again following the example of the Peruvian guano industry, part of this change would have to involve proper fertilizer use. Vogt praised the use of night soil by South Chinese farmers, noting that nitrogen-rich "Anglo-Saxon" feces brought particularly high prices there. Like the nineteenth-century proponents of sewage farming mentioned in chapter 1, Vogt believed humans needed to "close the circle" and stop throwing away the valuable manure produced by modern sanitation systems in misguided fear of epidemic disease.[44]

The *Road to Survival* did not inevitably lead human society down the toilet. Vogt's intense pessimism about population growth was balanced against an abundant technocratic optimism. He envisioned the establishment of an "international WPA" funded by the richer countries to promote "ecological health" in the rest of the world--not unlike the "global Marshall Plan" later promoted by U.S. politician Albert Gore, Jr. Vogt's testament had two commandments, one old

44. See ch. 1; Vogt, *Road to Survival*, 92, 110, 183-186, 221, 226.

and one new: 1) Renewable resources shall be managed to produce as much wealth as possible on a sustained-yield basis--the old conservationist "gospel of efficiency." 2) Human societies shall adjust their demand for such resources to this sustainable supply, either by lowering their living standard or maintaining fewer people. Vogt thought having few children was the only reasonable choice if modern civilized life was to survive.[45]

Scientists would be the judges of Vogt's new order. His program of research and action was derived from his experience as a scientist in Peru and as a conservation administrator for the Americas. The first task in regions with a "scientific vacuum" like Latin America would be to begin "ecological bookkeeping" through the gathering of climate data, the conduct of biological surveys, and the collection of other "elementary data." Vogt did not say directly who would be responsible for the interpretation of this data, but the disdain he expressed for the "dangerously misleading conclusions" derived from "so-called scientific work done in some of the poor countries" suggests that he thought Latin Americans could not be trusted to accomplish this by themselves, at least as long as their work was limited by poor training, poor pay, and insulation from the international scientific community. (His conflict with scientists in Peru, Mexico, and Chile was almost certainly influenced his views on this matter.) Vogt hoped the establishment of international cooperative research programs, as well as translation centers and clearinghouses for the diffusion of scientific knowledge

45. Ibid., 265; cf. Al Gore, *Earth in the Balance: Ecology and the Human Spirit* (Boston: Houghton Mifflin, 1992), ch. 15.

would remedy these shortcomings. The uses of this knowledge would then be adjudicated by boards of scientists, "scientific bureaucrats," in effect, who would advise politicians and directly oversee some programs. Vogt thought the Vannevar "Bush plan" for a National Science Foundation in the United States was a step in the right direction, as long as funding went to the study of the land and its health, and not to military and medical nostrums.[46]

Yet Vogt did not have complete faith in technocracy. He was ambivalent about the utility of purely technical knowledge. Although he anointed Gifford Pinchot of the U.S. Forest Service and Hugh H. Bennett of the U.S. Soil Conservation Service as the prophets of his new order, Vogt had a profound distrust for engineers who were the products of narrow technical training, particularly the U.S. Army Corps of Engineers who had drowned so much fertile farmland behind dams in the name of conservation. Vogt was even more distrustful of "a world dotted with TVAs." As he knew from personal observation in Latin America, big technological projects had great potential for graft and often disregarded the immense variation in "technical and social progress" around the world. Scientific research was worthless unless it was accomplished in a holistic spirit relating "the whole man to the total environment, recognizing the uniqueness of peoples and environments, and the fact that relationships. . . are constantly changing" over time.[47]

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46. Vogt, *Road to Survival*, 141, 143, 159, 265, 268-272.
47. Ibid., 127, 138-139, 268-272.

Vogt also hoped that room could be found for popular democracy in this new order somehow. He approved of the ongoing process of decolonization for countries like Indonesia. Yet he disapproved of popular desires perverted by free-market capitalism even more than he distrusted experts. Like any good liberal, he believed proper education provided an escape from this dilemma. Vogt generalized the strategy he and Enrique Beltrán had begun to develop for the Mexican state: In order to survive, states would need to implement a system of scientific and humanitarian education for all of society that emphasized the principles of holistic ecological health. Teachers would have to take the lead in this endeavor. This cadre would require proper training, preferably acquired on the land and among the people they would manage. As a result, these teachers would be capable of adapting this knowledge to local environmental and cultural variation (much as Carlos Llosa had used Vogt's understanding of the guano birds to come up with his artificial islands policy), as they came to understand the relationships that unite all of nature. Vogt envisioned the use of mass media as a tool to sell locally appropriate means of land management: "Advertising and publicity techniques that have girdled the globe with American tooth paste should sell sound land-use and ecological awareness; instead of promoting an American standard of living, they should promote a rational, national standard." Locally based institutions using local languages would orchestrate this education, preferibly modeled after the Inter-American Institute of Agricultural Sciences at Turrialba, Costa Rica, a Pan-American teaching center developed under Vogt's watch. National and state parks were also ideal instruments to instill these principles. Vogt had great faith in education, even for "so-called backward people." After all, he had observed Peruvian guano workers "many of them unable to read or write" who learned to "faithfully brush their teeth twice daily." Nevertheless, Vogt's advocacy for "a rational, *national* standard" for all peoples betrayed his belief that no system could hope to eliminate the gulf between ecologically rich and poor nations, and he made no call for any large-scale international redistribution of income.[48]

Vogt was neither a total apocalyptist nor an egalitarian--nor did he disdain technology. Having witnessed the sprouting of the Green Revolution at research labs in Mexico financed by the Rockefeller Foundation, Vogt had great hopes for genetically improved cultivars whose productivity would allow farmers to take marginal lands out of cultivation. Mass media also had a major role to play in his plans. But the linchpin of his system was "outwitting the libido." This required "a completely new approach to contraception" that went beyond his hero "Charles Goodyear's treatment of rubber" that had led to the mass-marketing of condoms. Above all, women needed a contraceptive technology of their own that was cheap and dependable: "If the United States had spent two billion dollars developing such a contraceptive, instead of the atom bomb, it would have contributed far more to our national security, while, at the same time, it promoted a rising living standard for the entire world." "Freedom of contraception" became Vogt's most influential maxim.[49]

48. Emphasis added; ibid., 272-277, 282.
49. Ibid., 265, 277-283.

This solution, if it was to have a global impact, hinged on Vogt's belief that humans universally share certain values that do not have to be taught by experts. Out of love for our children and our desire to care for their best interests, he thought families would freely choose to control their fertility when shown its necessity. Remarkably, at the time Vogt wrote *Road to Survival* he naively thought that conservative institutions such as the Roman Catholic Church would not be significant obstacles to this goal (Vogt was not an outspoken anti-Catholic at this stage.) In the final analysis, he still believed that traditional social institutions were compatible with his vision. No matter how radical some of his ideas might sound, he was a reformer, not a revolutionary. Even though "the handwriting on the wall of five continents" told him that "the Day of Judgment is at hand," Vogt believed the gate to life was wide and the road to survival broad. He thought the mass of humanity would choose the right path once they were told the truth.[50]

Vogt's Legacy

No doubt many of these pronouncements are familiar to those acquainted with the rhetoric of U.S. students of Latin America from this era. They tend to confirm the insight of historian Frederick Pike that new approaches to U.S. intervention in Latin America--especially Franklin D. Roosevelt's Good Neighbor Policy--emerged from new conceptions of the relation between humans and nature,

50. Ibid., 280-281; cf. Matthew 7:13.

particularly a "quest for equilibrium with nature" enunciated by a vanguard of professionals during the Great Depression.[51]

Vogt was both influenced by this intellectual shift and, in turn, influenced it himself. This is especially apparent where the so-called Berkeley School of cultural geography and demographic history is concerned. Beginning in the 1930s, this group of scholars founded by geographer Carl Sauer devoted its attention to the relationship between population, the environment, and subsistence in Latin America past and present, especially the impact of the European conquest on the New World.[52] The research of this original generation of ecological historians in the United States--all students of Mexico and the U.S. Borderlands--laid the foundations for present-day orthodoxy regarding the decline of aboriginal populations in the Americas. They argued that the population circa 1492 in the Americas was very high, especially in central Mexico and the central Andes. The indigenous population was so high, in fact, that it was on the verge of collapse in many regions--or in a few areas had already collapsed. The arrival of Old World diseases, rather than European brutality and military prowess, caused massive subsistence crises that came close to eliminating these populations. This

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51. Frederick B. Pike, *The United States and Latin America: Myths and Stereotypes of Civilization and Nature* (Austin: University of Texas Press, 1992), ch. 8; nevertheless, Pike is wrong to assert that "by 1945, interest in ecology had died" along with the New Deal and the Good Neighbor Policy among U.S. students of Latin America; see p. 293.

52. On the career of Carl Sauer and his impact on environmental studies, see Michael Williams, "Sauer and 'Man's Role in Changing the Face of the Earth,'" *The Geographical Review* 77:2 (Apr. 1987), 218-231; idem, "'The Apple of My Eye': Carl Sauer and Historical Geography," *Journal of Historical Geography* 9 (1983), 1-28; *Carl O. Sauer, A Tribute*, ed. Martin S. Kenzer (Corvallis: Oregon State University Press, 1987); *Land and Life: A Selection from the Writings of Carl Ortwin Sauer*, ed. John Leighly (Berkeley and Los Angeles: University of California Press, 1963).

population decline then left a dearth of exploitable labor that contributed to a long economic depression in the mining regions of Spanish America during the seventeenth century, the turn toward intensive exploitation of African slaves on plantations, and the drive toward extensive raising of livestock on the "Great Hacienda."[53]

It became possible to make this sort of argument at mid-century because population ecologists had demonstrated the potential for dramatic boom-bust cycles among wild animal populations. These included the famous studies by Charles Elton and his students of the predator-prey interactions of lemming, arctic fox, and snowy owl populations in northern Canada based on historical records of the Hudson Bay Company, Raymond Pearl's claim to have discovered a mathematical "law," the logistic curve, that described these biological boom-bust cycles, Aldo Leopold's studies of deer "irruptions"--and, of course, Vogt's studies of the guano

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53. Key early works of the Berkeley School that used population change to derive conclusions about ecological and economic change include Sherburne F. Cook, *The Historical Demography and Ecology of the Teotlalpan*, Ibero-Americana, no. 33 (Berkeley and Los Angeles: University of California Press, 1949); Woodrow Borah, *New Spain's Century of Depression*, Ibero-Americana, no. 35 (Berkeley and Los Angeles: University of California Press, 1951); Lesley Byrd Simpson, *Exploitation of Land in Central Mexico in the Sixteenth Century*, Ibero-Americana, no. 36 (Berkeley and Los Angeles: University of California Press, 1952).

This line of reasoning has had a far-ranging influence on Latin American studies and environmental historiography. See esp. François Chevalier, *Land and Society in Colonial Mexico: The Great Hacienda*, trans. Alvin Estis (1952; Berkeley and Los Angeles: University of California Press, 1963); Alfred W. Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Westport, CT: Greenwood Press, 1972); William H. Durham, *Scarcity and Survival in Central America: Ecological Origins of the Soccer War* (Stanford, CA: Stanford University Press, 1979); William M. Deneven, ed., *Native Population of the Americas in 1492*, 2d ed. (Madison: University of Wisconsin Press, 1992); Elinor G. K. Melville, *A Plague of Sheep: Environmental Consequences of the Conquest of Mexico* (Cambridge, UK: Cambridge University Press, 1994). Crosby acknowledged this influence in "The Past and Present of Environmental History," *American Historical Review* 100 (Oct. 1995), 1177-1189.

birds.[54] Vogt and the Berkeley School directly appropriated these findings for their studies of human ecology. As early as 1934, Vogt had already presented the argument that the collapse of the ancient Maya had been caused by a great subsistence crisis due to systematic destruction of Mesoamerica's lowland forest. This coincidence was no mere manifestation of the Zeitgeist. Vogt and the Berkeley School directly influenced one another through correspondence. For example, Vogt adopted the Mexican historian Lesley Byrd Simpson's contention that maize, rather than men, was the real "Tyrant of Mexico." Simpson became centrally concerned with the potential "for a Malthusian tragedy" in Mexico thanks to Vogt. By extension, Vogt's experience as a Lord of the Guanay continues to affect the ways we conceive of Latin America, past and present. This is yet another in a long line of examples in which natural science influenced the development of social thought (and vice versa).[55]

Vogt's impact on the formation of environmental history as a profession did not stop there. Playing the role of patron, as he had with Enrique Ávila and B. H.

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54. On Elton and Pearl, see Elton, *Voles, Mice and Lemmings: Problems in Population Dynamics* (Oxford: Clarendon Press, 1942); Kingsland, *Modeling Nature*, 56-94; Chitty, *Do Lemmings Commit Suicide?*; Crowcroft, *Elton's Ecologists*. On Leopold and deer irruptions, see below.

55. Vogt "The Agriculture of the Maya," *Southwest Review* 19 (1934), 65-77. For explicit evidence of this reciprocal influence, see idem, *Road to Survival*, 156-157, 168; Lesley Byrd Simpson, *Many Mexicos*, 4th ed. (Berkeley and Los Angeles: University of California Press, 1966), 12-21, 336-370; Vogt-Simpson correspondence, Vogt papers, ser. 1. This brief intellectual history calls for more systematic archival research. On the crossover between ecology and social thought, see Emanuel Gaziano, "Ecological Metaphors as Scientific Boundary Work: Innovation and Authority in Interwar Sociology and Biology,"*American Journal of Sociology* 101:4 (Jan. 1996), 874-907; Joel B. Hagen, *An Entangled Bank: The Origins of Ecosystem Ecology* (New Brunswick, NJ: Rutgers University Press, 1992), esp. ch. 1; Gregg Mitman, *The State of Nature: Ecology, Community, and American Social Thought, 1900-1950* (Chicago: University of Chicago Press, 1992).

Osorio Tafall, Vogt directly inspired Clarence J. Glacken (1909-1989) to make environmental studies his profession. Vogt befriended him in 1942 when Glacken's wife worked for Vogt at the office of the Coordinator of Inter-American Affairs in Washington. Vogt piqued Glacken's interest in conservation issues, particularly soil erosion. After Glacken returned from a tour of duty in Korea, where he was in charge of repatriating Koreans from Japanese-occupied territories after World War II, he wrote a personal appeal to Vogt. Following the path of many cerebral veterans enabled by the G.I. Bill, Glacken wanted to get a Ph.D. that would allow him to pursue his interests in human ecology as a professional. From El Salvador, Vogt directed his client to travel to Berkeley, meet Carl Sauer, and ask him about making an academic career as an East Asia expert. Sauer, who was an outspoken critic of the reductionist triumphalism of social science, convinced Glacken to study geography at Johns Hopkins University, and Vogt wrote him an enthusiastic recommendation. There, Glacken completed a dissertation on "The Ideas of the Habitable World" in Western thought since the late eighteenth century--including a discussion of "Population Growth and Resources," clear evidence of Vogt's influence. Continuing in their role as patrons, Vogt tried to arrange a publisher for Glacken's thesis, while Sauer gave Glacken an academic job working as part of the Berkeley School.

Sauer arranged for Glacken to deal with "over-all human time" at the June 1955 Symposium on Man's Role in Changing the Face of the Earth. Under Sauer's guidance this conference became the mythic birthplace of environmental history as a problematic, if not as a profession. (Only two of 75 participants were employed as "historians," even though "how we got where we are" was an explicit concern of the symposium, thanks to Sauer.) Meanwhile, Sauer protected Glacken from the "publish or perish" academic set while he expanded on the ideas of his dissertation. Its introduction evolved into one of the masterpieces of environmental history, *Traces on the Rhodian Shore* (1967), a richly detailed interpretation of nature in Western thought from Hippocrates to Humboldt. In later years, Glacken continued to acknowledge Vogt's broad influence in his teaching and writing. He prominently featured Vogt in the unpublished--and unfortunately lost--multi-volume sequel to this work. Through Glacken, Vogt contributed to the formation of a generation of academic experts on the human encounter with the natural environment.[56]

Vogt's influence was not limited to the ivory tower--not by a long shot. *Road to Survival* was the best-selling book on conservation issues in the United States before Carson's *Silent Spring*. Excerpts and reviews published in popular periodicals broadened Vogt's audience even further. An excerpt published in

56. Prominent figures trained or fundamentally influenced by Glacken include Yi-fu Tuan, William Deneven, Edmund Muncie, John Passmore, Eugene Hargrove, Max Oelschlaeger, and Richard Grove. Clarence Glacken to Vogt, 13 June 1946, Johns Hopkins University to Vogt, 9 June 1949, Vogt papers box 1:1; Vogt to Glacken, 18 July 1946, Vogt papers box 1:3; Vogt to Chairman of Executive Committee, Johns Hopkins University, 7 June 1949, Vogt papers box 1:4; Ravi Rajan, "Clarence Glacken: Pioneer Environmental Historian," in *Geneologies of Environmentalism: Clarence Glacken on Nature, Culture and History*, ed. Ravi Rajan and Michael Watts (Berkeley and Los Angeles: University of California Press,); Glacken, "Changing Ideas of the Habitable World," in *Man's Role in Changing the Face of the Earth*, ed. William L. Thomas, Jr. (Chicago: University of Chicago Press, 1956), 70-92; idem, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century* (Berkeley and Los Angeles: University of California Press, 1967), xi-xii; idem, "Population Growth and Resources," in *Geneologies of Environmentalism*, ch. 21 [ch. 1 of his Ph.D. thesis]; Conservation Foundation, *Future Environments of North America: Social and Cultural Purpose* (n.p., 1965); Williams, "Sauer and 'Man's Role in Changing the Face of the Earth.'"

Harper's Magazine featured CAG as a lone example of hope on a continent sliding to ruin. In this short article, Vogt repeated his stern warning regarding the revolutionary potential of Latin America. Five years before Fidel Castro initiated the 26th of July Movement at the Moncada barracks in Cuba, Vogt demanded that the United States,

> control American vandals abroad. We have spent millions of dollars trying to prove that we mean what we say about the Good Neighbor Policy--and at the same time we permit, even encourage, American business men to destroy the very means of subsistence of millions of people. This. . . can scarcely fail to have violent repercussions when the people of Latin America awake to what is being done to them. The fact that Latin Americans themselves are selling out their countires will be forgotten; the dead cats will be heaved at the Colossus of the North.[57]

In stark contrast, the condensed version of *Road to Survival* published in *Reader's Digest* systematically omitted Vogt's criticism of the United States and European colonial powers. In this butchered account, "the Japs who came to dinner" and other poor "men and women in overpopulated countries who produce excessive numbers of children" became the real threat to the "American standard of living" and global order. Vogt's recommendations that "colonial lands. . . be placed under an ecological trusteeship" and that international organizations offer people "a sterilization bonus" took on a perverted meaning in this context. And to make sure that the right-wing political implications of this message were clear to his 15 million worldwide subscribers (including the many Latin American readers of the Spanish-language edition), DeWitt Wallace, the immensely powerful editor

57. Vogt, "A Continent Slides to Ruin," *Harper's Magazine* June 1948, 487.

of *Reader's Digest*, juxtaposed a Panglossian "critique of *Road to Survival*" that told Americans to get ready for unprecedented prosperity during the 1950s.[58]

Unfortunately, the latter, poorly digested version of Vogt's argument came to dominate public discourse when magazines like *Newsweek* and *Business Week* published features on "Vogt's ecological Doomsday Book." This left Vogt open to poorly grounded attacks from technological optimists and cornucopians across the political spectrum. Many took aim at Vogt's scientific credentials. From the left, a professional geographer writing for *The Nation* utterly condemned Vogt for his "hysterical efforts" against "the spawning millions of backward countries, who must now have fewer children and conserve their dwindling resources--so that *we* may maintain our standard of living." This writer thought nobody could "foresee the end of technological advances." For example, "the sea has a virtually limitless sustenance capacity which can be developed through scientific research." Vogt's failure to ask "the Chinese, Puerto Ricans, Indians, or Africans what they think," in contrast, represented "the extent of science's bankruptcy in the face of modern problems." Closer to the political center, a breathless columnist for *Time* claimed that "to the real agricultural scientists, close to the soil and its sciences, such pessimism sounds silly or worse." Through the use of hybrids, agricultural chemicals, and scientific understanding, *Time* argued, "Man is master not only of the soil, but of the plants that grow in it, molding them plastically to suit human

58. Vogt, "*Road to Survival*: A Condensation from the Book by William Vogt," *Reader's Digest* Jan. 1949, 141-142, 151-153, 156; Vergil D. Reed, "Jackpot for 1960," *Reader's Digest* Feb. 1949, 88-90 [condensed from *Nation's Business* Nov. 1948]. On the influence of Wallace's magazine on popular perceptions of nature during this era, see David Peterson del Mar, "'Our Animal Friends': Depictions of Animals in *Reader's Digest* during the 1950s," *Environmental History* 3:1 (Jan. 1996), 25-44.

purposes." For example, the U.S. South was supposedly in the midst of "a real agricultural rebirth" where

> on thousands of once sterile slopes, the miraculous vine, kudzu, clambers like Jack's beanstalk. It chokes devouring gullies with entangled soil. It buries fences, leaps into trees. Its big leaves, which stay green until Christmas, are as nourishing to cattle as excellent alfalfa. When plowed under, kudzu enriches the soil.

Elsewhere, "enormous areas, especially in the tropics, will almost certainly yield, sooner or later, to scientific agriculture."[59]

In hindsight, this boundless faith in the ability of kudzu, the oceans, boreal and tropical forests to produce food for humanity sounds to us "silly or worse," yet it reveals the development of a deadly serious philosophical gulf that increasingly divided the world's environmental managers into optimist and pessimist camps, into a large majority of cornucopians and small minority of millenarians expecting the Apocalypse.

Further illustrating the crossover between North and Latin American discourse on population, Vogt's most influential left-wing critic did not even come from the United States. In 1952, at the request of the publisher Little, Brown, & Co., the Brazilian physician Josué de Castro (1908-1973) published *The Geography of Hunger*, a condensation of a multi-volume study he was planning on the global geopolitics of famine and malnutrition. He directly attacked Vogt, the "standard-bearer of . . . those who go in for neo-Malthusian theories while they defend and benefit from an imperialist economy," and he squarely blamed hunger on the

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59. "This Starving Planet," *Newsweek* 9 Aug. 1948, 69-70; "Arid Acres Point to Arid Living," *Business Week* 2 Oct. 1948, 82-83; Earl Parker Hanson, "Mankind Need Not Starve," *The Nation* 12 Nov. 1949, 464-467, Hanson's emphasis; *Time* 8 Nov. 1948, 27-31.

maldistribution of food by the world's capitalist ruling class. Like Vogt's other cornucopian critics, de Castro had abundant faith that technological progress, the conquest of new lands like the Amazon Basin for agriculture, and the conversion of the tropical world's vast cash-crop monocultures to food production would continue to produce an abundance of food for all social classes--as long as it was justly distributed. At the height of the Cold War, this runaway best-seller was showered with prizes in both the capitalist West and communist East, republished several times, and eventually translated into 30 languages.[60]

De Castro had more in common with Vogt than he realized (perhaps because he, too, gave Vogt's opus only a superficial reading). They both despised basic features of the world's "imperalist economy." Both believed mass education could remedy many of the world's environmental problems. Most significantly, de Castro numbered among the growing class of international environmental technocrats, the key to his influence. He started his career as a hygienist interested in the nutrition and living conditions of the urban working class of Recife, his birthplace. As we saw in chapter 1, the vast hinterland of this northeastern Brazilian city, the arid *sertão*, is disastrously (though irregularly) affected by the El Niño-Southern Oscillation cycle. De Castro's professional life was profoundly influenced by the *grandes sêcas* of 1931-1932 and 1957-1958 (both associated with

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60. Josué de Castro, *The Geopolitics of Hunger* (New York: Monthly Review Press, 1977), 66, rev. and enl. ed. of *The Geography of Hunger* (Boston: Little, Brown, 1952); Jean-Pierre Berlan, introduction to *The Geopolitics of Hunger*, 19-21. De Castro had already published preliminary versions of these arguments in Portuguese and Spanish under the titles *Geopolítica da fome: Ensaio sôbre os problemas de alimentação e de população do mundo* (Rio de Janeiro: Livraria-Editôra da Casa do Estudante do Brasil, 1951); idem, *La alimentación en los trópicos*, trans. Alfonso Reyes Mota (Mexico: Fondo de Cultura Económica, 1946).

Peruvian El Niño events). He had close official ties to the Food and Agriculture Organization of the United Nations (FAO), an organization established in the aftermath of World War II "to raise levels of nutrition and standards of living, to improve agricultural productivity, and to better the condition of rural populations" on a global scale. He was serving a stint as president of its executive council when he was first approached to write his famous English-language treatise on the "political implications" of the world hunger problem.[61]

As Josué de Castro's case makes clear, Vogt's legacy was less a function of how many people read his work than who read and acted on--or rebelled against--his words. Grace Barstow Murphy, Robert Cushman Murphy's wife, wrote Vogt, "Your book is the new Bible. I've already written . . . a clergyman you know to found a new religion on it." The conservation publicist and historian of the American West Bernard DeVoto plugged it whenever he could: "I am more steamed up about it than I can remember having been about any book for years." The wealthy founder of the Dixie Cup Corporation Hugh Moore claimed to have received a revelation from reading *Road to Survival* in 1948. These individuals played key roles in three of the biggest environmental controversies of the 1950s in the United States: the 1950-1955 battle against the construction of a dam in

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61. Berlan, introduction to *The Geopolitics of Hunger*, 19-21; Armando Sales, *Josué de Castro: O homem e o sonho* (Recife, Pernambuco: Editora Comunicarte, 1996), passim; de Castro, *Death in the Northeast* (New York: Random House, 1966), passim; César N. Caviedes, *El Niño in History: Storming through the Ages* (Gainesville: University Press of Florida, 2001), esp. 99-109; United Nations, Food and Agriculture Organization, "FAO: What It Is--What It Does," [cited 26 Sept. 2002], available from http://www.fao.org/UNFAO/e/wmain-e.htm. Other book-length biographies of de Castro and commentaries on his work include Alain Tobelem, *Josué de Castro e a descoberta da fome* (Rio de Janeiro: Editora Leitura, 1974); Rosana Magalhães, *Fome: Uma (re)leitura de Josué de Castro* (Rio de Janeiro: Editora Fiocruz, 1997).

Dinosaur National Monument (DeVoto), the 1958-1960 lawsuit against the spraying of DDT on Long Island (Murphy), and the emerging debate over the need for legalized abortion and government-coerced population control (Moore).[62]

No reader of Vogt's work was more important than Aldo Leopold. As we have seen, Vogt and Leopold began to build their friendship in the 1930s when Vogt was editor of *Bird-Lore* and published a precursor of Leopold's famed land ethic. In the turmoil over his termination as editor, Vogt toyed with the idea of going to the University of Wisconsin to study with Leopold before CAG's offer came in. In his stead, Vogt's Peruvian disciple Enrique Ávila studied wildlife management with Leopold, and Ávila strengthened the relationship of his two mentors in the process. Vogt and Leopold's friendship grew stronger yet when Vogt worked with Leopold's son Starker to organize a national game survey of Mexico. (Starker, a biologist, had been Carl Sauer's student at Berkeley in the late 1930s and helped introduce Sauer's ideas to Vogt and his father, and he remained active in conservationist causes.) In 1942, Vogt even tried to convince the elder Leopold to go on a lecture tour to South America in Gilbert Pearson's footsteps as a boon to "hemispheric science and its relations to strategic problems." Even personal features of their relationship had implications that extended far beyond the United States.[63]

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62. On Murphy and the DDT controversy, see epilogue. Ávila to Vogt, 29 Oct. 1948, Vogt papers box 1:1; Grace Murphy to Vogt, n.d. [ca. 1948], Vogt papers box 1:2; DeVoto quoted in Fox, *The American Conservation Movement*, 308; Donald T. Crichtlow, *Intended Consequences: Birth Control, Abortion, and the Federal Government in Modern America* (New York: Oxford University Press, 1999), 30-31; Gottlieb, *Forcing the Spring*, 37.

63. Leopold, "Conservation Esthetic," *Bird-Lore* Mar.-Apr. 1938, 101-109; Vogt to Aldo Leopold, 23 Oct. 1944, Vogt to Osorio, 14 Jan. 1946, Vogt papers box 1:4; Meine, *Aldo Leopold*, 380, 404-405, 467, quote p. 478.

But their intense shared interest in the "irruption sequence" among wild populations cemented their intellectual assocation. In 1940-1941, at the same time Vogt was preoccupied with the "irruption" of the guano birds caused by abnormal oceanic conditions off Peru, Leopold became obsessed with deer overpopulation caused by the extirpation of wolves on the forested Kaibab plateau north of the Grand Canyon. One of Leopold's biographers argues that the problem of "too many deer" became "the one big issue on which Leopold fought in the public arena" during his last years; furthermore, it led Leopold to consider the problem of resource supply that faces all living things as fundamentally a problem of land health. Like Vogt, he came to think that proper management required the restoration of nature's self-regulating processes. A personal encounter with a massive subsistence crisis among a population of wild animals was the liminal event that allowed Leopold to evolve "an ecological attitude toward deer, wolves, and forests," and Vogt toward guanayes, condors, anchoveta, El Niño--and people.[64]

In 1946, their relationship entered a new phase of intimate collaboration that led directly to the publication of their two great works. Ironically, considering the eventual public reception of their books, Leopold was much more pessimistic than Vogt about the future, a pessimism strongly flavored by Vogt's negative evaluation of the state of the rest of the world. After the Third Inter-American Agricultural Conference, held in Caracas, Venezuela, in 1945, the Pan-American

64. Flader, *Thinking Like a Mountain*, ch. 5, esp. 242-243, 268-270; contra Flader, Vogt's usage shows that "irruption" was not a word peculiar to Leopold's science at this time; see Vogt, "Informe sobre las aves guaneras," 86.

Union selected the United States to host the next such meeting. As Pan-American conservation chief, Vogt proposed organizing an Inter-American Conservation Congress in its stead, and he sent his prospectus to Leopold for comment. Leopold wrote back, "The only thing you have left out is whether the philosophy of industrial culture is not, in its ultimate development, irreconcilable with ecological conservation." Leopold's answer: "Industrialism might theoretically be conservative if there were an ethic limiting its application to what does not impair (a) permanence and stability of the land (b) beauty of the land"--a preliminary statement of his land ethic. "*But there is no ethic, nor likely to be*," Leopold continued. "Bill, your outline is excellent. That *the situation is hopeless* should not prevent us from doing our best." Vogt was slightly more optimistic: "You are, of course, correct in what you say about industrialism. I don't know how you would define ethic, but I am hopeful that horse sense may someday replace it as a limiting factor to preserve the permanence and stability of the land, even though there seems to be little hope for saving its beauty."[65]

Vogt already knew, of course, that these ideas about the incommensurability between conservation and industrial development were unwelcome in Latin America, and his visit to the University of Wisconsin in March 1946 had confirmed this. His lectures met with "passionate opposition" from Latin American students, their countries' future technocrats. But these objections seemed to strengthen Vogt's resolve to fight against developmentalism as his

65. Emphasis added; Leopold to Vogt, 25 Jan. 1946, Vogt papers box 1:2; Leopold to Vogt, 21 Jan. 1946; Vogt to Leopold, 28 Jan. 1946, both quoted in Meine, *Aldo Leopold*, 478.

horizons expanded from the Americas to the entire globe. In consultation with Leopold, he hatched the idea during this particular visit to Madison to write a book "as soon as possible"--what became *Road to Survival*--"because the problem of population and land use has been given only glancing consideration" in the charter of the recently founded United Nations. His prospectus, meanwhile, evolved into the First Inter-American Conference on Conservation of Renewable Resources held in September 1948 in Denver, Colorado. Vogt presided over this meeting attended by officials from 21 American republics and "a large proportion" of the hemisphere's conservation officials, including CAG's general manager Carlos Llosa. Ávila, despite his best attempts, could not attend because he was unable to obtain patronage for the trip from the Peruvian state--a situation he blamed squarely on discrimination against Puno, his place of birth. Those who did attend traveled over 500 miles around the Great Plains and mountain West to see U.S. government conservation projects in action. They focused on the organization of agencies to protect the land and its resources all over the hemisphere--though they carefully avoided the controversial birth control question. Thus, Vogt was the force behind yet another important event for the development of environmentalism in the Americas.[66]

Just before the appearance of *Road to Survival*, Leopold finished an essay collection of his own. Probably at Vogt's suggestion, he sent the manuscript to Alfred A. Knopf. This prestigious New York publisher was already known to be

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66. Vogt to Leopold, 27 Sept. 1946, quoted in Meine, *Aldo Leopold*, 479-480; Ávila to Vogt, 19 Dec. 1946, Vogt papers box 1:1; *MCAG* 40 (1949), xc; "Arid Acres Point to Arid Living," *Business Week* 2 Oct. 1948, 82-83; Vogt, "New Farms for Old," *Américas* Mar. 1949, 30-32, 40.

friendly toward conservation. But Knopf's editors saw no profit in Leopold's defense of wilderness and paean to the natural world surrounding his rural Wisconsin "shack." Starker Leopold's brother Luna--a hydraulic engineer who became an important U.S. conservationist in his own right--took on the task of marketing their father's "Great Possessions" manuscript to Oxford University Press. Repeating the role he had played in getting Roger Tory Peterson's bird book through the press, Vogt approached his own publisher, Sloane Associates, about Aldo Leopold's manuscript. Then Leopold died of a heart attack while fighting a grass fire at his shack in April 1948, only five months before he was expected to attend Vogt's Denver conference. Vogt met with Oxford University Press officials to assure them that the book they had just accepted for publication could be edited adequately by Luna. Thus, Vogt and Luna played a tried-and-true role in the appearance of *A Sand County Almanac and Sketches Here and There* late in 1949. These two environmental technocrats saw the *Principia* of the U.S. environmental movement through the press.[67]

A Sand County Almanac shared the same basic message and view of the world as Vogt's *Road to Survival*. Nowhere is this clearer than Leopold's presentation of "The Land Ethic." In this seminal essay, Leopold criticized "a conservation system based wholly on economic motives" since "most members of

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67. I refer to Edmund Halley's important role in guiding Isaac Newton's *Philosophiae Naturalis Principia Mathematica* (London: J. Streater, 1687), the cardinal work of the Scientific Revolution, through the press; see Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago: University of Chicago Press, 1998); Fox, *The American Conservation Movement*, 285-286; Meine, *Aldo Leopold*, 510-511, 517, 518, 523-524. Note that Luna took part in Sauer's famous 1955 Conference as an erosion expert; see Luna B. Leopold, "Land Use and Sediment Yield," in *Man's Role in Changing the Face of the Earth*, 639-647.

the land community have no economic value." He saw "an ecological comprehension of the land" derived from "ecological training" as leading to a solution, although he was acutely aware of the political and economic cleavages that prevented specialized forest, wildlife, and agricultural professionals from arriving at a concept of "land health." Leopold parroted Vogt's opinion that "accelerating wastage" due to "exploitative agriculture" had led many parts of the world to exceed "their sustained carrying capacity. Most of South America is overpopulated in this sense." As Knopf predicted, Leopold's book attracted little attention at first. But the notoriety surrounding Vogt's much more negative book--and the environmental movement it helped inspire--eventually produced a growing audience for Leopold's masterwork. It emerged as a runaway mass-market bestseller in the late 1960s, some two decades after it was published, when Vogt and his work had already faded from popular memory.[68]

In 1948, another prominent book took up the cause of population control. *Our Plundered Planet* covered almost exactly the same ground as Vogt's book, though it was much more impressionistic and less programatic than *Road to Survival*. Its author Fairfield Osborn had a long scientific pedigree: he was the long-time director of the New York Zoological Society and the son of famed paleontologist Henry Fairfield Osborn. He freely admitted that Leopold and Vogt, alone among his vast network of advisors, provided him with "a philosophical

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68. Aldo Leopold, *A Sand County Almanac*, 210, 219, 221-223. The mass marketing of U.S. Secretary of the Interior Stewart L. Udall's book *The Quiet Crisis* (New York: Holt, Rinehart & Winston, 1963) by Avon Books in 1964--which featured Leopold and his ideas--went further to prepare the way for Ballantine Books' republication of *A Sand County Almanac* in 1966; see Meine, *Aldo Leopold*, 524.

approach to the problem" the world was facing. The Latin American section of his chapter on "The New World: New No Longer" came straight from Vogt's Pan-American Union Conservation Section reports.[69]

The similarities between their books are legion. Osborn, too, was inspired by the incredible human destructiveness of World War II to write about another "silent war . . . man's conflict with nature" that promised to destroy our one "world society" unless humanity chose to travel down the "slow road to reclamation." In his view, the predictions of Malthus for industrialized Europe had merely been forestalled by the extension of their environmental exploitation to the United States and Canada. The ongoing destruction of the rest of the Americas, Africa, and Australia meant that the three great Old World concentrations of global population could no longer look to these "New Worlds" for salvation. Nor could chemical fertilizers, pesticides, and other products of the "flattery of science" provide a way out. Like Vogt, Osborn condemned the unending quest of European colonizers for "cash returns through export," their inattention to "basic subsistence" and their use of "government taxation" as a "thin veneer to cover forced labor or economic slavery" among the colonized--all in the name of "higher civilization." These wanton acts were responsible, he thought, for the global instability that gave birth to two world wars and the growing Soviet threat. Osborn also had little good to say about the "American way of doing business" that destroyed productive land and renewable resources for the profit of a few rather than "the benefit of all the people." But unlike Vogt, he thought well-planned and "ably administered" big

69. Fairfield Osborn, *Our Plundered Planet* (Boston: Little, Brown, 1948), 204-205.

development projects like the Tennessee Valley Authority were part of the solution for the "oncoming crisis" that faced the world. In the end, there was only one real solution for Osborn:

> Man must recognize the necessity of cooperating with nature. He must temper his demands and use and conserve the natural living resources of the earth in a manner that alone can provide for the continuation of his civilization. The final answer is to be found only through comprehension of the enduring processes of nature. The time for defiance is at an end.

This was an archetypal case when two books published simultaneously with virtually the same argument on the same subject served to broaden the audience, influence--and profitability--of both books.[70]

Again, this was no coincidence: Osborn, Leopold, and Vogt were closely linked by personal and institutional ties. They had already known each other for years when the New York Zoological Society called together a conference in March 1947 to discuss the creation of a conservation organization with a truly global scope. This trio took the lead in its planning and developed its statement of purpose: "to advance, for the benefit of mankind throughout the world, knowledge and understanding of the earth's natural and living resources and their essential relation to each other and to the sustenance and enrichment of life on earth." This meeting led directly to the formation of the Conservation Foundation in 1948. Here, Vogt's experience with the creation of groups like the Comité Nacional de Protección a la Naturaleza in Peru turned around and influenced the formation of this New York-based organization. Like its Latin American cousins, the

70. Ibid., vii, 33, 38, 67-74, 102-103, 116-117, 139-142, 166-175, 191, 192-193, 201.

Conservation Foundation would focus on the "conservation of soil, water, forests, vegetation, and wildlife through research and education." It was eminently technocratic: its original board of directors included a familiar cast of characters: Osborn (its chief), Leopold, Vogt, the English ecologist Charles Elton, and Yale zoologist G. Evelyn Hutchinson. (Hutchinson who was soon to publish an exhaustive study of the world's guano deposits, probably due to Vogt's influence; he, too, was a Lord of Guano.)[71]

Unlike the Committees for the Protection of Nature in the rest of the Americas, the Conservation Foundation had privileged access to vast technical and financial resources in the United States--and pretensions to global influence. During its first decade of existence, it gave its support to a variety of scientific studies, propaganda films and publications. The vast majority of these were focused on North America, but it also supported studies of population in Jamaica and soil erosion in Latin America, research on the exploitation of the sea to feed the world's growing population, and the graduate training of resource experts to serve business, industry, and government. By the 1960s--when Vogt wrapped up his career as its director--the Conservation Foundation had acquired quite a reputation as both a producer and clearinghouse for environmental knowledge. But in the 1970s, a new generation of leaders abandoned the anti-developmental perspective of the Conservation Foundation's founders and began to search for "common ground" between "business and environment." Environmental historian Samuel Hays has interpreted this shift in the Conservation Foundation as representative of a

71. Osborn to Vogt, 4 Nov. 1948, Vogt papers box 1:2; Meine, *Aldo Leopold*, 495.

larger tendency for "technical professionals" to neutralize the more radical demands of grassroots environmental activists during the 1970s and 1980s in the United States. If Hays is at all correct, this is a cruel betrayal of the environmental technocrats who gave the Conservation Foundation its initial impetus.[72]

The world's most powerful technocrats quickly lined-up their forces against Vogt and his allies. In 1949, Fairfield Osborn was invited to present his ideas on "the problem of world production" at an international media event, the Mid-Century Convocation on the Social Implications of Scientific Progress held at the Massachusetts Institute of Technology. This was a set-up. After Osborn had his say, a high-powered panel of scientists and engineers including Vannevar Bush, the well-known author of *Science: The Endless Frontier* (1945) and architect of the National Science Foundation, and Henry Tizard, the definition of the scientist in power as leader of Britain's war effort, ruthlessly attacked neo-Malthusianism. "Science also increases exponentially; in the same way that men lead to more men and machines make more machines, so ideas create more ideas," Bush retorted. "The point I think is this, that science gets there first."[73]

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72. Hays, *Beauty, Health, and Permanence*, ch. 12, esp. pp. 419-422. Research publications funded by the Conservation Foundation from 1948-1958 include Luna B. Leopold and Thomas Maddock, Jr., *The Flood Control Controversy: Big Dams, Little Dams, and Land Management* (New York: Ronald Press, 1954); Conservation Foundation and FAO, *Soil Erosion Survey of Latin America* (New York, 1955); G. W. Roberts, *The Population of Jamaica* (Cambridge, UK: Cambridge University Press, 1957); Lionel Albert Walford, *Living Resources of the Sea: Opportunities for Research and Expansion* (New York: Ronald Press, 1958); Conservation Foundation, *Resource Training for Business, Industry, Government: Including a Report of the First Conference on Graduate Training in Resources, University of Michigan, April, 1956* (New York, 1958).

73. Mid-Century Convocation on the Social Implications of Scientific Progress, *Mid-Century: The Social Implications of Scientific Progress. Verbatim Account of the Discussions Held at the Massachusetts Institute of Technology on the Occasion of the Mid-Century Convocation,*

Meanwhile, Vogt got into trouble with his superiors at the newly created Organization of American States--exactly the sort of trouble Ávila and Osorio thought they would face if they voiced their true opinions during Mexico's guano controversy. (Even more glaringly, Josué de Castro's outspoken support for redistribution of wealth forced him to live out his life in exile after fleeing the 1964 right-wing military takeover in Brazil.) Vogt's support for contraception on demand was controversial, to say the least, and his negative assessment of the possibilities for industrialization in Latin America was downright insulting to regional developmentalists. An article published in the *Saturday Evening Post* brought this controversy to a head. Vogt criticized the "Santa Claus complex" behind President Truman's "bold new" Point IV Program which promised technical assistance and economic aid to counter "hunger, misery, and despair" among the world's "undeveloped areas and backward peoples." (As a sign of the times, technical experts were to be the administrators of this vast aid program to the Third World.) Vogt was afraid that well-meaning Americans ignorant of the needs and desires of these "so-called backwards peoples" would saddle them with unpayable debts, while ignoring the population problem and other basic causes of underdevelopment. Late in 1949, he chose to resign rather than put down his pen.[74]

The same defects that cost him his job at the OAS won Vogt an even more visible position in the accelerating U.S. birth control movement. In May 1951, the

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March 31, April 1 and April 2, 1949 ed. John Ely Burchard (Cambridge, MA: MIT Press, 1950), ch. 3 [quote pp. 88-89].

74. Vogt, *People! Challenge to Survival* (New York: Sloane Associates, 1960), 213-214; idem, "Let's Examine Our Santa Claus Complex," *Saturday Evening Post* 23 July 1949, 17-19, 76, 78; "Vogt's Stand Costs Job," *Science News Letter* 31 Dec. 1949, 424; *Current Biography* (1953), s.v. "Vogt, William."

Planned Parenthood Federation of America, as activist Margaret Sanger's Birth Control Federation of America had come to be known, named Vogt its national director. Planned Parenthood was the keystone organization of a movement dominated by professionals that aggressively promoted the use of scientific understanding and contraceptive technologies for family planning. Vogt's appointment symbolized the convergence of the birth control and population control movements during the 1940s and 1950s. With direct financial assistance from the radical Hugh Moore, Vogt helped turn Planned Parenthood into a leading voice for global population control.

But Vogt's combative tendencies led him into conflict with Sanger and heiress Katherine Dexter McCormick, just as they had dogged his relationship with colleagues at the Audubon Society and CAG. Vogt and Sanger had a falling out over funds raised by Sanger's International Planned Parenthood Federation (est. 1952). More importantly, Vogt infuriated McCormick (an MIT graduate) when he tried to divert her philanthropy away from research into the use of hormones to control ovulation and fertilization in mammals. Vogt was less than enthusiastic about supporting this line of research, surely because so few (predominantly male) scientists thought it would lead to an oral contraceptive. Vogt's inability to divine the future has led teleological historians to write him out of histories of the U.S. birth control movement.[75]

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75. Elizabeth Siegel Watkins, *On the Pill: A Social History of Oral Contraceptives* (Baltimore, MD: Johns Hopkins University Press, 1998), 13-28; Crichtlow, *Intended Consequences*, 13-19, 30-31; Linda Gordon, *Woman's Body, Woman's Right*, 341-390, 396-397; James Reed, *From Private Vice to Public Virtue: The Birth Control Movement and American Society since 1830* (New York: Basic Books, 1978), 281-293, 334-345, 363, 411 n. 1, 434 n. 32.

Meanwhile, McCormick pushed her research team to locate “a ‘cage’ of ovulating females” on which to test this hormone therapy. Beginning in 1954, research biologist Gregory Pincus, the Searle pharmaceutical company, and their collaborators organized human field trials of a promising oral contraceptive in Puerto Rico. Following Vogt’s logic, they perceived this poor U.S. dependency as already overpopulated. They also expected cooperation from its U.S.-dominated scientific establishment. Twenty-three medical students at the University of Puerto Rico served as the first test subjects. These scientifically trained women found it extremely difficult to adhere to the experiment’s invasive regimen, even when their grades were threatened. Prisoners at the Women’s Correctional Institute were less-willing participants, while poor women involved in a slum-clearing program proved more cooperative. Like the ongoing Tuskegee Study of the advancement of syphilis among untreated Southern black males, the organizers of these field trials felt no scruples about using women of color in a colonial situation as experimental guinea pigs. It is worth noting that these scientists found plenty of willing participants once they gave up part of their “experimental control” and empowered Puerto Rican women to simply select themselves for participation. Thus, this brief intellectual history of the “world population problem” again circles back to Latin America. Even the wealth used to fund development of the pill had a southern connection: beginning in the 1890s, McCormick-International Harvester had built a

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Reed foolishly suggests that this inability was related to Vogt’s disability: “Crippled by polio in adolescence, Vogt was more of an artist than a dynamic leader. His original interest in conservation had grown out of bird watching”; Reed, *From Private Vice to Public Virtue*, 341-342. Following Reed, Vogt merits only a footnote from Watkins, and no mention from Gordon, even in her chapter on population control.

significant share of its fortune through its domination over henequen and manila fiber production in Yucatán and the Philippines used to make binder twine.[76]

In 1960, the U.S. Food and Drug Administration approved the use of Enovid as an oral contraceptive. Planned Parenthood's leadership (if not its local clinics) immediately endorsed "the Pill" with great enthusiasm. By the time he stepped down as head of Planned Parenthood in 1961, Vogt's wish for a technological fix to the "population explosion" had finally come true. Nevertheless, its supposed "revolutionary" consequences were mainly restricted to affluent, married, white women in the First World during its first decade of use. Intrauterine devices (IUDs), surgical sterilization, and abortion emerged as the technologies of choice for crusaders against Third World overpopulation. In all these ways, (predominantly male) physicians extended their expert authority over female reproduction, as part of a long process of "professionalization of birth control." Paradoxically, women also became more active participants in their own reproductive health with the advent of the pill. In a small way, through his advocacy of human population control, Vogt helped make the female body part of the technocratic domain.[77]

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76. Annette B. Ramírez de Arellano and Conrad Seipp, *Colonialism, Catholicism, and Contraception: A History of Birth Control in Puerto Rico* (Chapel Hill: University of North Carolina Press, 1983), ch. 9 [quote p. 107]. Cf. James H. Howard, *Bad Blood: The Tuskegee Syphilis Experiment*, rev. ed. (New York: Free Press, 1993); Susan M. Reverby, ed., *Tuskegee's Truths: Rethinking the Tuskegee Syphilis Study* (Chapel Hill: University of North Carolina Press, 2000). On International Harvester's southern connection, see Allen Wells, "Henequen," in *The Second Conquest of Latin America: Coffee, Henequen, and Oil during the Export Boom, 1850-1930*, ed. Stephen C. Topik and Wells (Austin: University of Texas Press, 1998), 85-124; Gilbert M. Joseph, *Revolution from Without: Yucatán, Mexico, and the United States, 1880-1924*, 2d ed. (Durham, NC: Duke University Press, 1988).

77. Watkins, *On the Pill*, 28-52; Ramírez and Seipp, *Colonialism, Catholicism, and Contraception*, 131-148, 176-179; Reed, *From Private Vice to Public Virtue*, 294-308; Gordon,

In his last major work *People! Challenge to Survival* (1960), Vogt made it clear that his Latin American experience was still central to his thinking on population. By this time, after years of close association with the WASP-ish leaders of the population control movement in the United States, Vogt had developed a virulent dislike for the Roman Catholic Church. Secular Scandinavia became his great success story, while the Catholic Church became his whipping boy: "Without birth control, breeding at the leporine rate of the Roman Catholic countries, Scandinavia would probably be as badly off as El Salvador."[78] After two decades, Vogt still credited his experience as an ornithologist in Peru for his zealous interest in population issues. In fact, he used a long description of the sufferings of the guano bird hatchlings during the 1939-1941 El Niño to inspire concern among his North American readers. It is so vivid that it deserves quoting in full:

> The sheer horror of the rising tidal wave of numbers is still hard to comprehend. It is, perhaps, because I lived with it in a strange and poignant way that I sense so strongly the threat of its impact.
>
> In 1940, while I was doing research on the guano bird colonies of millions of cormorants and pelicans off the coast of Peru, one of the recurrent famines hit. The islands were covered with young birds, each nearly as tall as a year-old child, and to the unprofessional eye, resembling black-fronted penguins.

Woman's Body, Woman's Right, 249-300; "Curriculum Vitae," ca. 1964, Vogt papers, overview folder. Cf. Christopher Sellers, "Thoreau's Body: Towards an Embodied Environmental History," *Environmental History* 4:4 (Oct. 1999), 486-514.

78. Vogt, *People! Challenge to Survival*, 194, 199, 211-213. Both Meine and Fox are wrong to assert that "the Catholic Church's resistance to birth control" in Latin America turned Vogt "into a neo-Malthusian," as Fox is wrong to imply that fear of technology run amok led Vogt to his conclusions; see Fox, *The American Conservation Movement*, 306-307; Meine, *Aldo Leopold*, 478.

> As the food supply shrank and the adults had to range farther and farther afield in search of fish, the young became thinner and more vocal. Like human babies, these cried from hunger and now the complaint went on all through the night. I could roughly gauge the success of the adults' fishing by the cries from the two million young.
>
> They were probably suffering also from thirst under the Peruvian desert sun, since the freshly caught fish was their only source of liquid. I would go out on the *pampa* in the morning and be almost knocked down by the horde of downy babies. They would flap their unfledged wings, while they gave their hunger call, at the feet of this strange, uncormorant-like creature who was, withal, vertical and moving.
>
> There was not a thing one could do for them. Day by day there were fewer begging, more staggering about and listlessly drooping. And then more--hundreds of thousands more--of the pitiful, collapsed, downy clumps that were the dead.
>
> When the rare adult returned with food, he would be literally overwhelmed by screeching young. Whether or not he fed his own offspring, or merely those who could best fight their way to him, I could not tell. Finally, perhaps because they were themselves dying, the parent birds simply did not return to the island.
>
> What had been an animated nursery turned into a wide desolation with no sound but the sea and the gulls, and no movement but the scavenging gulls and condors.
>
> Human beings die more stoically. But here was mass death in unforgettable shape and sound. Somehow, ever since, it has been possible to understand more fully the famines of China and India.[79]

It would be wrong to give Vogt and the guano birds too much credit for inspiring the international population control and environmental movements. Certainly other "more oppressive fears" such as "the advent of atomic energy, the possibility of World War III, the breakdown of colonialism all over the world, and the rising discontent of the colored races" inspired widespread postwar "hysteria," as one of Vogt's critics sarcastically noted.[80]

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79. Vogt, *People! Challenge to Survival*, 124-125.

80. Hanson, "Mankind Need Not Starve," 464; cf. Ralph H. Lutts, "Chemical Fallout: Rachel Carson's *Silent Spring*, Radioactive Fallout, and the Environmental Movement," *Environmental Review* 9:3 (Fall 1985), 210-225.

Interest in eugenics, the use of hereditarian principles to improve plant, animal, and human "racial stocks," also motivated many prominent population control advocates, including Margaret Sanger and Raymond Pearl (the father of the logistic curve). Vogt, for his part, was quite willing to serve on the council of the American Genetic Association. Prominent eugenicists such as Frederick H. Osborn, Fairfield Osborn's cousin, occupied important positions in John D. Rockefeller III's Population Council as well as the Conservation Foundation.[81]

As the U.S. environmental movement took off during the 1960s, responsibility for population control evolved into a new sort of "white man's burden," particularly for ecologist Garrett Hardin, author of the "The Tragedy of the Commons," progenitor of the repugnant "lifeboat ethic," and enthusiastic promoter of government reproductive coercion.[82] Hardin and the anti-immigrant Zero Population Growth movement conveniently ignored the fact that Vogt and Osborn originally placed much of the onus for the world's environmental problems

81. Osborn to Vogt, 30 Nov. 1948; C. E. Leighty to Vogt, 13 Aug. 1949, Vogt papers box 1:2. On these points see Raymond Pearl, *The Natural History of Population* (New York: Oxford University Press, 1939); Robert C. Cook, *Human Fertility: The Modern Dilemma* (New York: W. Sloane Associates, 1951); idem, "Latin America: A Decade of Decision," *Population Bulletin* 17:2 (Apr. 1961), 17-39; Frederick Henry Osborn, *This Crowded World* (New York: Public Affairs Committee, 1960), ["prepared in cooperation with the Population Council"]; idem, "Overpopulation and Genetic Selection," in *Our Crowded Planet: Essays on the Pressures of Population*, ed. Fairfield Osborn (Garden City, NY: Doubleday, 1962), 51-70 ["sponsored by the Conservation Foundation"]; Garland E. Allen, "Old Wine in New Bottles: From Eugenics to Population Control in the Work of Raymond Pearl," in *The Expansion of American Biology*, 231-261; Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (Berkeley and Los Angeles: University of California Press, 1985), 60, 85-95, 170-175, 251-252, 258-259; Crichtlow, *Intended Consequences*, 18-19; Fox, *The American Conservation Movement*, 309-313.

82. See Garrett Hardin, "The Tragedy of the Commons," *Science* 13 Dec. 1968, 1243-1248; idem, "Lifeboat Ethics: The Case against Helping the Poor," *Psychology Today* Sept. 1974, 38-43, 123-126; George R. Lucas and Thomas W. Ogletree, eds., *Lifeboat Ethics: The Moral Dilemma of World Hunger* (New York: Harper & Row, 1976).

on the competitive greed and overconsumption of the First World. Birth and population control were for everyone, in Vogt's book, even if he still betrayed a profound distrust of peoples from the Third World.

The horrors of mechanized warfare during the twentieth century proved unable to deflate the sense of superiority of elites in the rich countries of the Northern Hemisphere. Racists, environmental determinists, conservatives, liberals, and communists shared this perspective, including critics of Western imperialism like Vogt. Meanwhile, as decolonization accelerated after World War II, the native-born, but foreign-trained technocrats who took power in so much of the postcolonial world also tended to adopt this superiority complex--including the belief that the world was overpopulated. But rather than heed the warnings of men like Vogt and think in terms of ecological limits, most looked to economic development, modernization theory, or carefully managed Soviet-style social revolution as the answer. The right men with the right knowledge in the right positions could engineer the world out of its problems. This technocratic attitude--and the elitism inherent to it--was the organizing principle of the Golden Age of Development. It was the fountainhead of the supposed "ecological innocence" violated by Rachel Carson and *Silent Spring*.[83]

As we shall see in the next chapters, this attitude drove the rapid development of the Peruvian fishing industry. Many Peruvians saw the prospect of

83. See Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca, NY: Cornell University Press, 1989), esp. 345-418; Dean C. Tipps, "Modernization Theory and the Comparative Study of Societies: A Critical Perspective," *Comparative Studies in Society and History* 15:2 (Mar. 1973), 199-226; Sánchez-Albornoz, *The Population of Latin America*, 182-218; Guha, *Environmentalism: A Global History*.

rapid global population growth as an opportunity rather than something to fear. They thought Peru had enough marine resources to supply much of the world's needs for vitamins and protein, if only Peruvians possessed the technology to exploit them. This cornucopian belief goes a long way toward explaining why pessimists like Vogt and the Comité Nacional de Protección a la Naturaleza had so little impact on the course of events in Peru after World War II.

Yet this chapter has shown that activities on the supposed periphery of scientific culture had a profound effect on environmentalism in other parts of the Americas, even among its core figures. Unfortunately, Vogt's perception of profound ecological and cultural inequalities between the United States toward Latin America ended up reinforcing prejudices in the North toward the South.

Meanwhile, the persistence of social inequalities, especially among scientists charged with managing Peru's marine environment, fundamentally affected the course of fishery industrialization in Peru. Counterintuitively, intense disagreement between experts helped push forward the development of marine science in Peru. This is testimony to the endurance of a fundamental technocratic dogma: that we can find that one right answer--and locate the one Road to Survival--as long as we search long and hard enough for it.

Chapter 6

Salomon's House Divided:

Marine Science and Peru's Fisheries

Science only grows through criticism, and the friction of mind on mind ought to polish our understanding of these problems until there can be no question as to what is the ultimate truth.

--William Vogt to Francisco Ballén (1941)

During the first half of the twentieth century, Peruvians established a conservation technocracy that completely revived the fortunes of the guano industry. The Compañía Administradora del Guano succeeded marvelously as a development scheme on a number of levels: in terms of the fertilizer it produced for Peruvian agriculture, the changes in agricultural practice it promoted, the conservation techniques it implemented, and the managerial apparatus it supported. Meanwhile, developmentalists searched for other ways to exploit Peru's rich marine resources and replicate CAG's technocratic achievement. CAG's basic success enabled it to influence the development of other forms of marine production in Peru.

In many ways, CAG came to represent a real-life example of Francis Bacon's old philosophical ideal of Salomon's House. In his utopian description of the ideal state, *New Atlantis* (1627), Bacon described a hierarchically organized research institute that applied his inductive method of empirical science. A small group of brilliant savants occupied the highest position of authority in Salomon's House. It was their job to interpret the knowledge provided by lower echelons of fact-gatherers, experimenters, and compilers under them, apply this knowledge to gain power over the natural world, and use this knowledge/power to advise and promote the interests of the government of Bensalem, or New Atlantis. The purview of these "Fathers of Salomon's House" included all of nature, and their success as advisers ultimately depended on their accurate interpretation of the multitude of facts provided by their underlings. Even though it was utopian in conception, Bacon's ideal has influenced numerous, real-life technocratic projects. In some instances, technicians have "asserted their right to technocratic rule on the basis of a mastery that they did not possess." [1] But in the case of CAG's savants, their dramatic success in the realm of guano production was used to justify their ambition to rule other economic realms. A holistic vision of Peru's marine ecosystem motivated their anthropocentric quest to enlarge "the bounds of human empire, to the effecting of all things possible."[2] As the authoritarian political experiments in fascist Italy, Spain, Portugal, "corporatist" Brazil and other Latin American states make all too clear, "organic" conceptions have often been used to justify the subjugation of both humans and nature.[3]

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1. For a detailed discussion of the influence of the Salomon's House ideal on arms production and technocratic rule in France, see Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815* (Princeton, NJ: Princeton University Press, 1997), quote p. 346. Alder makes the remarkable observation that French technocrats achieved great political influence even though most of their economic and technical projects--the basis of their claim to power--ended in miserable failure. More generally, see Winner, *Autonomous Technology*, 135-140.

2. Francis Bacon, quoted by Carolyn Merchant, *The Death of Nature: Women, Ecology and the Scientific Revolution*, 2d ed. (New York: HarperCollins, 1990), 186. In her commentary on "Mechanism and the New Atlantis" (pp. 180-186), Merchant argues that Bacon's "*mechanistic* style of problem solving, which pays little regard to the whole ecosystem of which people are only one part" provided the main intellectual motivation for the twentieth century's "totally artificial environments created by and for humans" (p. 186, emphasis added).

3. "Organic-statist" political ideas profoundly influenced discussion of authoritarianism and technocracy in Latin America and Mediterranean Europe during the 1970s: see Phillippe C. Schmitter, "Still the Century of Corporatism?" *The Review of Politics* 36:1 (Jan. 1974), 85-131; Nicos Poulantzas, *The Crisis of the Dictatorships: Portugal, Greece, Spain*, trans. David Fernbach

From the very beginning, besides declaring war against the guano birds' predators, parasites, and diseases, CAG's "fathers" attempted to extend their technocratic powers to the organized hunt for sea lions and the policing of artisanal fishing in Peru. As CAG's managers gained confidence, they presumed the skill and authority to develop and manage Peru's entire marine environment. They soon dreamed of establishing a vast, scientific fishing industry. These grand aspirations brought CAG into conflict with other members of Peruvian society who sought to make productive use of Peru's marine environment. To increase its scientific knowledge and to reinforce its technocratic authority, in 1929, CAG hired a foreign expert, the German oceanographer Erwin Schweigger, to study the problem of fishery development in Peru. But CAG simply did not have the coercive power nor resources to accomplish these goals. As a consequence, the industrialization of Peru's rich fisheries languished through the 1930s.

This situation began to change in the 1940s. To resolve the fertilizer crisis of the late 1930s, CAG set out to build a fishmeal production facility with the hope that the Peruvian state would also grant it a permanent monopoly over economic use of anchoveta, the largest exploitable living resource from Peru's marine environment other than plankton. Like so many attempts at technology transfer, this project failed, even with the help of a team of North American fishery experts.

(London: Humanities Press, 1976), originally published as *La crise des dictatures: Portugal, Grèce, Espagne* (Paris: F. Maspero, 1975); Kenneth Paul Erickson, *The Brazilian Corporative State and Working-Class Politics* (Berkeley and Los Angeles: University of California Press, 1977), ch. 1; Alfred Stepan, *The State and Society: Peru in Comparative Perspective* (Princeton, NJ: Princeton University Press, 1978).

Though he opposed many of these efforts, William Vogt provided a big rhetorical boost to a related project. If he was right about the complexity of the guano birds' marine community, CAG scientists needed to study the entire biological "chain" that connected guano to agricultural production. By identifying and exploiting its "weak points," they might be able to "open new horizons to guano production" and properly explore possibilities for the rational exploitation of all species along the Peruvian coast.[4]

This is exactly what CAG proceeded to do, as it built an elaborate marine science apparatus--a much grander Salomon's House--on the ruins of its fishmeal project. Even though CAG's drive to monopolize control over ocean production fell short as a technocratic management scheme, it was a tremendous boon to the development of marine science in Peru.

But CAG's marine scientists hardly worked together in organic harmony. On close examination, CAG's version of Salomon's House was fraught with divisions. Its experts seldom agreed on the meaning of "facts" regarding Peru's coastal environment, much less how these facts should be applied to its management. Internal enmity based on personality, politics, and ethnic discrimination provided the social basis for some of these conflicts. Remarkably, sexism was a rather minor issue, even though women played an important role in these debates. Such social divisions contributed to discord over the capabilities of Peru's scientific establishment. In the final analysis, different conceptions of the

4. *ICAG*, 25; *MCAG* 38 (1947), ii-iii; *MCAG* 40 (1949), iv-v.

expert's duty provided the most basic grounds for disagreement: Was it CAG's job to protect the environment or promote its exploitation?

If studies of more recent times are any indication, this sort of conflict is probably common, even typical of the way science operates all over the world. Nevertheless, the clarity and intensity with which these conflicts were enunciated--as well as the fact that they have been preserved on paper at all--is both rare and remarkable, especially since they occurred on the southern "periphery" of the world of science. Yet despite all this conflict at CAG, almost everyone concerned agreed on one basic point: improvements in Peru's scientific capabilities and knowledge of its marine environment would ultimately resolve all of these disputes.

This scientific community's war against itself had important consequences for Peru's marine environment. Some startlingly bad science achieved undeserved influence and led to some poorly considered decisions. As we shall see in following chapters, the failure of CAG's experts to agree created a broad opening for the unrestricted development of anchoveta extraction in Peru--which led, in short order, to the guano industry's demise.

Managing the Sea Lion Hunt

The desire to develop production from Peru's entire marine environment was the original inspiration for the studies that led to CAG's creation. Other, unsuccessful attempts to develop marine production and institutionalize marine science in Peru before 1940 make CAG's initial triumph, as well as later successes and failures, much more striking, since all these projects reflected so many of the same concerns.

In 1906, the Ministerio de Fomento originally hired Robert Coker, the eventual reformer of the Peruvian guano industry, as an expert in fish culture. Peruvians wanted him to investigate the natural history of all marine "species that have or could have commercial value." The Ministerio de Fomento hoped these studies would provide a scientific basis for Coker to "propose adequate regulations for fishing, guano extraction, and the sea lion hunt." Coker was specifically directed to consider the introduction of new economic varieties of fish from other parts of the world to Peru's marine and inland waters. This was a major preoccupation of fishery science at the time, with even bigger ecological consequences: The eventual introduction of the Great Lakes trout (*Salvelinus namaycush*) to Lake Titicaca in 1937 as part of a government hatchery project led within a decade to the extinction of an endemic fish species (*Orestias cuvieri*). One can cite numerous examples of similar debacles initiated by well-meaning scientists: the aforementioned introduction of the neotropical cane toad to Oceania, the forestalled transplantation of Peru's guano birds to Mexico, or worse, the utter destruction of one of the world's greatest centers of freshwater fish diversity after the Nile perch was introduced to Lake Victoria in Africa. Nevertheless, self-confident conservationists proceeded apace with projects to improve on nature.[5]

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5. *MMFOM* 10 (1906), xxiv; *MMFOM* 11 (1907), 293-295; Jean-Christophe Balouet and Eric Alibert, *Extinct Species of the World: 40,000 years of Conflict*, trans. K.J. Hollyman, ed. Joan Robb (New York: Barron's, 1990), 167-169. On the introduction of new fish species and their ecological consequences, see Jerry C. Towle, "Authored Ecosystems: Livingston Stone and the Transformation of California Fisheries," *Environmental History* 5:1 (Jan. 2000), 54-74; Tijs Goldschmidt, *Darwin's Dreampond: Drama in Lake Victoria* (Cambridge, MA: MIT Press, 1996).

Coker carefully surveyed artisanal fish production along the coast and in the Sierra. He concluded that, more than anything, Peru needed a permanent research institute that would produce and distribute practical knowledge that even the most humble fisherfolk could use to their advantage. Likewise, the British ornithologist Henry Forbes pushed for the establishment of one or two coastal research stations that could monitor oceanic conditions, plankton and fish production. Both of these scientists clearly believed that progress in local scientific knowledge had to precede technological progress and eventual industrialization in Peru.[6]

Coker's vision of a marine science institute in Peru did not come to fruition for almost 50 years, but his declarations regarding Peru's sea lions or *lobos del mar* (*Otaria flavescens*) had an immediate impact. At that time, many Peruvian fishermen believed "a working understanding" operated between the lobos and the guanayes: sea lions attacked schools of fish from below and herded them to the surface where birds could pick them off at will. This belief led the Peruvian state to ban lobos hunting in 1896, with little effect. Some apologists for the guano industry, in contrast, thought lobos hunted young, unwary birds and ate the guano birds' food, and so advocated their destruction. Coker took a middle position: he determined that sea lions were neither particularly beneficial nor harmful to the guano birds. Therefore, following the standard principles of conservation science,

6. Coker, "Pisicultura y ostricultura," *MMFOM* 12: anexo 150 (1908), 416-419; idem, "Informe preliminar sobre los estudios que practica el piscicultor contratado," *BMFOM* 5:7 (July 1907), 96; idem, "Estudios sobre la pesca," *BMFOM* 8:4 (Apr. 1910), 13-16; idem, "El lago Titicaca y sus recursos," *BMFOM* 8:6 (June 1910), 29-39. For Forbes's recommendations, see *MCAG* 5 (1914), 96-101.

a few thousand could be hunted sustainably each year "under important and specified restrictions" that took into consideration the sea lions' breeding behavior.[7]

Many parts of the lobos del mar were valuable to humans. Its two most important products were oil and leather. Sea lion blubber was refined to supply the regional market for oil and lubricants (illus. 29). Hunters used choking lassos or clubs to kill the animals in order to protect their hides, which were used to produce water-resistant leather products. Most importantly, young animals were used to produce "fantasy articles," including fur purses, hats, and gloves. On occasion, lobos meat was salted and marketed locally, their ligaments used as sinew, and their stomachs as oil cases. Their testicles sometimes supplied traditional Chinese medicine. But hunters usually left behind everything but their hides and blubber.[8]

The response to Coker's report underscores how sensitive the rulers of Peru's Aristocratic Republic were to conservation issues. With enthusiastic support from CAG, the Peruvian state followed Coker's suggestion and reopened hunting in 1910 by decree. In 1911, CAG itself officially killed 6,800 lobos during five months of hunting for a gain of S/.217,967 (US$45,100). Later that year, the guano

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7. Murphy, *Bird Islands*, 79; Coker, "La caza de lobos en el Perú," *BCAG* 9:8 (Aug. 1933), 224, 234-237, originally published as "La caza de lobos y pesca de ballenas y bufeos en el Perú," *BMFOM* 5:12 (Dec. 1907), 64-95; idem, "Informe preliminar," 94; Raúl Palacios Rodríguez, *La República, 1884 a 1906*, bk. 12, vol. 2 of *Historia marítima del Perú* (Lima: Instituto de Estudios Histórico-Marítimos del Perú, 1991), 346; cf. César Belaúnde Guinassi, *La legislación pesquera en el Perú* (Lima: Editorial Universitaria, 1963).

8. *MCAG* 7 (1916), 77-78; *MCAG* 15 (1924), 89-90; *MCAG* 18 (1927), 203; *MCAG* 31 (1938), 252-253; Coker, "La caza de lobos en el Perú," 236-237; Reginald H. Fiedler, Norman D. Jarvis, and Milton J. Lobell, *The Fisheries and Fishery Industries of Peru with Recommendations for their Expansion and Development: A Report of the United States Fishery Mission to Peru in 1941* (Washington, DC: United States Department of the Interior Fish and Wildlife Service, 1942), 189; Alberto González Zúñiga, "Lobos marinos: Fuente de riqueza," *BCAG* 20:5 (May 1944), 127-133.

birds abandoned their chicks en masse, causing guano production to plummet. This inspired a boisterous debate. Some congressional partisans blamed the hunt for this disaster. CAG's managers put the onus instead on El Niño's "sinister ocean currents." In fact, they advocated the culling of an additional quarter of the sea lion population to protect the guano birds, figuring this would not do too "much damage to the equilibrium pursued by nature." With backing from virtually everyone concerned, the Peruvian government appointed naval captain A. R. Pimentel to decide the issue scientifically. After a cursory investigation, he concluded that the lobos and guano birds ate fish of completely different size and rejected the idea that sea lions assisted the guano birds in any way. It was true that lobos sometimes mutilated young birds, but he figured this was an accidental consequence of their "blood instinct" to grab anything of the right size that moved underwater. Pimentel came to the same conclusion as Coker: "Experience will tell us the number of lobos that can be hunted annually without causing extinction of the species."[9]

Over the next two decades, the Peruvian state handed out the official concession to hunt sea lions to many different parties. CAG's managers frequently complained that hunters violated the sanctuary of the guano islands and "created a happy world for birds of prey . . . the worst enemy of the guano birds" with the gory remains they left behind. CAG's pleading for "technical direction by experts" became even more shrill when the Peruvian state opened the hunt to all comers. Finally in 1936, with a view toward resolving the Depression-era shortfall in guano production, the Benavides regime gave over the entire lobos hunt to

9. *MCAG* 3 (1912), 3, 11, 45-54, 57; *MCAG* 7 (1916), 75-79.

CAG's "efficient organization and control." CAG's supposedly conservation-minded managers proved to be efficient agents of death for the sea lions. Between December 1941 and March 1942 alone, hunters contracted by CAG killed at least 36,500 lobos--88 percent pups.[10]

This carnage continued despite the appeals of CAG's own scientists. William Vogt observed that CAG's hunters focused their deadly activity during the breeding season and only targeted females and pups. "It is obvious this industry will not last very long," he concluded. Based on Charles Elton's ecological theory of appropriate food size, Vogt speculated that the lobos hunt had allowed the population of bonito, a large, predatory, tuna-like fish, to mushroom in size and consume much larger quantities of anchoveta. He feared that this had contributed to the crash in the guano bird population during the devastating 1939-1941 El Niño. Therefore, he recommended that CAG should leave the lobos alone and focus its effort on reducing the number of bonito to restore some semblance of ecological balance. Erwin Schweigger also admitted the potential for "great unfavorable changes in the maritime ecology" if the lobos were overhunted. But he vehemently objected to Vogt's conclusions on empirical grounds: he had never seen sea lions feed on bonito except when they had already been caught by fishermen; he thought squid, octopus, and *lenguado* (sole) were much easier for the lobos to catch; most

10. *MCAG* 8 (1917), ix, 43-46; *MCAG* 10 (1919), ix; *ECAG*, 19; *MCAG* 14 (1923), 25-26; *MCAG* 15 (1924), xxi, 89-90; *MCAG* 17 (1926), 106; *MCAG* 18 (1927), 203; *MCAG* 22 (1931), xiv; *MCAG* 25 (1934), xi, 179-181; *MCAG* 26 (1935), xiii, 258; "Encomendando a la Compañía la caza de lobos del mar," *BCAG* 12:8 (Aug. 1936), 340; González, "Lobos marinos," 129; Macera, "El guano y la agricultura peruana de exportación," 451; Peter Muck and Humberto Fuentes, "Sea Lion and Fur Seal Predation on the Peruvian Anchoveta, 1953-1982," in *The Peruvian Anchoveta and Its Upwelling Ecosystem: Three Decades of Change*, ed. D. Pauly and I. Tsukayama (Callao: Instituto del Mar del Perú, 1987), 237-238.

importantly, he noted the biogeographical tendency of bonito to live out to sea and the anchoveta and lobos to concentrate near shore--in effect, they occupied different environments.[11]

The scale of the lobos hunt, meanwhile, began to inspire rabid criticism from budding Peruvian conservationists. In his book *Privilegios naturales del Perú*, the physician Alberto González Zúñiga upbraided these "blind" hunters for "sowing terror with garrote in hand," thereby transforming the sea lions' "homes" into "concentration camps." He implored CAG and the Peruvian state to implement a management plan based on "scientific precaution." If they did not act soon, he feared the lobos del mar would suffer the same fate as the southern fur seal or *lobos de dos pelos* (*Artocephalus australis*) which had been hunted to the brink of extinction during the nineteenth century. The fact that the sea lion population still numbered in the hundreds of thousands at this time deafened most people to these cries, even if the lobos were in decline near settled areas. Coastal fishermen, for their part, were glad to get rid of a pest that got tangled in their nets and lines and stole fish when it could.[12]

Eventually, the strong 1957-1958 El Niño caused the falling sea lion population to go into a tailspin. In November 1958, President Prado completely banned and enforced stiff fines against lobos hunting. But by 1961, there were

11. Vogt journal, Isla Chincha Norte, 24 Jan. 1940, Vogt papers, box 3:1; Vogt, "Los lobos y las aves guaneras," *BCAG* 15:10 (Oct. 1939), 397-399; idem, "Informe sobre las aves guaneras," 40, 80-81, 111; Schweigger, "Informe sobre la caza de lobos del mar," *BCAG* 16:9 (Sept. 1940), 296-297; Schweigger to Vogt, 25 May 1942, Vogt papers, box 1:3, p. vi.

12. González, "Lobos marinos," 119-135; *BCNPN* 20 (1965-1970), 65; Schweigger, "La bahía de Chimbote," *BCAG* 18:10 (Oct. 1942), 337-338; Fiedler, Jarvis, and Lobell, *The Fisheries and Fishery Industries of Peru*, 348; Muck and Fuentes, "Sea Lion and Fur Seal Predation on the Peruvian Anchoveta," 237-238..

only about 8,000 lobos left on the entire Peruvian coast. The complete cessation of legal hunting--backed by adequate enforcement--allowed the sea lion population to recover somewhat to about 35,000 in 1984. (Under similar protection, the fur seal recovered from a low of 4,000 to about 16,000 in 1984.) Neither species is anywhere near its former abundance today, and never will be as long as Peru's giant, diversified fishing industry lasts.[13]

Why did scientific, sustained-yield conservation so obviously fail in this case, even in the hands of CAG? This case vividly shows the dangers that exist when well-meaning scientists express ambivalence on a policy issue and cautiously call for further study. Neither Coker and Pimentel, nor Schweigger and Vogt, could unequivocally determine the lobos' complicated ecological role and promote a strong policy of resource conservation. This left an opening for those interested in maximizing profit from a seemingly inexhaustible resource--including CAG. Unlike what happened with guano extraction, hunters had to kill potential parents, the source of numerical increase, in order to profit from the lobos. Note also that all scientific studies of the lobos were based on an instrumental premise: to determine their ecological impact on other economic species. This way of thinking made the lobos economically expendable as "varmints" when the Peruvian fishing industry began its rise after 1941. Recent scientific studies, as it turns out, have shown that Peruvian pinnipeds are opportunistic predators and vary their feeding

13. Belaúnde, *La legislación pesquera en el Perú*, 283, 290, 294-295; Muck and Fuentes, "Sea Lion and Fur Seal Predation," 235, 238. Cf. Fritz Trillmich and Kathryn A. Ono, eds., *Pinnipeds and El Niño: Responses to Environmental Stress*, Ecological Studies, vol. 88 (Berlin: Springer-Verlag, 1991).

depending upon availability. Scientists looking for simple ecological relationships were destined to be disappointed where the lobos were concerned.[14]

Since the lobos had no lord protectors with a strong developmental interest in their conservation, sustained-yield management was never seriously considered as an option by anyone who mattered politically. No one did anything of consequence to save the lobos until it was almost too late, for a simple reason: they were not worth the bother.

Enforcing Conservation

The Peruvian state fared little better in its attempts to regulate artisanal marine fishing, although its failures on this count did not have the same dire ecological consequences as they did for the lobos del mar. These attempts dated all the way back to March 1822 when the newly independent Peruvian Republic first required all fishermen to register with the state. Beginning in 1884, the Peruvian state tried unsuccessfully to control the use of dynamite, also known as the "American net" (*chinchorro americano*), by fishermen. Even though Coker and Forbes discounted the threat posed by the illegal use of dynamite and other extant fishing practices, Augusto Leguía's government issued a series of prohibitions against coastal fishermen during its drive to reform the guano industry, ostensibly to protect the guano birds. In November 1909, it passed a law that limited all fleets to 12 consecutive hours of fishing during guano bird breeding season; it directed the port guard to watch for illegal possession of birds, eggs, or dynamite; and it

14. Muck and Fuentes, "Sea Lion and Fur Seal Predation," 234, 245-246.

gave CAG and the Peruvian Corporation the right to enforce maritime regulations. Following Forbes's suggestion, in 1916 fishing boats were prohibited from approaching within one mile of guano islands. In the early 1920s, Leguía extended this zone to two miles and established criminal fines of up to S/.100 (US$26 in 1922) for violating these laws. Owners of violating fishing fleets could have part of their catch confiscated and receive an even higher fine (up to S/.1000). CAG officials enthusiastically promoted these fishing regulations.[15]

Enforcement of these laws was a major problem from the outset. Even though Peru had a maritime authority (*capitanía*) under the Ministerio de Marina installed in its major ports, local law enforcement in fishing communities--where it existed--depended upon *sargentos de playa*, local deputies linked to the *capitanía* who were appointed by their own communities. Since this system of enforcement was an important vehicle for political patronage, it could not work without local cooperation and could not hope to control the traditional activities of entire communities merely by decree. CAG's general manager Francisco Ballén wrote scores of letters and several newspaper articles during the 1920s in a vain attempt to get coastal authorities to evict long-established seasonal fishing colonies from Islas Lobos de Afuera and Lobos de Tierra, on the basis of reports that they stole eggs from local bird colonies (illus. 30). Even CAG's guardians refrained from denouncing or evicting these colonies, in recognition of the mainland goods these fishermen ferried to their lone outposts and the company they provided. (Today,

15. Belaúnde, *La legislación pesquera en el Perú*, 336-337; Palacios, *Historia marítima del Perú*, bk. 12, vol. 2, 331, 340, 342; *ECAG*, 47, 49-50, 55, 61-64; *MCAG* 14 (1923), 20-23.

visits by local fishermen still provide island guardians with their only human companionship.) As a compromise, Leguía's regime tried during the 1920s to limit these colonies to one landing site on each island, but these rules were ignored. Elsewhere along the coast, port officials arbitrarily issued licenses to fishermen that allowed them to ignore the guano island exclusion laws. Fishermen organized by the Callao and Vicinity Fishermen's Union successfully lobbied several times during the 1920s for the blanket right to approach the guano islands for various types of fishing, including special preferences for modern, motorized craft, even though Ballén and Peru's Minister of Public Works both sounded like broken records in favor of the exclusion laws. CAG's authority as a conservation organization had clear limits.[16]

CAG responded to these problems by calling for comprehensive reform of fishery enforcement. Since it could not get the Peruvian navy to send gunboats to force fishermen off the guano islands, CAG asked the government to follow Forbes's old suggestion and establish a fishing police. Ballén used the severe 1925-1926 El Niño to bolster his argument for increased guano bird protection and fishery enforcement. As guano production continued to fall through 1927-1928, Leguía's government responded by establishing a Policía Pesquera under CAG's administration. With the aid of three speedy patrol boats custom-built in Europe,

16. *MCAG* 11 (1920), 41-42; *MCAG* 13 (1922), 69-70; *MCAG* 14 (1923), 17-20; *MCAG* 15 (1924), 71, 79-83; "El acceso de pescadores a los grupos de Lobos," *BCAG* 1:9 (1925), 340-341; *MCAG* 22 (1931), 210; *MCAG* 23 (1932), 222; *MCAG* 24 (1933), xiv, 155-157. On the organization of the maritime authority in Peruvian fishing communities, see Eugene A. Hammel and Ynez D. Haase, *A Survey of Peruvian Fishing Communities*, Anthropological Records, vol. 21, no. 2 (Berkeley and Los Angeles: University of California Press, 1962), 212; John Gillin, *Moche: A Peruvian Coastal Community*, Smithsonian Institution, Institute of Social Anthropology, no. 3 (Washington, DC, 1947), 28-37.

CAG's policemen had a decided technological advantage over the sail- and human-powered vessels that dominated fishing in Peru before World War II (illus. 31-32). The fishery police used its authority to detain several law breakers and see that they were criminally prosecuted during its brief operation under CAG, including the owners of registered craft at Isla Lobos de Tierra.

Needless to say, this police action was extremely unpopular among Peru's maritime populace. In an abrupt turnabout, the military government that replaced Leguía transferred administration of the Policía Pesquera to the maritime authority in November 1931. It also turned over CAG's three valuable patrol boats to the Peruvian navy for "special needs" of national defense. Despite entreaties that lasted into the 1950s, CAG was never again able to enforce fishery regulations on the high seas.[17]

This brief experiment in conservation enforcement fell short because CAG overreached the limits of its power and influence within the Peruvian state. CAG clearly encroached upon the jurisdiction of the maritime authority and the networks of patronage in ways that both benefited and restrained the fishermen who frequented coastal ports. CAG also violated the Peruvian military's jealously guarded monopoly on advanced weaponry. Without a doubt, only sustained, organized repression would have stopped all trespassing around the guano islands. CAG (thankfully, from the point of view of Peru's fishermen) never acquired the

17. *MCAG* 13 (1922), 72; *MCAG* 16 (1925), 30-38; *MCAG* 17 (1926), xv-xvi; *MCAG* 19 (1928), 248-253; *MCAG* 20 (1929), xi-xiii, 258-263; *MCAG* 22 (1931), 227-234; *MCAG* 23 (1932), 216-220; *MCAG* 25 (1934), xi; *MCAG* 26 (1935), xiii, 269-270; *MCAG* 38 (1947), lxxxix-xc; CAG, Servicio de Policía Pesquera del Litoral, *Reglamento de la Policía Pesquera: Resoluciones pertinentes y fórmulas de los documentos que usara en su ejercício* (Lima: Librería e Imprenta Gil, 1928).

apparatus to accomplish this task. Yet CAG could count one enforcement success. The presence of armed guards on the islands who might report the serial numbers of registered, law-violating boats did tend to discourage actual landings on most islands. Trespassing remained a serious problem only at coastal points, which influenced CAG's decision to concentrate its guardian force at these coastal locations beginning in the late 1940s. These enforcement failures point out a perennial problem with nature sanctuaries throughout the world. Sanctuaries only work well if the people who live with them benefit in some way from their protection. A state cannot simply ban a traditional economic activity and expect it to disappear, even with moderate enforcement. In this case, fishermen had little to gain by following Peru's arbitrary and unenforcable fishing laws, but neither could they benefit much from landing on the islands and raising havoc among the bird colonies.[18]

These enforcement problems with artisanal fishermen also point to a basic weakness in CAG's technocratic organization that foreshadowed its ultimate downfall. CAG technocrats never effectively administered any part of the Peruvian marine environment except the bird colonies, despite their grand pretensions. They

18. The relationship between local peoples and nature sanctuaries is a major public policy issue throughout the world. For an introduction, see Stephan Amend and Thora Amend, eds., *National Parks without People?: The South American Experience*, esp. Injoque and Suárez, "Problems in the Enforcement of a Strict National Park Policy in the Case of Peru." It is also increasingly an issue for historical research; see Simonian, *Defending the Land of the Jaguar*; Karl Jacoby, *Crimes against Nature: Squatters, Poachers, Thieves, and the Hidden History of American Conservation* (Berkeley and Los Angeles: University of California Press, 2001); Sterling Evans, *The Green Republic: A Conservation History of Costa Rica* (Austin: University of Texas Press, 1999); Mark Spence, *Dispossesing the Wilderness: Indian Removal, National Parks, and the Preservationist Ideal* (New York: Oxford University Press, 1999); Louis S. Warren, *The Hunter's Game: Poachers and Conservationists in Twentieth-Century America* (New Haven: Yale University Press, 1997).

had to share Peru's coastal waters with others. Even when the stakes were low and Peruvian fishermen were not working in ecological opposition to the guano industry, the Peruvian state found it impossible to resolve this conflict between client parties engaged in production from the marine environment. Since there was no compelling economic or political interest at stake, rather than search for one ideal solution in accord with the technocratic ideal, government officials let these competing segments of the state and civil society live in conflict with each other.

CAG's managers rightly understood that a *large* fishing industry might threaten the guano industry, particularly during the peak summer nesting months when the marine upwelling region narrows along the coast and makes it easier for both humans and birds to catch fish. Many Peruvians used dynamite as a labor-saving fishing technique, even though it wasted fish and unintentionally killed other marine life. CAG managers indoctrinated to the "gospel of efficiency" vocally disapproved of this "pernicious practice." They even claimed that dynamite seriously damaged the reproductive capacity of anchoveta by destroying its egg stock. These claims were dubious: A two-year-old female anchoveta may release up to 20,000 eggs into the ocean. During the peak breeding month of September, Peru's coastal waters became a sort of egg soup as breeding females released *quadrillions* of eggs (10^{17}). In fact, the North American Fishery Mission to Peru concluded in its 1942 report that the use of dynamite did more to impede the "growth and development of fishing methods" in Peru than harm its marine ecology, especially since dynamited fish tended to deteriorate rapidly on their way to market.[19]

Peruvian fishermen did no major damage to the guano industry before the 1950s for one major reason--they could not. Fishing in Peru was quite undeveloped before the 1940s, although it was not a "decadent native system slightly influenced by Mediterranean methods" as Robert Cushman Murphy and later historians have often claimed. Many fishermen still used "primitive" but "not inefficient" small rafts, nets, hooks, and harpoons to catch fish for subsistence and a limited coastal market. They hardly touched the anchoveta, the primary food supply of the guano birds (illus. 33). As late as 1941, there were nearly the same number of *caballitos de totora* as motorized craft in use along the Peruvian coast (illus. 34). But artisanal fishermen, particularly immigrants from the Mediterranean whose sailing craft dominated major fishing ports, were not ignorant of improvements promised by new fishing technologies. Around 1908, Peruvians rapidly adopted the cotton trammel net (*trasmalla*), an important European innovation. Traditional communities of fisherfolk were also quite aware of the dangers that new technologies posed toward their way of life. For example, in 1939 in a significant case of a local revolt against technological modernization with nativist overtones, artisanal fishermen from Puerto Chicama torched a group of

19. Fiedler, Jarvis, and Lobell, *The Fisheries and Fishery Industries of Peru*, 66-67. For typical CAG attacks on dynamite use, see *MCAG* 3 (1912), 47; *MCAG* 11 (1920), 41-42; *MCAG* 13 (1922), 72-73; *MCAG* 15 (1924), 72; see also Palacios, *Historia marítima del Perú*, bk. 12, vol. 2, 331, 340, 342. For information on *anchoveta* biology and later fishing systems, see C. P. Idyll, "The Anchovy Crisis," *Scientific American* June 1973, 22-29; Gerald J. Paulik, "Anchovies, Birds and Fishermen in the Peru Current," in *Environment: Resources, Pollution and Society*, ed. William W. Murdoch (Stamford, CT: Sinauer, 1971), 167-170.

modern, motorized boats owned by Gildemeister & Co. and operated by Italian fishermen. They wanted to stop these immigrants from taking over local fish production and prevent this foreign sugar leviathan from tightening its control over the supply of food to its army of proletarians.[20]

CAG's struggle with Peru's artisanal fishermen had little or no impact on either guano or fish production. But it did have political and ideological importance. It made CAG extremely unpopular with Peruvian fishermen, and they became perennial opponents of the guano industry as a consequence. This became a big problem when the fishing industry grew much larger. Morevover, this case reveals the potentially totalitarian implications of technocratic ambition. In the view of CAG's managers, these traditional fishing communities threatened the success of the guano industry through their ignorant, inefficient use of Peru's natural resources. Like many other Peruvian developmentalists, CAG's managers thought technological progress doomed these traditional fishing communities to disappear. (Ironically, industrial fishermen used this exact argument against the

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20. Murphy, *Bird Islands*, 107; Schweigger, "Informe anual del experto contratado por el gobierno," *BCAG* 15:8 (Aug. 1939), 313-330; Fiedler, Jarvis, and Lobell, *The Fisheries and the Fishery Industries of Peru*, 16, 44-68, quote p. 68.

Notorious--and inaccurate--accounts of fishing sector stagnation before the 1950s include David Carson Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry in the Post World War II Period," (Ph.D. diss., American University, 1971), 4-7; Arturo Zócimo Vázquez Párraga, "Economic Cycle, Migration, and Employment: A Model of Conjunctural Development. The Fishmeal Industry in Peru, 1940-1985," (Ph.D. diss., University of Texas at Austin, 1986), 126-130. See also Palacios, *Historia Marítima*, bk. 12, vol. 2, ch. 9; Murphy, *Bird Islands*, ch. 9; Schweigger's report in *MCAG* 22 (1931), 276-280; Clinton R. Edwards, *Aboriginal Watercraft on the Pacific Coast of South America*, IberoAmericana, no. 47 (Berkeley and Los Angeles: University of California Press, 1965). On the ancient foundations of fish production in Peru, see María Rostworowski de Diez Canseco, *Recursos naturales renovables y pesca, siglos XVI y XVII* (Lima: Instituto de Estudios Peruanos, 1981). On resistance to the expansion of the Casa Gildemeister's economic empire, see Klarén, *Modernization, Dislocation, and Aprismo*, ch. 2, 4.

guano industry years later.) Peru's fishermen needed uplift through education and the rule of law. If they resisted, they needed the firm hand of discipline, and if they completely failed to cooperate, repression. Who could provide this paternal guidance better than an "aristocracy of knowledge," CAG's own marine science experts?

A House Divided

CAG's managers never opposed fishery development in Peru as long as it followed what they considered to be rational, scientific principles. Hence, CAG lobbied the state during the 1920s to expand the scope of the navy's newly created School of Fishing and Salting in Callao (est. 1920). In line with suggestions made by both Coker and Forbes--and the desire of industrial firms and populist politicians to provide a cheap supply of food for Peruvian workers--CAG called for a school run by an "Oceanographic Cabinet" of foreign experts that was dedicated to scientific study, the education of local fishermen, and the development of a food fish industry to feed "the great proletarian masses" in the cities.[21]

CAG itself worked vigorously to institutionalize marine science investigation in Peru. In 1929, President Leguía authorized CAG to hire an expert who would study Peru's volatile marine environment and help establish a fishing industry based on "the most rational and scientific form of exploitation." This time, Peru looked for technical assistance to Germany, the preeminent world leader in oceanography and fishery science during the 1920s (with the possible exception

21. *ECAG*, 51-52; *MCAG* 16 (1925), 30-38.

of Japan). It is unclear exactly how CAG first obtained the services of Erwin Hirsch-Schweigger (1888-1965), a native of Thorn, from an industrial fishing concern in Germany. It is highly probable that Gildemeister & Co. was involved, since it was interested in improving its own fishing capacity and had a long tradition of recruiting German technicians from the Hamburg-Bremen region where Schweigger worked. He was a wounded veteran of World War I, a Ph.D. graduate from the Institut für Meereskunde at the University of Berlin, and like Robert Coker, a specialist in the culture of shellfish (illus. 35).[22]

Upon his arrival in Peru, Schweigger pragmatically tried to limit himself to basic empirical research on the Pacific environment and a cursory investigation of fish production from the ocean and Lake Titicaca. He thought a comprehensive study of the entire fishing sector would absorb too much "time and . . . energy for only one man," and he did not want to leave behind an incomplete and useless body of work if conditions forced him to end his investigations and return to Europe. This actually happened as he feared: with the onset of the Great Depression and political unrest in Peru, CAG was forced to terminate his services after only seven months. Schweigger returned to Germany and took a managerial position in the

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22. "Contratación de un experto en pesquería," *BCAG* 5:7 (July 1929), 366-367; Gamarra, "Fallecimiento del Dr. Erwin Schweigger," *BCONAFER* 3:8 (Aug. 1965), 3; *Diccionario histórico y biográfico del Perú*, s.v. "Schweigger, Erwin." Schweigger's early published works include, E. Hirsch-Schweigger, "Muschelkultur," *Ebenda* (1920), 4-[?]; "Wege für eine deutsche Austernzucht," *Ebenda* (1924), 50-[?]; both cited by E. Ehrenbaum in "Literatur-Verzeichnis der Fishereibiologischen Abteilung in Hamburg, 1909-1924," in "Bericht über die Arbeiten in der Fishchereibiologischen Abteilung des Zoologischen Staatsinstuts in Hamburg," *Berichte der deutschen wissenschaftlichen Kommission für Meeresforschung*, n.s., 1 (1925), 54. On oceanography in Germany during this era, see Wolfgang Schott, *Early German Oceanographic Institutions, Expeditions, and Oceanographers* (Hamburg: Deutsches Hydrographisches Institut, 1987).

Hamburg fishing industry. But before he left, Schweigger encouraged Peru to establish a state fishing company similar to CAG that would direct scientific research, teach new fishing techniques, market refrigerated fish, and perhaps manufacture fishmeal for fertilizer or livestock feed. The Peruvian state established the Compañía Nacional de Pesca in 1936 to produce and market refrigerated fish for urban consumers, but this and other similar experiments during the 1920s and 1930s came to nought because of weak local demand.[23]

By 1937, Schweigger was extremely eager to leave Germany. He expressed his desire to return to Peru and resume his marine research to an old friend, Johannes Wille, an expatriate German scientist who ran the entomology program at the Escuela Nacional de Agricultura. Besides the timing, circumstantial evidence suggests that Schweigger was of Jewish descent: He had abandoned use of the surname Hirsch-Schweigger, and none of his maternal family remained in Germany by the 1960s. None of Schweigger's surviving scientific colleagues in Peru know much about his ethnic background--it was never an issue important enough to be spoken about. Wille passed on news of Schweigger's plight to Francisco Ballén who initiated negotiations to rehire Schweigger and rescue him from the darkening shadows of war.[24]

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23. Schweigger, "Posibilidades pesqueras del Lago Titicaca." *BCAG* 6:8 (Aug. 1930), 467-473; idem, "Estudio sobre la industria pesquera," *BCAG* 5:10 (Oct. 1929), 533-535; idem, "Informe anual del experto en pesquería," *BCAG* 6:10 (Oct. 1930), 569-574; idem, "Temperaturas en las islas guaneras del Perú (1926-1930)," *BCAG* 7:3 (Mar. 1931), 121-143; *MCAG* 22 (1931), xiii, 280; *MCAG* 29 (1938), xiv; Gamarra, "Fallecimiento del Dr. Erwin Schweigger," 3; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 6; Baltazar Caravedo Molinari, *Estado, pesca y burguesía: Teoría y realidad* (Lima: Centro de Proyección Cristiana, 1979), 20-21.

24. Personal communication, Felipe Ancieta Calderón, Abelardo Vildoso, Aurora Chirinos de Vildoso, Rómulo Jordán, Callao/Lima, Peru, May-June 2001; Gamarra, "Fallecimiento del Dr. Erwin Schweigger," 3-4.

Schweigger had been a minor figure in Germany's scientific universe, but when he returned to Peru he instantly became a big fish in a little sea. Schweigger knew he had come to Peru to stay: He almost immediately initated proceedings to obtain Peruvian citizenship. He remained CAG's resident oceanographer for more than two decades, and played a central role in the institutionalization of marine science in Peru. Like so many countries eager to bolster their technical capabilities, Peru was able to take great advantage of the global diaspora of scientists from Germany, Spain, and other European countries under totalitarian control during this era.[25]

Of course, Schweigger did not accomplish the transformation of Peru's scientific capabilities by himself, but instead depended on the growing community of technocrats employed by CAG, especially Luis Gamarra Dulanto (1904-1969?). Like CAG's upper management and so much of Peru's scientific establishment, Gamarra was born into Lima's white upper class. Following in the footsteps of José Antonio de Lavalle y García, Gamarra graduated from the new campus of the Escuela Nacional de Agricultura at La Molina in 1930 with a degree in agronomic engineering and expertise in cotton cultivation. From 1933 until his retirement in 1967 he worked part-time as a professor at his alma mater (where he acted as the contact who passed on news of Schweigger's situation from Wille to Ballén),

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25. *MCAG* 29 (1938), xiv, 244-245; *MCAG* 30 (1939), x, 64-5; Gamarra, "Fallecimiento del Dr. Erwin Schweigger," 4. On the Nazi-era German "brain drain," see *Forced Migration and Scientific Change: Emigré German-Speaking Scientists and Scholars after 1933*, ed. Mitchell G. Ash and Alfons Sollner (Cambridge, UK: Cambridge University Press, 1996); Thomas F. Glick, "Science and Society in Twentieth-Century Latin America," in *CHLA*, vol. 6, pt. 1, 464, 467, 484-486; Mariscotti, *El secreto atómico de Huemul*. For the period before 1933, see Lewis Pyenson, *Cultural Imperialism and Exact Science: German Expansion Overseas, 1900-1930* (New York: P. Lang, 1985), esp. ch. 3 on physics in Argentina.

authored a variety of scientific studies, attended several international scientific conferences, and played a leading role in a number of Peru's scientific institutions. He took over as director of CAG's Sección Técnica in 1934 and stayed at CAG for the rest of his career. As we saw in chapter 3, from this position he took charge of CAG's work in agronomy, led its hygienic campaigns against chickens and rats on the guano islands, and organized its struggle against the "Malthusian crisis" of fertilizer supply in Peru during the late 1930s. He and Schweigger soon became allies in CAG's internal politics and life-long friends of a sort.[26]

CAG's overseers wanted its brain trust to work together to figure out new ways Peru could take advantage of its marine resources. To this end, in February 1939, Schweigger, Vogt, and Gamarra crowded aboard the *Chincha*, one of CAG's best ships, for a month-long tour of Peru's northern coast (illus. 36).[27] But instead of working in concert, their relationship was riven by discord. This voyage inaugurated a conflict that had a profound influence on the evolution of environmental technocracy, not only at CAG but in all of Peru. It began with a controversy regarding the nature of Peru's marine environment, but it soon devolved into a debate over the role of the expert in Peru's political economy. An analysis of this struggle reveals the underpinnings of one of the most difficult barriers to technocratic governance: the failure of experts to agree.

The heatedness of their disagreement stemmed partly from the seriousness of the crisis in guano production at the time. In 1938, a year of record guano

26. *Diccionario histórico y biográfico del Perú*, s.v. "Gamarra Dulanto, Luis."
27. Vogt journal, Chucuito to Isla Don Martín, 10 Feb. 1939, Vogt papers, box 3:1.

production, CAG's harvest still fell short of national demand by almost 100,000 metric tons.[28] Then in February 1939, right before the eyes of CAG's new scientists, the guano birds started to leave their nesting colonies. As we have seen, this marked the beginning of a long "ecological depression" that worsened to the point that it threatened CAG's organizational existence. Based on 24 years of written reports from CAG's guardian network as well as Eltonian theory, Vogt concluded that lack of food caused the birds to leave. Working-class men of color with only a basic education thus provided the empirical basis for Vogt's scientific understanding, a foundation that depended on Vogt's shaky confidence in their ability as observers.[29]

But where were the anchoveta? Vogt, an ornithologist comfortable with the idea that some animals migrate thousands of miles each year, postulated that the guano birds merely followed the migration of the anchoveta south during years of abnormal oceanic conditions. He used as authoritative support for this argument studies of the migration of the California sardine in the supposedly analogous environment of the California Current. Schweigger vigorously disputed this contention, noting that he and several other observers had seen anchoveta at the surface on occasion and frequently caught them at depth along the Peruvian coast during the El Niño crisis. Peruvian fishermen, he noted, had not seen any schools of fish heading south, and birds that returned from this direction later on still had a famished appearance. Schweigger also accused Vogt of falsely twisting the

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28. See app. 2-4.

29. Vogt journal, Isla Asia, 6 Feb. 1939, Isla Guañape Alto, 12 Feb. 1939, Isla Chincha Norte, 18 Dec. 1939, Vogt papers, box 3:1; Vogt, *Informe sobre las aves guaneras*, 64-65.

quantitative evidence by using data samples that were too small to be statistically significant and by proposing a rigid seven-year cycle for El Niño conditions that did not fit with recorded sea-surface temperatures. Schweigger wondered why Vogt refused to consider what he saw as obvious--the anchoveta migrated during El Niño years, but vertically, not horizontally.[30]

Gamarra was even more strident in his public criticism of Vogt's use of evidence. He wrote to his superiors accusing Vogt of ignoring contradictory reports from locals and CAG's own guardians regarding the presence of anchoveta at the surface when the "northern current" was at its strongest. Gamarra further castigated Vogt for discounting an experiment by CAG's chief of guardians Felipe Sánchez. In February 1941, Sánchez dropped dynamite charges to three different depths off the Islas Pescadores; the deepest explosion at 18 *brazas* (30 meters) brought a large number of stunned and killed anchoveta to the surface. This appearred to prove that anchoveta were present at depths beyond the reach of the guano birds.[31]

Instead of praising this attempt by a non-scientist to contribute to the debate, Vogt attacked this experiment, the views it appeared to bolster, and those who held them. He countered that Schweigger and Gamarra were hardly guiltless when it came to ignoring contrary evidence. He thought their scattered

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30. Vogt, *Informe sobre las aves guaneras*, 84-85, 88-89; Schweigger to Vogt, 25 May 1942, Vogt papers, box 1:3, pp. v-viii; Frances N. Clark, "Measures of Abundance of the Sardine, *Sardinops caerulea*, in California Waters," California Bureau of Marine Fisheries *Fish Bulletin* 61 (1939).

31. Gamarra, "Memorandum sobre el informe del Dr. W. Vogt relativo a la experiencia para determinar la relación entre la cantidad de alimento ingerido por las aves guaneras y el guano aprovechable," 9 May 1941, Vogt papers, box 3:2, pp. 3-4.

observations lacked the scientific rigor of his systematic observations at Isla Chincha Norte: "One occurrence of the *anchobeta* [sic]. . . is certainly far less significant than the statistics that you object to," Vogt admonished. Sánchez's experiment regarding the presence of anchoveta at depth, likewise, was "interesting but not at all conclusive. . . . One can scarcely establish a biological fact on the basis of a single experiment." Anyway, the issue was moot where the guano birds were concerned, Vogt reasoned: "There would not have to be a complete absence; a considerable reduction would be sufficient," to cause a marked decline in the guano bird population. "The fact is that there was not enough fish available for the birds to eat, and when it comes to finding anchobeta, *I have more confidence in the birds than in human beings*." As this final statement proves, mere empirical observation was not going to resolve the issue: Vogt simply did not believe in the observations of his colleagues. The trust necessary for the idealized function of empirical science and a smoothly functioning technocracy did not exist among CAG's scientists.[32]

Vogt's rivals had little trouble detecting his disdain for their scientific capabilities. Schweigger used his modest English skills to express how "bitter" he was toward Vogt's "wrong pride" regarding his observations of the Peru Current and ability to identify fish, "which evereybody [sic] understands . . . as a willful blow against me." Nor could Schweigger and his wife ignore Vogt's personal

32. Emphasis added; Vogt to Ballén, 16 May 1941, Vogt papers, box 3:2, pp. 3-4; Vogt to Schweigger, 12 July 1943, Vogt papers, box 1:4, pp. 2. The importance of trust to the social functioning of observation networks has become an important issue among historians of science; for an introduction see Steven Shapin, "Cordelia's Love: Credibility and the Social Studies of Science," *Perspectives on Science* 3:3 (1994), 255-275; Karin Knorr-Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press, 1999).

slights, particularly his inability to "find time to see us in our new house" or even to spend "half an hour . . . for saying farewell to us personally" when he left Peru. In a diatribe against Vogt's science, Gamarra implied that ethnic or national prejudice caused Vogt to disregard "experiments by important and notable Peruvian bacteriologists and physicans . . . men of science" whose international "prestige and long years of practice regarding bacillus and Aspergillus infections" Gamarra thought authoritatively proved that illness was the cause of the guano bird's decline. Vogt, in reply, contended that he "did not say or in any way intimate, that Peru lacks technical men. As I know well, it has very excellent ones, including Mr. Gamarra himself. . . . I have the highest regard for Mr. Gamarra, personally, and for his work."[33]

This was a lie. Behind his back, Vogt called Gamarra "an active knife wielder in the good old Latin tradition" who "really doesn't know what it is all about" to be a scientist. Other private statements by Vogt and his wife reveal the origin and extent of Vogt's dislike of Gamarra and his distrust for Peruvian science in general. Although he depended on CAG's workers for some important qualitative observations, his experience led Vogt to doubt the value of any statistical data they gathered. He completely lost his faith in their worth when he and Schweigger discovered that the tugboat engineers who shuttled goods to the

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33. Gamarra, "Memorandum," pp. 3-4; Schweigger to Vogt, 25 May 1942, Vogt papers, box 1:3, p. i.

guano islands often wrote down sea-surface temperatures in their logs without putting thermometers in the water.[34]

This deficiency was not the seat of Vogt's distrust, however. Vogt's self-centered reliance on his own abilities as an observer rested on his experience at one of world's centers for ornithological research, where his work had set the standard for the dedicated amateur as scientist. Likewise, both William Vogt and his wife came to Peru with a set of cultural expectations about human behavior formed by their bourgeois lifestyle in New York City. They tended to ascribe differences in custom they encountered abroad either to ignorance or to the environment--not to race, although their derogatory statements often can hardly be distinguished from those of a racist.[35] Like so many scientific travelers, both women and men, the Vogts felt that their cosmopolitanism and education made them well-suited for the role of anthropologist to an entire nation.

This mindset affected their first sensations of Peru. The moment she arrived, Juana Allraum Vogt remarked in her journal that Peru was "a very dirty place" with "very dirty people"--although she quickly tried to reassure herself regarding her fortitude with a disingenuous caveat: "the dirt doesn't seem to bother me." She took special note of one of her husband's assistants who feared "that these animals he is maltreating for the purposes of science. . . will *cautir* him. . . by which the animal's vengeance is visited indirectly on the evil-doer through

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34. Vogt to Robert Cushman Murphy, 2 Dec. 1946, Vogt papers, box 1:4; Vogt to Schweigger, 12 July 1943, Vogt papers, box 1:4, p. 1.

35. Michael Adas argues that environmental determinism was much more important than racism in the historical formation of ideologies of Western dominance in *Machines as the Measure of Men*, esp. 338-342.

mysterious illness, etc." She added, "Ampuero is not too bright, I fear," thus discounting both the birds' real trauma and this Peruvian's humble respect for the natural world (illus. 37).[36]

William Vogt was equally puzzled by "the emotional state of some of these people." To him, their "national mournfulness" was "as hard to understand . . . as it is to know what is happening to the nervous system of a brooding guanay." Peruvians' sullen attitude stood in contrast to the "equally persecuted American negro who has developed to an almost unique degree the gift of laughter." He ascribed the Peruvian temperament not to inheritance, but to "the harsh environment of these people--the desert coast, the frigid, arid sierra, the dreadful selva." He blamed Peruvians' high death rate, alleged inability to concentrate, and "lack of vigor" to a poor diet supposedly too high in carbohydrates.[37]

Clearly, the Vogts were environmentalists of the determinist sort before they ever set foot on Peruvian shores. Their understanding of animal behavior influenced their perceptions of human behavior, and vice versa. The fact that months of inactivity on the isolated guano islands plunged Juana into depression did nothing to improve their regard for the Peruvian environment. Nor was it good for their marriage: the Vogts divorced soon after their sojourn in Peru.

These views also affected William Vogt's private evaluation of Peruvian scientists and the quality of their work. After having tea one evening with "one of Peru's outstanding men of science," Vogt outlined his unnamed host's capabilities

36. Journal of Juana Allraum Vogt, Talara, 3 July 1939, Isla Chincha Norte, 9 Oct. 1940, Vogt papers, box 5:1.

37. Journal of William Vogt, Lima, Sept. 1940, Vogt papers, box 3:1.

and liabilities in a revealing journal entry, one of the few he made that was not directly related to his ornithological research in Peru. This "loveable, sweet, apparently honest" man had "probably been intelligent, though his mind is slipping." After cursorily glancing at his major work, Vogt determined that this "carefully done" book "would not stand up under the kindest North American criticism," despite the fact that it was based on "an enormous amount of labor . . . probably with a solid foundation," for one thing because it was "extremely badly documented." Nor did Vogt expect much from this man's future work: "his pleas for a second volume sound like 15*th* Century vaporings." In Vogt's view, the quality of this scientist's work befit his working environment: "He lives in a house that is dismal as only a middle-class Peruvian house can be, with no comfortable furniture, not a decent reading light, the chairs falling to pieces. No college prof I've ever known at home has had to endure such uncomfortable living and working conditions." "Yet," Vogt wrote in mock amazement, "he is one of Peru's outstanding sabios [scholars]."[38]

The liabilities of this one scientist symbolized for Vogt the failings of the entire scientific complex in Peru. "The really good men are paid less than 600 soles a month [US$189]" when "almost any U.S. scientific publication cost[s] 25-30 soles per year." This made competition for jobs "so sharp that all sorts of back-stage knifing goes on. . . . The practicing scientist is almost forced to resort to splashy performances in order to make enough of an impression to hold his job"--as if the same could not be said for the United States during the Depression, or today,

38. "Peruvian science," Vogt journal, Sept. 1940, Vogt papers, box 3:1.

for that matter. Publication standards in Peru, likewise, “are extremely low; much of the published material is an unacknowledged synthesis of work from other countries. And such things as priority, one-time publication, etc., mean nothing to most of the scientists here.” Vogt wondered if behind these poor conditions of pay, work, and living, “there is also something in the Peruvian temperament that is anti-pathetic to the sustained work that is the basis of sound science.” With the “notable exception” of CAG’s general manager Francisco Ballén, Peruvians to Vogt, “seem to have grasshopper minds, to a far greater degree than we of the U.S. . . . Many of the people I work with seem to have a constitutional difficulty in sticking at anything more than a few moments. . . . *small wonder that Peruvian science is so pathetic*.”[39]

Obviously, Vogt thought Peru lacked the right conditions and the right men, much less the proper knowledge base, for an adequate technocracy. He verged on a racist dismissal of Peruvians’ inherent capabilities for science, though his paternal treatment of Enrique Ávila would seem to indicate that he had some hope for Peru’s scientific future. If any part of his evaluation was correct, it did not bode well for the rational development of Peru’s other marine resources.

But this negative evaluation of Peru’s scientific capabilities cannot explain Vogt’s antagonism toward his German colleague who had excellent scientific training by almost anyone’s measure. The available evidence suggests that their disagreement is best explained as both an interpersonal and interdisciplinary conflict over the standards of professional propriety, expertise, and authority.

39. Ibid., emphasis added.

Part of their misunderstanding can be ascribed to their contrasting preference for holist versus specialist study. Even though he focused on the guano birds, Vogt presumed to study the entire complex of interspecies relations that affected the birds' well-being, as one would expect from his scientific upbringing among the polymaths of U.S. ornithology and conservation. He thought only a holistic ecological study of Peru's marine environment would provide an adequate knowledge base for the management of guano production. Schweigger acknowledged the value of such a study, but he criticized Vogt for taking on "a work which never one man alone can do." During his intense, highly specialized training in the German university tradition, the idea had been instilled in Schweigger that an individual scientist could only become an expert on a single group of closely related organisms. Outside a narrowly defined field of expertise, the scientist had to bow to the authority of other experts, which Vogt failed to do, in Schweigger's view. He particularly frowned on Vogt's analysis of the food chain governing Peru's marine community, a classic tool of Eltonian ecology (illus. 38). Even though Vogt's diagram provided some idea of the ecological complexity of this community, Schweigger noted that it did not even begin to include all of the significant relationships that potentially affected the guano birds. In short, Vogt's work did not meet his own holistic standard. Schweigger had zeroed in on a major reason why many ecologists at this time migrated away from community ecology toward the study of population dynamics. It was difficult to formulate practical, quantitative research problems within the holistic rubric of community ecology, much less to establish a framework for the technocratic management of entire communities. Despite the contribution of the "energy-economics" school led by Charles Elton, holistic studies only experienced a major renaissance after World War II when ecologists encouraged by funding from an immense military-industrial complex began to use radioactive isotopes to study the flow of energy and chemicals through what then came to be known as "ecosystems."[40]

Vogt and Schweigger also had different approaches toward the use of physical data and the study of change in these conditions over time. Following a venerable tradition of German oceanography typified by the work of Schweigger's former colleague Gerhard Schott, Schweigger preferred to gather hard data from as many observers as possible in order to interpolate average conditions along the entire Peruvian coast. Vogt, on the other hand, was primarily concerned with the changing environmental conditions of a small region surrounding the Islas Chincha, especially the effect of environmental extremes on the well-being of the guano birds. Vogt thought Schweigger's observations were "literally and figuratively superficial" because he cared little for their larger ecological context. To Schweigger's horror, Vogt did not hesitate to derive the physical conditions of another site using observations of animal behavior as a proxy, even though he had no direct knowledge of these conditions. Schweigger thought this lack of precision led Vogt to embark "on many doubtful ideas" that failed to consider "all the particularities of the Humboldt current I have collected during all these years." As

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40. Schweigger to Vogt, 25 May 1942, Vogt papers, box 1:3, pp. iii, viii. On the turn toward the study of populations and then ecosystems, see Worster, *Nature's Economy*, 291-315, 362-378; Kingsland, *Modeling Nature*; Taylor, "Technocratic Optimism, H. T. Odum, and the Partial Transformation of Ecological Metaphor after World War II."

a hyper-empiricist, Schweigger was uncomfortable following Vogt on what he considered flights of theoretical fantasy.[41]

More importantly, Schweigger and Vogt had contrasting attitudes toward the function of debate in a scientific community. Schweigger was highly sensitive to criticism, while Vogt thought his own abrasive personality was a virtue. He believed that "science only grows through criticism. . . . The friction of mind on mind ought to polish our understanding of these problems until there can be no question as to what is the ultimate truth." Paradoxically, Schweigger was not hesitant to publish. His output of scientific articles was substantial, although much of this production was narrowly empirical. Vogt's major product, in contrast, was a highly speculative report with clear policy recommendations to his superiors at CAG; he published practically nothing in English based on his ornithological work in Peru. As a consequence, Schweigger's observations had a much greater impact on broad scientific understanding of Peru's marine environment, while Vogt's recommendations had a direct effect in the short term on the management of the guano birds.[42]

Vogt's profession of faith in the ability of science to "grow through criticism" notwithstanding, this three-way debate between a Peruvian agronomist, New York ornithologist, and German oceanographer left other Peruvian officials with a conundrum. Should the environmental technocrat rely on the gradual

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41. Schweigger to Vogt, 25 May 1942, Vogt papers, box 1:3, pp. iii-iv; Vogt to Schweigger, 12 July 1943, Vogt papers, box 1:4, pp. 1-2. Cf. Schott, *Geographie des Indischen und Stillen Ozeans*.

42. Vogt to Ballén, 16 May 1941, Vogt papers, box 3:2, p. 4.

accumulation of local empirical knowledge or have faith in existing theory, even though it might not apply to Peru's situation? Should the technocrat act cautiously or aggressively based on this knowledge? How could anyone really tell when this understanding was fundamentally affected by personal or professional conflicts? The accelerating drive to develop Peru's fisheries made these issues all the more pressing.

A False Start

As the crisis of Peruvian guano production worsened during the El Niño of 1939-1941, CAG officials considered the possibility that they could circumvent this problem by exploiting a different level in the Humboldt Current food chain. They initiated a plan to harvest fertilizer directly from the sea as fishmeal.

CAG sent Luis Gamarra on a long expedition to study the fishing industry in the United States. There he established contacts with officials from the U.S. Fish and Wildlife Service, boat and net manufacturers, and various fish, fish oil, and fishmeal companies in New Jersey, Washington State, and California. Late in 1940, he submitted an enthusiastic report estimating that CAG could rapidly set up a manufacturing complex capable of producing 50,000 metric tons of fishmeal per year. Francisco Ballén was immediately won over by Gamarra's optimism, and he began to envision the implantation of an industry that would "contribute to the satisfaction of rising demand for nitrogen fertilizer from the nation's agriculture," besides producing "a product with excellent market openings" that CAG could sell for high prices abroad. Thus, CAG's conservation technocrats gave birth to a plan to establish a fishmeal industry in Peru modeled, more or less, after the guano industry.[43]

They were not the only party interested in the development of Peru's vast marine resources, however. Nor were these other parties satisfied to let CAG's technical corps attack this problem alone. But everyone concerned seemed to want experts to lead this charge. Once again, Peruvian state officials consulted foreign experts for assistance. Their endeavors bore fruit, but not in the way CAG's leaders intended.

In 1940, Manuel Prado's government issued Law 9140 for the Promotion of Industry. Although this law has sometimes been hailed as a fundamental shift in the political economy of the Peruvian state, it had little impact on manufacturing in Peru in the short term, except for hesitant steps toward the construction of an immense hydroelectric-coal-steel complex near Chimbote, the future center of Peru's fishing industry. Rapid industrialization was largely a phenomenon of the 1950s and 1960s in Peru. Nevertheless, this law did have important consequences for the technocratic development of Peru's marine fisheries. It included a clause that established a Peruvian Fishery Commission composed of national experts who were entrusted with mapping out the future of the fishing industry in Peru. Ballén, Schweigger, and Gamarra, all CAG stalwarts, occupied three of its chairs. This sort of top-down organization, in which a bureaucratic commission with broad powers is initiated by decree or legislation, became typical of state-led development

43. Gamarra, "La industria de la fabricación de harina de pescado en el Perú," *BCAG* 16:11 (Nov. 1940), 340-379.

projects during the mid-twentieth century in Peru and other Latin American states. Their popularity, which grew in following years, was testimony to the influence of the technocratic ideal and goes a long way toward explaining the epochal growth of state bureaucracies during this era.[44]

While this "oceanographic cabinet" was getting organized, President Prado made a direct request to the United States for aid. He asked the U.S. to send a mission of fishery experts to Peru as representatives of its "Good Neighbor Policy." This action was significant in a number of ways. It was an important case in which a Latin American government took initiative to encourage the administration of Franklin D. Roosevelt to back up its international policy of military nonintervention and noninterference with direct measures that would improve the economies and living standards of its neighbors to the south. Thus, Peru helped in a small way to shape the evolution of the Good Neighbor Policy after 1939. Prado's request also helped to inaugurate Peru's alliance with the United States during World War II, a policy highlighted by Prado's triumphal visit to Washington (where he was feted as "a great scientist and professor" by the Harvard Club), the forced internment of much of Peru's 17,000-plus Japanese population to "protect" the Panama Canal, and the signing of a general trade agreement. This agreement promised to provide the United States with agricultural staples and strategic materials at controlled wartime prices, placing a ceiling on the profits of Peruvian

44. *Peru: Obra de gobierno del Presidente de la República Dr. Manuel Prado*, 43; Thorp and Bertram, *Peru, 1890-1977*, 186-187, 190-195, 259-273; *MCAG* 30 (1939), 61-62; *MCAG* 33 (1942), ix, 67-68. Detailed studies of state formation during the mid-twentieth century are lacking for Peru. For an overview covering all of Latin America, see Laurence Whitehead, "State Organization," in *CHLA* (1994), vol. 6, pt. 2, pp. 3-95.

agro-exporters. As we have seen, this international relationship had a major impact on patterns of guano distribution and the attitudes of agribusinessmen toward Prado and his successor. It also manifests the importance of food production and resource conservation to U.S.-Latin American relations during this period, relations which provided William Vogt with the opportunity to make a career for himself as an international conservationist. Where the long-term development of Peru's fishing industry was concerned, this alliance did not entwine Peru into strict relations of depedence on U.S. economic power and authority. Prado's political economy on this count was decidedly nationalist, even though it was never designed to encourage autonomous economic development.[45]

In January 1941, three experts from the U.S. Fish and Wildlife Service in Washington, DC, arrived in Peru. The economist Reginald H. Fiedler (b. 1898) had been the chief of the Division of Fishery Industries at the Service since 1929. He led the North American Fishery Mission and was to perform an economic and statistical analysis of Peru's fish marketing, distribution, and consumption. The chemist Norman D. Jarvis (b. 1899) had worked at the Service as a fisheries technologist since 1930; he came to evaluate the handling and preservation of fish. Both Fiedler and Jarvis had degrees in fishery science from the University of Washington and had already worked together on a study of the *Fisheries of the*

45. On these points see David Green, *The Containment of Latin America: A History of the Myths and Realities of the Good Neighbor Policy* (Chicago: Quadrangle Books, 1971), vii-x, 294-295; Irwin F. Gellman, *Good Neighbor Diplomacy: United States Policies in Latin America, 1933-1945* (Baltimore: Johns Hopkins University Press, 1979), esp. ch. 11, 12; Pike, *The United States and Latin America*, 267-281, 287-294; Thorp and Bertram, *Peru, 1890-1977*, 186-187, 205-206; Caravedo, *Burguesía e industria en el Perú*, ch. 5, 6; Cotler, *Clases, estado y nación*, 253-260; Jochamowitz, *Ciudadano Fujimori*, 79-85.

Virgin Islands (1932). Jarvis was also an expert on the fisheries of Puerto Rico and the Gulf of Mexico, and both were thought to have a special understanding of issues related to fishery development in Latin America. Fishery engineer Milton J. Lobell, meanwhile, took charge of the study of fishing techniques and biological issues.

Their studies paralleled the activity of various health, economic, and military advisors in Peru, including a U.S. Department of Agriculture mission to the Peruvian Amazon designed to expand strategic procurement of rubber, quinine, and other jungle products for the war effort. But these scientific bureaucrats were not mere envoys of the Good Neighbor Policy and U.S. interests, they also helped to shape them: Long before he was chosen to lead this mission, Fiedler had been an outspoken advocate for a U.S.-funded statistical survey to further "conservation of Inter-American fisheries" as a follow-up to his survey of fishery economics in the United States and Virgin Islands.[46]

These experts came to Peru to reverse a paradoxical situation: Peru was a net importer of fish and fish products even though it had one of the richest marine ecosystems in the world. They were rather shocked to discover that even though

46. Fiedler, Jarvis, and Lobell, *The Fisheries and Fishery Industries of Peru*, 2; Fiedler, "Need and Plan for a Statistical Program in Furthering Conservation of Inter-American Fisheries," U.S. Department of the Interior, memorandum S-352 (1940), cited in Fiedler, Lobell, and Clarence R. Lucas, *The Fisheries and Fishery Resources of the Caribbean Area (A Report of the Caribbean Fishery Mission of 1942)* (Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service, Sept. 1947); Jarvis, *The Fisheries of Puerto Rico*, U.S. Department of Commerce, Bureau of Fisheries, Investigational Report [BFIR], no. 13 (Washington, DC, 1932); idem, *Fishery for Red Snappers and Groupers in the Gulf of Mexico*, BFIR, no. 26 (Washington, DC, 1935); Fiedler and Jarvis, *Fisheries of the Virgin Islands of the United States*, BFIR, no. 14 (Washington, DC, 1932); Thorp and Bertram, *Peru, 1890-1977*, 186-187; *American Men of Science: A Biographical Dictionary*, 6th ed., ed. J. McKeen Cattell and Jaques Cattell (New York: Science Press, 1938), s.v. "Fiedler, R(eginald) H(obson)" and "Jarvis, Norman D(onald)."

Peru produced a total catch of 11,863 metric tons worth S/.2,373,000 (US$365,000) in 1940, it exported almost no fish or fish products and barely touched its vast anchoveta stocks. Meanwhile, Peru imported over 5,800 metric tons of fish from 1936-1939, more than two-thirds of which was canned fish for luxury consumption, and nearly one-third of which came from Japan. Peru imported a whopping 182,184 metric tons of fishmeal from the U.S. and Japan in 1937-1938, probably for use as fertilizer. With the onset of World War II, there was simply no way these patterns could continue--and few people in Peru wanted them to.[47]

To members of the North American Fishery Mission, the status of the Peruvian fishing industry was primarily a technological problem to be solved by the introduction of new craft and techniques. To this end, they sailed to Peru in the *Pacific Queen*, an 80-foot, state-of-the-art trawler newly built in Tacoma, Washington (illus. 39). They used it all along the Peruvian coast to test fishing gear, measure environmental conditions, and train a Peruvian fishing and scientific crew. Fiedler, Jarvis, and Lobell intended Peru to use this craft and crew to establish an anchoveta fishery for the production of fishmeal, preferably organized under an independent administrative and research agency with capabilities similar to CAG.

The North American Fishery Mission to Peru became a model for U.S. fishery missions all over the world designed to increase the supply of protein and vitamins to Allied forces. The U.S. State Department almost immediately

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47. Fiedler, Jarvis, and Lobell, *The Fisheries and the Fishery Industries of Peru*, 8-9, 14, 16, 36; Gamarra, "La industria de la fabricación de harina de pescado en el Perú," 342; Caravedo, *Estado, pesca y burguesía*, 25-26.

approached the governments of the Caribbean basin with a similar plan "to further economic and social cooperation among the nations of the Western Hemisphere." This led directly to the U.S. Fish and Wildlife Service Caribbean Fishery Mission of 1942 headed by Fiedler and assisted by Lobell. Fiedler continued his flurry of wartime organizing activity with missions to the South Pacific islands, Iceland, and England in 1943-1944. In 1944-1945, Lobell led a similar mission to Chile and completed a long, unpublished report outlining a ten-year fishery development plan for Peru's neighbor to the south. President Prado's appeal helped to set in motion a major strategic endeavor by the United States to survey and exploit the world's fishery resources. Meanwhile, ideologues all over Latin America began to view the ocean as the next frontier of modern development.[48]

The recommendations of the North American Fishery Mission meshed well with CAG's plan to establish a fishmeal industry in Peru under its control. After the mission returned to the United States late in 1941, CAG received the sole right to "anchoveta fishing on a grand scale." CAG officials had argued successfully, at least for the time being, that they alone could prevent any competition for this natural resource that might "disorganize national fertilizer distribution and

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48. Fiedler, Jarvis, and Lobell, *The Fisheries and the Fishery Industries of Peru*, 3, 191-223, 333-338, 351; Fiedler, Lobell, and Lucas, *The Fisheries and Fishery Resources of the Caribbean Area*, 1, 4; *American Men of Science: A Biographical Directory*, 8th ed., ed. Jaques Cattell (Lancaster, PA: Science Press, 1949), s.v. "Fiedler, R(eginald) H(obson)"; Milner B. Schaefer, "Confidential: Report on Assistance to the Government of Chile in the Preparation of a Request to the Special Fund for the Establishment of a Technical Institute of Fisheries Development," draft manuscript, n.d. [1961], Schaefer papers, 3/212, app. 2.

The Peruvian Ministry of Fisheries a few years later named its monthly publication *Pejecholo en la Marcha hacia el Oeste* to glorify Peru's "march to the west" to control its "fourth natural region"; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 44; see also Osorio, "El destino marítimo de México."

international marketing." With experts like Schweigger at its command, CAG looked ready to establish a modern fishmeal industry "compatible with the protection of the guano industry." CAG negotiated an initial loan with the Banco Industrial del Perú for S/.650,000 (US$100,000) to purchase the *Pacific Queen*, a purse-seine net outfit, a complete terrestrial fishmeal plant with lighter fleet, and a mechanized storage and transport facility from California. But the interruption of regular shipping during World War II and a sharp, El Niño-induced drop in company earnings hampered CAG's ability to import the equipment necessary to complete a fishmeal production complex in Callao for several years.

After the war, CAG continued to have trouble acquiring sufficient capital and staff to get its fishmeal plant operating, despite spending almost three times the original loan, a price that included sending two more Peruvians to study the fishing industry in the United States. Critics viciously attacked this project as a boondoggle, even though CAG had spent barely half the amount Gamarra originally estimated it would take to build an operating fishmeal production complex. CAG's managers stubbornly stumbled forward with the original plan. Finally, in 1955 CAG put the idle plant up for sale at the greatly depreciated price of S/.901,474 (US$47,000). The Italian-Peruvian entrepeneur Marcos Ghio bought the plant for an undisclosed amount and proceeded to build a valuable private company during the Peruvian fishmeal boom. CAG never produced a gram of fishmeal.[49]

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49. *MCAG* 33 (1942), ix, 69-72; *MCAG* 37 (1946), ix; *MCAG* 36 (1955), 16; Gamarra, "La industria de la fabricación de harina," 340, 368-377; Lanatta, *Informe*, 90-91; Jaysuno Abramovich, *La industria pesquera en el Perú: Génesis, apogeo y crisis* (Lima: Imprenta La Popular, 1973), 18.

Was this a failure for technocracy? CAG's zealous leaders overestimated the ability of expertise to solve this new development problem. But what had gone wrong? When CAG took over and revived the guano industry, it used technical knowledge to adapt the *existing* system of guano production to the ecological conditions necessary for the growth of the guano bird population. With its fishmeal plan, in contrast, CAG tried to build an industry using new technology where none of its type existed in Peru. To make matters worse, it first entrusted this endeavor to an agronomist who had no experience with fishing. Boosters of this project had been forewarned of its likelihood of failure: The North American Fishery Mission prudently predicted that "the yield of this fishery, at least for several years to come, will probably not be as large as prophesied . . . because of the inexperience of the operators of the boats and gear and because of unforeseen technical difficulties." The mission also cautioned against Ballén's dream of mining fertilizer directly from the sea: fishmeal was simply too valuable as a high-protein livestock feed for it to be wasted as fertilizer. Schweigger, Vogt, former CAG agronomist Rómulo Lanatta, and a series of expert oversight committees appointed by the Peruvian state echoed these conclusions. By preventing CAG from raising enough capital to finish its fishmeal complex, expert criticism ensured the failure of a project already delayed by wartime and hampered by problems inherent to technology transfer.[50]

50. Fiedler, Jarvis, and Lobell, *The Fisheries and the Fishery Industries of Peru*, 343, 359; Lanatta, *Informe*, 31-34, 83.

A Vexing Experiment

Why did CAG proceed with this fishmeal project when its own scientists objected to several of its fundamental premises? The debate over a simple experiment by one of the fishmeal plant's main booster helps us to elucidate some reasons why. The elements of this debate demonstrate that scientific investigation cannot resolve some fundamental questions linked to resource development, no matter what its protagonists believed science and technocracy could accomplish.

Soon after he completed his plan for the development of a fishmeal production complex, Luis Gamarra performed a basic experiment in an attempt to bolster his claims regarding the desirability of an industrialized anchoveta fishery in Peru. He wanted to determine the amount of guano produced when "the machinery of the digestive tube of marine birds" accomplished "the transformation of a primary material." For this purpose, he captured nine adult guanayes of nearly the same weight and placed them in three cages. He force-fed a carefully weighed quantity of fresh *machete* fish to six of the birds; the other three he allowed to starve, ostensibly as an experimental control. After three days he weighed the amount of guano produced by both sets of birds. The force-fed birds consumed an average of 110 grams of fish and produced an average of 28 grams of excrement (a 3.9:1 ratio). The so-called controls, meanwhile, produced an average of 18 grams of guano each during their fast. Gamarra then took a crucial (and highly problematic) step: he reasoned that he should subtract the latter average from the former to obtain the "real" ratio of fish consumed to guano produced by the six force-fed birds. Through a couple more calculations (that do not add up on close examination), he concluded that each guanay consumed 16.5 grams of fish for each gram of guano produced. Gamarra then arbitrarily assumed that one half of this guano was lost into the sea, arriving at a final ratio of 32:1 [sic]. This compared quite unfavorably to the results of a fishmeal reduction experiment he supposedly performed on Isla Don Martín. He claimed to have produced 2.5 tons of fishmeal and 240 liters of oil from ten tons of anchoveta (a 4:1 ratio)--how he did not say. But his message was clear: humans could exploit this resource much more efficiently than the guano birds. To make a fishmeal industry seem even more lucrative, he calculated that Peru could gain an additional S/.461 (US$71) of profit from every ton of fishmeal sold on the international market beyond the S/.70 earned after cost from each ton of guano sold in Peru.[51]

This shoddy experiment did nothing to improve Vogt's opinion of Gamarra. He publicly attacked the experiment's elements: the exceedingly small number of birds and short study period involved, Gamarra's simplistic understanding of the digestive process, his unwarranted extrapolations. (No one seemed to question Gamarra's unlikely claim that he manufactured fishmeal at a 4:1 ratio or pointed out that his numbers did not add up.) Vogt thought to repeat the experiment, but he could not acquire enough anchoveta from local fishermen at the remote Islas Chincha to do so. Instead, using an analysis of the stomach contents of 23 wild birds, some rather fantastic over-estimates of the total population of guano birds, and comparisons with other bird species, Vogt guessed that the guanayes consumed

51. Gamarra, "Relación entre la cantidad de alimento ingerido por las aves guaneras y el guano aprovechable que producen," in Lanatta, *Informe*, 65-74, originally published in *BCAG* 17:3 (Mar. 1941), 103-115.

a maximum of 5.0 to 7.3 grams of fish for every gram of guano produced. To clinch his argument for the efficiency of the guano industry, he asserted that the guano birds had a tendency to drop their pellets at night, and he figured that guano "lost" to the sea entered the nitrogen cycle and ultimately produced more anchoveta, anyway (see illus. 38). This meant that the elimination of the guano birds to increase the fish catch--a possibility that a few forward-looking fishing boosters were already considering as early as 1942 [!]--might actually decrease the number of anchoveta by eliminating an important contributor to the nutrient cycle in the ocean food chain. Gamarra countered that his approach to the problem simply came closer to scientific exactitude: he thought his experiment, because it was quantitative and involved direct measures, was therefore more concrete, more objective, and more certain than the "unstable base" Vogt used for his extrapolations and speculations. Their relationship deteriorated further from this dispute.[52]

It would seem that this tedious quarrel could simply be dismissed as bad science on both sides, but it was hardly trivial. Despite its basic flaws, Gamarra's study, 32:1 consumption-to-production ratio, and US$71 of "lost" profit per ton of guano produced, were cited repeatedly by fishmeal industry boosters as scientific evidence for the inefficiency of the guano industry. The population estimate of 30 million birds used by Vogt in his calculations, likewise, was often cited by industry boosters, even though it was based on an ad hoc assertion by Gamarra that Vogt

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52. Vogt to Ballén, 16 May 1941, Vogt papers, box 3:2, p. 2; Vogt, *Informe sobre las aves guaneras*, 60-64, 109; Gamarra, "Memorandum," p. 2-3.

followed only for the sake of argument. (Subsequent analysis of aerial photographs indicated that the likely breeding population at the time was about 10 million birds of three species.)

In the meantime, Vogt's conflict with Gamarra over this issue carried over to Gamarra's relationship with Vogt's disciple. In 1946, Enrique Ávila proposed to repeat Gamarra's guano productivity experiment; Gamarra bristled at this implied criticism and even threatened to have him fired. Although Gamarra eventually relented, Ávila shrewdly waited until the early 1950s to do the study, after he had already solidified his position at CAG and when his employer was beginning to become worried about competition from other fishmeal producers. He constructed his experiment much more carefully than Gamarra, though he still relied on a small sample. Ávila captured 12 two-month old guanay chicks (instead of adults) from Isla Chincha Norte and transported them to Callao; three died on the trip, and only six were healthy enough for the study. These he fed and weighed daily, and he carefully measured their excrement at the end of two periods of two months each. Ávila used a regression analysis to test the accuracy of his final data and made a comparison to known nest deposits in wild conditions on Isla Don Martín. During the first two months, his chicks consumed an average of 6.32 grams of fish for every gram of guano produced; during the second two months they produced at a 4.46:1 ratio. The accumulated deposits of these captive chicks were comparable to the weight of wild nests, which Ávila took to mean that guanayes deposited most of their excreta at the colonies (which, again, was not a logical conclusion, since his experiment did not involve adults). Ávila used his results to criticize Gamarra's sloppy work and to savage the wild claims by other so-called experts that every piquero eats seven times its own weight in fish each day.[53]

To confuse matters even more, in his 1950 survey of worldwide guano production Yale ecologist G. Evelyn Hutchinson rejected Gamarra's figures as "almost certainly wrong" since his so-called controls were "obviously unwillingly converting themselves into guano." Hutchinson determined from chemical analyses that their consumption-to-production ratio was no better than 9.8:1 and probably closer to 15.3:1. According to this study, Gamarra's ratio (before he arbitrarily doubled it) had been correct--but by accident. Finally, in the late 1950s, one of Ávila's successors repeated his experiment with much greater care in an attempt to prove definitively that chick mortality during El Niño events was due to starvation, not disease. He arrived at a food:guano conversion ratio of 6.88:1. These studies were never cited by fishing industry partisans with any regularity, however, despite their greater claims to accuracy and relevance for the management of Peru's marine environment.[54]

The crux of this matter actually had little to do with the numbers involved. However ridiculous their attempts, CAG's scientists were performing a time-honored ritual while debating Gamarra's vexing experiment. They were demonstrating their devotion to the experimental philosophy and the "gospel of

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53. Ávila to Vogt, 7 Oct. 1946, Vogt papers, box 1:1; Ávila, "Potencia deyectiva del guanay (*Phalacrocorax bougainvillii*)," *BCCAG* 1:2 (Sept. 1954), 21-49; cf. Emmanuel Pozzi-Escot, "La fabricación de abonos en el Perú," *Anales del Primer Congreso Nacional de Ingenieros Agrónomos* 2 (1947), 641.

54. Mario Barreda O., "Recuperación de guanayes (Phalacrocorax bougainvillii) caquecticos en cautividad.--Estudio de su ingestion y deyección," *BCAG* 35:4 (Apr. 1959), 10-22; Hutchinson, "The Biogeochemistry of Vertebrate Excretion," 86-88.

efficiency," basic tenets of the technocratic ideal. At its deepest level, this debate represented a disagreement over the fundamental nature of Peru's marine ecosystem and the proper role of humans in this natural order. These experiments established an arena accessible only to a handful of technocrats where basic, philosophical issues could be wrestled over without creating a chaotic, democratic free-for-all.

As many students of technocracy have pointed out, ceremonial display has been crucial to the rise of experts to power. Such rituals include privileging "hard" quantifiable data that can be used to calculate efficiency over "hard to decode" qualitative trends, and making "economese" and other technical jargon the lingua franca of debate. Respectability--and the legitimacy of power--are at stake in these displays. Though not in this particular case, such displays of respectability often come down to tangible, seemingly objective "matters of diploma" (i.e., degrees, scholarships, and other credentials that might appear as lines on a résumé) rather than abstruse, subjective "matters of science" (i.e., the quality and importance of work in a specialized research field, issues requiring evaluation by other experts). It is often easier to judge the aesthetics of such ceremonies--and then simply choose which side "looks best" based on other political and economic interests--than it is to evaluate the applicability of an abstract experiment to a policy debate.[55]

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55. On these points, see Markoff and Montecinos, "The Ubiquitous Rise of Economists," 37-41, 43-47, 53-54, 60; O'Donnell, *Modernization and Bureaucratic-Authoritarianism in South American Politics*, 79-82, 99, 102-105; Meynaud, *Technocracy*, 293-303; Porter, *Trust in Numbers*, passim.

In one sense, this debate was an extension of the dispute over the cause for the guano birds' decline during the 1939-1941 El Niño. If basic food scarcity was the cause, as Vogt believed, then a fishing industry of any size could only hurt the guano birds, especially during El Niño years. But if disease was a major factor, or the fish simply had moved deeper out of reach of the birds, as Gamarra and Schweigger believed, then a limited fishing industry would not be a problem. This sort of issue could be addressed by further scientific research. CAG's scientific trio of Gamarra, Schweigger, and Ávila, a Peruvian veterinarian, and another agronomist devoted a great deal of attention to this question when a weak El Niño in February 1948 negatively affected the bird colonies as far south as Isla Tortugas. They unanimously confirmed Vogt's position that lack of food, not disease, caused these upsets.[56]

But Gamarra's experiment was not designed to address this problem. He wanted to determine if humans could make more efficient use of anchoveta as a "primary material" than could the digestive "machinery" of the guano birds. This question derived from one of the core principles of conservation, the "gospel of efficiency," by which humans should strive toward the "highest use" for human benefit of the various natural resources at their disposal in a particular

56. Ávila, "Sobre la diftero viruela [fowl pox] en los guanayes," manuscript, 16 Sept. 1949, Vogt papers, box 1:1; Gamarra, "Alteración de las condiciones hidrográficas a principios del año 1948," *MCAG* 40 (1949), cxxviii-cxxix; Schweigger, "Extrato del informe sobre la situación hidrográfica en el verano de 1948, presentado por la Sección Oceanográfica," *MCAG* 40 (1949), cxxix-cxxx; Rafael La Rosa Llosa and Teodoro Ramos Saco, "Informe sobre la mortandad de las aves guaneras," *MCAG* 40 (1949), cxxx-cxxxiv.

environment.[57] The larger the fish consumption-to-guano production ratio, the more humans could profit by extracting fishmeal rather than guano from Peru's marine ecosystem. According to Elton's pyramid of numbers (and basic laws of thermodynamics), a large population of fish were required to support a small number of predatory birds. Humans would be "eating lower on the food chain," so to speak, by exploiting the anchoveta directly rather than waiting for birds to convert them into guano. In other words, Peruvians could probably generate much greater surplus value from natural capital and human labor by establishing a large-scale fishing industry. Because this question was framed on the narrow grounds of efficiency, and therefore amenable to further scientific investigation, it virtually guaranteed that scientists would remain a part of any future debate over the institution of a fishmeal industry.

In this vein, Vogt and Gamarra succeeded in turning this controversy into a debate over the ability of experts to manage Peru's marine environment efficiently. Both men assumed that the Peruvian populace could not be trusted to manage an industrial anchoveta fishery on their own. But were Peruvian experts competent enough to guide the exploitation of the anchoveta on a large scale without destroying Peru's natural patrimony? But a philosophical issue lay at the heart of this controversy: Should Peru endeavor to exploit its natural resources to the maximum? Of course, scientists had no more qualifications to answer this moral question than anyone else in Peru.

57. On the "highest use" of land and sea resources as part of the "gospel of efficiency" preached by early twentieth-century conservationists in the United States, see Hays, *Conservation and the Gospel of Efficiency*, passim; Flader, *Thinking Like a Mountain*, 65-67.

Like most developmentalists of his era, Gamarra believed it was the moral duty of the scientist--and all patriotic Peruvians--to promote the maximal use of Peru's natural resources: "It is not right that Peru should lose this enormous quantity of money that could have moved the country forward" if it rejected the opportunity to exploit the anchoveta directly, Gamarra exhorted. "As Peruvians and employees of this company we are ready to place the entire sum of our strength toward preventing our posterity from making accusations against us" for failing to maximize the production of wealth in Peru. Gamarra was a great skeptic regarding the ability of nature to regulate itself. Reflecting his training as an agronomist, he thought rational man was quite capable of "exploiting natural resources prudently and scientifically." The guano birds, on the other hand, did not "conform to these norms; they ingest all the fish that come into their reach as do . . . other wild animals and insects that attack crops." In short, nature could be greatly improved upon under human management.[58]

Conversely, like many ecologists of his era, Vogt envisioned nature almost as an organism in its own right. He believed natural communities achieved their healthiest, most productive "climax" state when left alone by humans. As a foreigner, he had no reason to share Gamarra's nationalistic biases. Vogt admitted that he did not have sufficient knowledge to predict the future of an industrial anchoveta fishery. "But we do know," Vogt warned, "from the reactions of hundreds of forms of life all over the earth, that exploitation of natural resources by man is *almost always a dangerous proceeding*, unless it is done with care and skill,

58. Gamarra, "Memorandum," pp. 4-5.

especially since guano is a resource that will exist in perpetuity." Vogt raised the specter of the California sardine. Many experts at this time thought that the sardine was being severely overfished (it was still over a decade away from total collapse). Vogt pointed out that this dire situation had emerged even though scientific understanding of the sardine was vastly superior to knowledge of the anchoveta and its ecology. To make matters more difficult, scientists still knew little about the ecology of the sardine, even after years of sustained scientific research. On these grounds, Vogt thought the economic and biological risks of a Peruvian fishmeal industry were great, no matter how carefully it was managed--and we already know of Vogt's pessimistic evaluation of the technocratic corps in Peru that presumed to develop this new natural resource.[59]

Other Peruvian officials tended to agree with Gamarra's position, but they were willing to concede to Vogt their ignorance of Peru's marine environment. Therefore, they consulted yet another foreign expert in search of a technocratic solution to this issue.

In 1941, CAG officials invited the planktonologist Mary Sears (1905-1997) to Peru so they might "reach . . . a better understanding of some factors that affect the life of the birds and production of guano that until now were beyond human control." She obtained a grant from the U.S. Committee for Inter-American Cultural and Artistic Relations and a faculty fellowship from Wellesley College

59. Vogt's emphasis; Vogt to Ballén, 20 Oct. 1940, Vogt papers, box 1:3; Vogt, "Informe sobre las aves guaneras," 111, 118-120.

that gave her the chance to study the plankton and oceanographic conditions of the Bahía de Pisco during the 1941-1942 U.S. academic year.[60]

Once again, CAG could not have acquired an expert more qualified for the job. Sears had completed a Ph.D. in zoology and oceanography from Radcliffe College and was still working at Harvard as a research assistant for Henry Bryant Bigelow, founder and director of Woods Hole Oceanographic Institution. She specialized on a topic with the most basic implications for economic production from the sea: the relation between nutrient cycling and plankton production at the rich Georges Bank fishery off the Maine coast. Like so many of the marine scientists who came to work in Peru, her career blossomed after she returned home. During what one historian of science has called the "dark age for women in the professions," Sears was one of the architects of U.S. oceanographic research. She served as the main organizer of the Oceanographic Unit of the Navy Hydrographic Office, then as founding editor of the journal *Deep-Sea Research* (1953-1974). Sears became a senior scientist at Woods Hole and was one of only four women to serve on its board of directors between 1940 and 1970. Sears was widely recognized as the organizing force responsible for the success of the First International Oceanographic Congress held at the United Nations in 1959, a role her Peruvian experience prepared her to play.[61]

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60. *ICAG*, 26; Vogt journal, Isla Chincha Norte, 5 Sept. 1941, Vogt papers, box 3:1.

61. *ICAG*, 26; Margaret W. Rossiter, *Women Scientists in America: Before Affirmative Action, 1940-1972* (Baltimore: Johns Hopkins University Press, 1995), xv, 7, 243, 307, 338, 500 n. 13; Tim Hilchey, "Mary Sears, 92, Oceanographic Editor and Scientist at Woods Hole," *New York Times* 10 Sept. 1997: B7, col. 1; *American Men and Women of Science: Physical and Biological Sciences*, 14th ed. (New York: Jaques Cattel Press, 1979), s.v. "Sears, Mary"; Roger Revelle, "The Oceanographic and How It Grew," in *Oceanography: The Past*, 22; Dael Wolfle, "The 1959 Oceanographic Congress: An Informal History," in *Oceanography: The Past*, 42-48.

More than any other marine scientist recruited by Peru during this era, Sears encountered the inversion of social inequalities that so often happens when scientists travel from North to South across the magical barrier that divides the "core" from the "periphery" of the world of science. Even though she made a major contribution to the development of marine science by almost any standard, the course of her career was always constrained by her gender. Sears's social subordination in the United States likely shaped the fact that she became a planktonologist in the first place, which from an anthropocentric perspective involves tedious microscopic study of the ocean's humblest creatures. It probably played a role in her recruitment to travel to Peru. But Sears saw this trip as a tremendous opportunity, and she always remembered her Peruvian voyage with great fondness for a basic reason: This was the *only* time during her entire career when she was allowed to do science at sea. In fact, she had an entire ship and team of male assistants at her disposal. By one common measure, this was Sears's only chance to be a "real" oceanographer. In the United States, as a woman, she was always forbidden from participating in offshore expeditions. (Oceanography is often defined as the practice of science on ships at sea.) In short, Peru was the one place Sears was treated with the respect her training, experience, and expertise deserved.[62]

Sears's publications just before her trip to Peru included Henry Bryant Bigelow, Lois C. Lillick, and Sears, "Phytoplankton and Planktonic Protozoa of the Offshore Waters of the Gulf of Maine," *Transactions of the American Philosophical Society* 31:3 (1940), 149-237; Sears, "Notes on the Phytoplankton on Georges Bank in 1940," *Journal of Marine Research* 4:3 (1941), 247-257; Sears and G. L. Clarke, "Annual Fluctuations in the Abundance of Marine Zooplankton," *Biological Bulletin* 79:2 (1940), 321-328.

62. Kathleen Broome Williams, *Improbable Warriors: Women Scientists and the U.S. Navy in World War II* (Annapolis, MD: Naval Institute Press, 2001), ch 2, and personal communication.

Nevertheless, Sears's nationality and language skills affected whom she associated with in Peru. Rather than teaming up with Schweigger or some Peruvian scientist, she worked most closely with her compatriots Vogt, Fiedler, Jarvis, and Lobell. Vogt tried to take advantage of his special relationship with Sears to bolster his position regarding CAG's plans to establish a fishmeal industry. Indeed, her plankton studies and preliminary studies of the anchoveta around the Islas Chincha seemed to confirm many of Vogt's assertions. In Sears's view, the distress of the guano birds had a "more immediate cause" than changing environmental conditions: Poor production of surface phytoplankton appeared to have led to the "disappearance" of the adult anchoveta stock in 1941. Significantly, she speculated that lack of phytoplankton had a direct impact on the anchoveta population by preventing the "year class" of fry from coming to sexual maturity, and thereby depressing the availability of food for the guano birds in an absolute sense. At the very least, Sears vindicated Vogt's contention that the entire food chain of the guano birds needed further investigation. But her declarations were never as clear-cut or authoritative as Vogt tried to pretend they were, and her observations and interpretations did not always coincide coincide with his.[63]

Compare the nineteenth-century naturalist Alfred Russel Wallace's experience crossing the North-South divide. During his eight-year trip to the Dutch East Indies, when he independently formulated the theory of evolution by natural selection, Wallace was treated as a gentleman scientist. Back in England, he returned to his low social station--an important reason why Charles Darwin received practically all the credit for this great discovery. See Nancy Leys Stepan, *Picturing Tropical Nature* (Ithaca, NY: Cornell University Press, 2001), ch. 2.

63. Sears, "Qué es el plankton y porqué debemos estudiarlo," trans. Enrique Ávila, *BCAG* 17:12 (Dec. 1941), 459-461; Vogt, *Informe sobre las aves guaneras*, 72-75; Vogt journal, Isla Chincha Norte, 21 Sept. 1941, 29 Oct. 1941, Vogt papers, box 3:1. Sears later published a much more detailed account of her findings in Peru: Sears, "Notes on the Peruvian Coastal Current: I. An Introduction to the Ecology of the Pisco Bay," *Deep-Sea Research* 1:3 (1954), 141-169, trans. by

In short, Sears's plankton research did not resolve this debate directly as CAG's managers hoep it would. However, Sears's prophetic testimony provided a big boost to the technocratic ideal:

> Studying plankton in connection to the anchoveta-guano bird problem . . . is going to have importance on that day when the fishing industry becomes a noted source of income. In this manner, *a comprehension of the various conservation problems can be attained before the problems appear*, and before the overexploitation of these resources determines the ruin or the deterioration of the industry--as has occurred in many European and North American countires. . . . Here in Peru, we can profit by the errors of others, and with a little bit of intelligent foresight avoid similar disasters.[64]

With this statement, Sears provided Peruvian economic planners with an out from the fishmeal controversy. Unlike Vogt, she firmly believed Peru could put its faith in the ability of conservation technocrats. Therefore, CAG could proceed cautiously with its fishmeal industry plans without putting the guano birds in dire jeopardy.

To an extent, even Vogt shared this faith. Although he thought poorly of Peru's existing scientific capabilities, he believed Peruvians could be redeemed with the proper education. To this end, building on his experience training Enrique Ávila, Vogt drafted an elaborate plan to provide Peru with an educational apparatus to train marine scientists. Vogt's program called for the hiring of three-to-six U.S., Peruvian, or Chilean specialists a year over a 15-year period and the purchase of equipment to be used for basic marine research. In the course of their research,

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Ávila under the title "Notas sobre la Corriente Costanera del Perú: I. introducción a la ecología de la Bahía de Pisco," *BCCAG* 1:2 (1954), 133-179.

64. Sears's emphasis; Sears, "Qué es el plankton," 463-464.

these specialists were to train local apprentices. Peru actually implemented a similar plan two decades later.[65]

Vogt believed in the possibilities of a conservation-oriented technocracy, but he would never plead allegiance to the developmental orthodoxy that had provided the reason for hiring technocrats in the first place. CAG's overseers did not welcome his heretical attacks on Peru's national development, and they terminated him with the hope that his less costly Peruvian disciple would show greater patriotic loyalty to their vision of national progress.

Salomon's House Transformed

In the years that followed Vogt and Sears's return to the United States, Erwin Schweigger continued his studies of the ocean environment and fishing practices in Peru with a view toward establishing "intensive" fisheries at several ports along the coast. For example, he tested a number of techniques for the "scientifically based" exploitation of the bonito; he hoped this research would avoid the cost and inefficiency of "empirical fishing." As we shall see in the next chapter, such empirical studies contributed to the successful industrialization of this fishery during the 1940s.[66]

Schweigger also gathered data of unprecedented detail and completeness regarding oceanic conditions off Peru. During his tenure at CAG, he published

65. Untitled manuscript, Vogt papers, box 3:2, folder "Fieldwork--Field Notes--Chincha Islands--Field Notes."

66. Schweigger, "La pesca del 'bonito' por el 'Pacific Queen,'" *BCAG* 20:8-9 (Aug.-Sept. 1944), 257-282, 289-321, quote p. 289; idem, "El dorado frente a la costa peruana," *BCAG* 22 (1946), 267-284; idem, "Pesca en el litoral peruano: Base científica para su incremento," *BSGL* 63:1-2 (1946), 94-102; idem, "El atún frente a la costa peruana," *BCAG* 25:8 (Aug. 1949), 219-247.

over 40 articles based on these observations in Spanish, English, and German.[67] Schweigger also produced four benchmark books on the oceanography of the Peruvian littoral: *Pesquería y oceanografía del Perú y proposiciones para su desarrollo futuro* (1943), *El litoral peruano* (1947), *Atlas de la Corriente Costanera Peruana* (1951), and *Die Westküste Südamerikas im Bereich des Peru-Stroms* (1959). These publications and the "*mapas mensuales*" (monthly summary maps) of oceanic conditions he compiled provided the empirical basis for pioneering papers by foreign scientists on the physical nature of the El Niño phenonmeon.[68] Like Robert Cushman Murphy, Schweigger deserves a great deal of credit for revealing its importance to the larger scientific world; Schweigger also used the Pacific Science Congress to spread knowledge of El Niño.[69] As we shall

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67. Key articles by Schweigger include "Los fenómenos en el mar desde 1925 hasta 1941"; idem, "Las irregularidades en la corriente de Humboldt en los años 1939 a 1941: Una tentativa de su explicación," *BCAG* 18 (1942), 27-42; idem, "La 'legítima' Corriente del Niño," *BCAG* 21:8-9 (Aug.-Sept. 1945), 255-336; idem, "Der Peru-Strom nach zwölfjährigen Beobachtungen," *Erdkunde* 3 (1949), 121-132, 229-241; idem, "Estudio comparativo de temperaturas del mar y el régimen de vientos entre los años 1954 y 1939/53," *BCCAG* 2 (1955), 53-64; idem, "El mar durante el año 1955." *BCAG, suplemento científico* (Lima) 33:7-8 (1957); idem, "Anomalias térmicas en el Oceano Pacífico oriental y su pronóstico," *BSGL* 78:3-4 (1961), 3-50.

68. Pivotal articles on El Niño (and "La Niña") by foreign scientists who relied on Schweigger's work include Martin Rodewald, "Beiträge zur Klimaschwankung im Meere: 10. Beitrag: Die Anomalie der Wassertemperatur und der Zirkulation im Nordpazifischen Ozean und an der Küste Perus im Jahre 1955," *Deutschen Hydrographischen Zeitschrift* 11:2 (1958), 78-82; idem, "Beiträge zur Klimaschwankung im Meere: 11. Beitrag: Die ostpazifische 'Wärmewelle' von 1957/1958," *Deutschen Hydrographischen Zeitschrift* 12:5 (1959), 204-210; idem, "Beiträge zur Klimaschwankung im Meere: 13. Beitrag: Die Asymmetrie im zeilichen Verlauf der Wassertemperatur-Anomalien in Puerto Chicama (Peru)," *Deutsche Hydrographische Zeitschrift* 17:3 (1964), 105-114; Jacob Bjerknes, "'El Niño' Study Based on Analysis of Ocean Surface Temperatures, 1935-57," *Inter-American Tropical Tuna Commission Bulletin* 5:3 (1961); Warren S. Wooster, "El Niño," *California Cooperative Oceanic Fisheries Investigations Reports* 7 (1960), 43-45; idem, "Yearly Changes in the Peru Current," *Limnology and Oceanography* 6:2 (1961), 222-226. Cf. César Caviedes, "El Niño 1972: Its Climatic, Ecological, Human, and Economic Implications," *The Geographical Review* 65:4 (Oct. 1975), 506.

69. Schweigger "Studies of the Peru Coastal Current with Reference to the Extraordinary Summer of 1939," in *Proceedings of the Sixth Pacific Science Congress of the Pacific Science*

see in chapter 8, all this work helped make later scientists a bit overconfident that they understood the vagaries of Peru's marine environment.

Unlike Vogt, Schweigger became a Peruvian citizen. He participated actively in local scientific, intellectual, and political life and eventually organized Peru's first university-based teaching program in oceanography and fishery engineering in 1960. He ended up dying in West Germany in 1965 only because he had been invited there to give a series of conferences and was struck by a sudden, unexpected illness. With all of these accomplishments, it is little wonder that Peruvians now proudly claim this German immigrant as one of their own.[70]

Schweigger could not have accomplished all of this without the help of a growing marine science organization at CAG. Beginning in 1946, CAG's new general manager Carlos Llosa began to plan for this expansion. After a discussion with Ávila, he decided to send Schweigger's former assistant Antonio Landa to the United States to study so he could become CAG's resident anchoveta expert. Llosa hoped to send as many as five "boys" (*muchachos*) to the U.S. for training, and he began to implement plans for a small marine research lab on Pisco Bay. (Illus. 1 shows Ávila and his family on the grounds of this facility.) Note that Llosa's

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Association Held at the University of California, Berkeley, Stanford University, and San Francisco, July 24th to August 12th, 1939 (Berkeley and Los Angeles: University of California Press, 1940), 3:177-195; idem, "Abnormal Summers in the Peruvian Coastal Current," in *Proceedings of the Eighth Pacific Science Congress of the Pacific Science Association, Held at the University of the Philippines, Diliman, Quezon City, 16th to 28th November 1953* (Quezon City: National Research Council of the Philippines, 1955), 3:801-816.

70. Schweigger, "La Facultad de Oceanografía y Pesquería de la Universidad Nacional 'Federico Villarreal,'" in *Memoria del I Seminario Latinoamericano sobre el Océano Pacífico Oriental* (Lima: Universidad Nacional Mayor de San Marcos, 1966), 210-212; Gamarra, "Fallecimiento del Dr. Erwin Schweigger," 4; Marcos Cueto, *Excelencia científica en la periferia*, 207.

language at this stage, despite Mary Sears's example, excluded the possibility of sending "girls" abroad for education. At least for the moment, Llosa ignored the fact that several bright, young Peruvian women such as Aurora Chirinos (de Vildoso) and Norma Chirichigno Fonseca were pursuing professional careers in marine science through the Ministry of Agriculture's new Dirección de Pesquería.[71]

CAG's version of Salomon's House continued to be riven by dissent. Soon after Ávila's return to Peru, he and Schweigger tried on their own, after a long face-to-face discussion, to prevent conflict by clearly defining their fields of specialization and segregating their responsibilities. In 1946, Llosa dashed these plans by installing Luis Gamarra as "coordinator" of all scientific activities at CAG; Schweigger considered quitting rather "than work under the technical orientation of a self-styled pouter pigeon." Two years later, CAG installed Schweigger as the chief of its new Departamento de Oceanografía e Ictiología (signficantly, with no mention of "*ornitología*.") This administrative reshuffling released CAG's marine studies from the meddling of Gamarra, but it also formally subordinated Ávila to his German colleague, thereby enflaming his jealousy toward Schweigger. As we have seen, Ávila believed racism prevented him from receiving equal pay for equal work. Ávila did not consider Schweigger much of an oceanographer, in the holistic sense: "I'm not interested in pure science," Schweigger once admitted to Ávila, "I am first of all a fisherman." Schweigger also had a tendency to talk down to his young Peruvian associate: "Now, Avila,

71. Ávila to Vogt, 2 July 1946, Vogt papers, box 1:1; interviews with Aurora Chirinos de Vildoso and Abelardo Vildoso, Callao, Peru, 11 June 2001.

Don’t make the same mistake that Vogt did [b]ecause you see some emaciated birds . . . . You surely realize by this time that to talk of food scarcity is sheer foolishness.” To top things off, Ávila thought Schweigger was far too careless with empirical data gathering, his supposed strong point, and thus, “a fantastic science faker.” This continuation of the conflict that had divided Schweigger and Vogt contributed to the emergence of a permanent rift between bird and fishery scientists in Peru with far-reaching consequences.[72]

But in the short term, the spectacular success of the guano birds during the early 1950s helped smooth-over many of these cracks in CAG’s technocratic foundation. CAG used some of its record profits to establish three well-equipped marine biology research stations.[73] It staffed them, at first, with young male Peruvians who had received advanced foreign educations paid for, in part, by company scholarships. Enrique Ávila, CAG’s University of Wisconsin-trained ornithologist, managed the station on Isla Don Martín. After Antonio Landa completed an M.A. in ichthyology at Stanford University’s Hopkins Marine Station on Monterey Bay, the center of California’s dying sardine industry, he set up a fishery research station for CAG at Chimbote, the focus of Peru’s own emerging fishing industry. CAG appointed Mario Barreda Oyanguren, a holder of an M.S. in limnology and biology from the University of Michigan and son of the long-time president of the Comité Nacional de Protección a la Naturaleza, as head of its station at Pisco Bay. Thanks to Carlos Barreda and Enrique Ávila’s influence,

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72. Ávila to Vogt, 12 Dec. 1945, 24 Jan. 1946, 7 Oct. 1946, 19 Dec. 1946, 23 Mar. 1948, 26 Apr. 1948, 6 Apr. 1949, Vogt papers, box 1:1.

73. See app. 4.

provincial origin began changing from a liability to a real social advantage, at least where becoming a marine scientist was concerned. All three of these young men were natives of Puno on the shores of Lake Titicaca. Ávila's successor Rómulo Jordán was a native of Cuzco. Curiously, much of Peru's first generation of professional marine scientists was born in the high Andes.

Like its foreign advisors, CAG's scientific staff was not limited to "lords" of guano. At Chimbote, Blanca Rojas (de Mendiola) served as Landa's assistant. When he left CAG to take a better-paying job with the Inter-American Tropical Tuna Commission, Rojas replaced him as station chief, while another woman, Obla Paliza (de Clark), took over as Rojas's assistant. Like Sears, Rojas specialized in planktonology. Rojas and Paliza, along with Chirichigno, Chirinos, and several other Peruvian women all eventually had successful scientific careers at the Instituto del Mar del Perú (IMARPE), the national oceanographic institute that replaced CAG's marine science endeavors.[74]

Even though CAG could never get its fishmeal plant into operation, it did get something valuable from the project. It used the *Pacific Queen* during the 1940s as an experimental bonito trawler, a provisioning craft, and even as a tugboat. In 1950, CAG turned over control of the *Pacific Queen* to its scientists who coverted it into the first civilian Peruvian vessel devoted solely to oceanographic research. They equipped it with a "Fishfinder" echosonograph and helped introduce this valuable technology to the Peruvian fishing industry. Finally,

74. *BCNPN* 10:2 (1953), 53-55; *BCCAG* 1:1, 1:2, 2 (1953-1955), cover; interviews with Aurora Chirinos de Vildoso and Abelardo Vildoso, Callao, Peru, 11 June 2001.

CAG in 1953 initiated publication of Peru's first, independent marine science journal, the *Boletín científico de la Compañía Administradora del Guano*.[75]

Thus, the technocratic drive to manage production from Peru's marine environment gained momentum during the late 1940s and early 1950s. Even though CAG's attempts to manage the sea lion hunt, control artisanal fishing, and initiate a fishmeal industry all fell short, CAG's managers never gave up their dreams of comprehensive control of Peru's marine ecosystem. Meanwhile, they used the growing wealth produced by CAG's bird management policies to build an elaborate marine science apparatus. The institution of this real-life version of Salomon's House was one of CAG's greatest accomplishments as an experiment in environmental management.

These Lords of Guano hoped to use science, not only to extend their ability to manipulate Peru's marine environment for human benefit, but to make an unassailable case that CAG deserved technocratic authority over Peru's fishing industry. This ambition set the stage for conflict with the arrival of the Peruvian fishmeal boom of the 1950s. The unprecedented growth--and abrupt collapse--of the guano bird population, meanwhile, raised the stakes for this conflict much higher. As we have seen, CAG's scientific cadre worked for a house divided against itself on many levels. As a consequence, in the end, scientists proved not only unable, but *unwilling* to prevent the collapse of the structure that the Lords of Guano had so carefully built.

75. *MCAG* 35 (1944), 51-52; *MCAG* 40 (1949), xxxiv; *MCAG* 42 (1951), vii; *MCAG* 46 (1955), xviii.

Chapter 7

Engineering the Fishmeal Boom

The National Fishing Industry always has been and always will be disposed to heed any fishing regulation that is the fruit of scientific studies.
--Arturo Madueño (1954)

The Lords of Guano did not act as diehard opponents of fishery development in Peru, as many later observers have come to believe.[1] From the Compañia Administradora del Guano's foundation, its managers and scientists acted as outspoken advocates for the industrial exploitation of Peru's marine creatures as long as it followed the dictates of marine science. They even tried to establish a fishmeal industry of their own. In fact, CAG provided a necessary jump-start to industrialized fishing in Peru by importing vital expertise, technology, and know-how. The North American Fishery Mission of 1941 and the circumstances of World War II provided a crucial missing factor: an opening to a foreign market. This led directly to the institution of a small export fishing industry to supply food to Allied Forces. Conservation technocrats set in motion a process of epochal importance for more than just Peruvians and their marine environment. They presided over the birth, development, near death (and eventual revival) of the largest industrial fishery on earth.

1. Pablo Macera, the twentieth-century guano industry's only other significant historian, argues inexplicably that CAG neglected fishery development before World War II, failed to listen to its scientists out of "political conservatism" and institutional laziness, and then failed to act vigorously against the rise of the Peruvian fishmeal industry; "El guano y la agricultura de exportación," 455-456, 483.

In many ways, the spectacular growth of the Peruvian fishmeal industry was one of the great industrialization success stories of the twentieth century. It became a model for fishery development all over the world. Yet despite what many Peruvian nationalists and entrepreneurs--and not a few economists and historians--have argued, industrialists should not take sole credit for this creation, nor blame Yankee imperialism or state intervention for its shortcomings. This admirable achievement was not the predetermined result of technological progress or a natural stage in Peru's modernization that took place once Peru's ruling aristocrats had left behind the "traditional" mentalities of their "feudal" past so Peru could finally exploit its rich "factor endowments." Nor was its emergence the unplanned result of "muddling through" the rapidly changing circumstances of the post-war world.[2] The Peruvian fishmeal boom happened by design.

The new captains of the Peruvian fishing industry, several of whom were trained technicians, made sure that experts continued to influence this process. From the beginning, these entrepreneurs promoted and paid for the organization of an elaborate scientific apparatus to regulate their endeavors. They repeatedly promised to follow its dictates--at least as long as they corresponded with their interests. Of course, there lay the rub. Different parts of the fishing industry had different wants and needs. In accord with the technocratic ideal, Peru's besieged

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2. These opinions, in a variety of forms, pervade the literature on the development of the Peruvian fishmeal industry, whether Peruvian or foreign: Caravedo, *Estado, pesca y burguesía*; McEvoy, *The Fisherman's Problem*, 192, 209, 217-218; Abramovich, *La industria pesquera en el Perú*; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry"; Vázquez, "Economic Cycle, Migration, and Employment"; Ludwig Meier Cornejo, *El futuro de la pesquería: Corrigiendo los errores del pasado* (Lima: Sociedad Nacional de la Pesquería, 1990); Michael Roemer, *Fishing for Growth: Export-led Development in Peru, 1950-1967* (Cambridge, MA: Harvard University Press, 1970).

and rapidly changing ruling class thought experts would be able to come up with the “one right answer” that would benefit most everyone with a vested interest--if only the right kind of experts studied Peru’s problems long and hard enough. This belief was a tremendous boon to marine science research in the southeastern Pacific, and a lasting legacy of the Lords of Guano.

This is not the place to tell the full story of the rise and fall of Peru’s fishmeal industry, nor of the technocrats who managed it. Instead, this and the final chapter will explain how the fates of the guano industry, the anchoveta’s avian predators, Big Oceanographic Science, and a vast, new industrial regime were tied together politically and ecologically.

Peru’s First Fishing Boom and the Law of the Sea

After the visit of the North American Fishery Mission in 1941, industrialized fishing in Peru finally took off, at first to provide vitamin-rich fish livers and protein to a war-torn world. Hostilities cut off the international supply of preserved fish and fish liver oils from two of the world’s largest producers, Japan and Norway. Beginning in 1942, a handful of Peruvian petty capitalists started exporting fish livers cut from the bonito (*Sarda chilensis*). At first, they discarded everything but the fish livers, but they soon acquired an export market in the Northern Hemisphere for barrel-salted bonito (see table 7). Meanwhile, the Banco Popular, an institution controlled by President Manuel Prado’s family, lent capital to a consortium led by a Peruvian physician to build three plants to can and sell bonito as “tuna” to the Allied forces and U.S. consumers. Prado’s government also played a direct role in these developments: Following the recommendations of the North American Fishery Mission (and rejecting CAG's desire to monopolize control over marine production in Peru), it created the Dirección de Pesquería y Caza (Fishing and Hunting Directorate) under the new Ministry of Agriculture in July 1943 to provide scientific and technical assistance to this nascent industry. In short order, officials from this new state bureaucracy negotiated a trading relationship that removed all duties and tariffs from Peruvian fish exports to the United States. Clearly, the Peruvian state played a crucial role in the success of these early endeavors. The frequently repeated assertion by fishing industry partisans that their success was simply "a healthy result of private enterprise . . . developed without economic aid" is a fiction.[3]

By the end of the war, there were 12 companies operating 23 canneries with installed equipment valued at S/.15 million (US$2.3 million) in Peru, despite logistical difficulties importing fishing and canning gear. These obstacles to technology transfer forced this nascent industry to depend almost entirely on existing artisanal producers for their catch--an indication that lack of a market, rather than lack of a progressive mentality among Peru's fisherfolk, had been the real barrier to past expansion. The entrepreneurs profiting from this burst included just one major foreign firm, Wilbur-Ellis Peruana (est. 1944), a subsidiary of the San Francisco fishing company. Wilbur-Ellis was of crucial importance, however, because it supplied materials needed for canning and served as the major U.S. distributor of Peruvian bonito. It also sent a series of industrial engineers from the

3. Tarnawiecki, "A Survey of the Development of Oceanic Fisheries in Peru," 130.

United States to oversee these developments, and they provided vital know-how that smoothed the transfer of a series of new technologies from North to South. Two of CAG's biggest beneficiaries, the Gildemeister juggernaut and a Chancay-valley cotton planter, bought stakes in Peru's first fishing boom soon after the war, as did the brothers of President Prado and his successor José Bustamante. In 1945, these industrialists established a committee under the Sociedad Nacional de Industrias, a relic of the Aristocratic Republic, to defend their political interests formally before the Peruvian state.[4]

Like agro-exporters during CAG's early years, fishery industrialists counted a scientist-technician among their staunchest, most outspoken allies. The fishery engineer Enrique M. del Solar Cáceda played a leading role in the organization of this industry as a technician, ideologue, and investor (illus. 40). His career in many ways paralleled that of agronomists José Antonio de Lavalle y García and Gerardo Klinge. Del Solar's family owned a hacienda in the Pisco Valley, but its fortunes were on the wane. He started his career as a salesman for Enrique Ferreyros & Co., a family that built an enormous fortune selling agricultural machinery to Peru's agro-exporters. Del Solar was the son of a minor lord of the Aristocratic Republic.

During the 1930s, in order to strengthen cultural and economic links between the two countries, the Japanese government offered scholarships to young Peruvians who wanted to study science and engineering. Japan was one of the

4. Ibid., 135; Caravedo, *Estado, pesca y burguesía*, 23, 26-27, 35, 92-93; Thorp and Bertram, *Peru, 1890-1977*, 180-181; Belaúnde, *La legislación pesquera en el Perú*, 229; *Peru: Obra de gobierno del presidente de la República Dr. Manuel Prado*, 99; Fiedler, Jarvis, and Lobell, "The Peruvian Fisheries," *The Geographical Review* 34:1 (Jan. 1944), 118; Abramovich, *La industria pesquera en el Perú*, 16-18; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 12; cf. Portocarrero, *El Imperio Prado*, 129-170.

world's fastest rising scientific and industrial powers, but few sons of Peru's Eurocentric elite showed even the slightest interest in studying in the homeland of a reviled minority in Peru. Nevertheless, two daring young students seized this opportunity: Rafael Dávila Cuevas, the Lima-born son of migrants from the highland city of Huancayo, to study geophysics, and del Solar to study fishery engineering (with hopes of eventually starting a fishing business). Dávila eventually moved on to Southern California where he studied with Jacob Bjerknes and Harald Sverdrup, founders of the Bergen school of physics-based meteorology and oceanography, in UCLA's crash wartime meteorology course; he eventually founded the modern meteorological profession in Peru. Enrique del Solar preferred to return home where he took positions with the Ministry of Development and Peruvian Fishery Commission. He was Peru's first native-born fishery scientist.[5]

Del Solar worked alongside Schweigger and the North American Fishery Mission aboard the *Pacific Queen* during most of 1941. They made a curious bunch in the tense political climate of the times. Based on this fieldwork, del Solar

5. Interview with Alfonso del Solar, Lima, Peru, 13 June 2001; E. R. Headrick to M. de Freyre y Santander, 17 Mar. 1942, Office of Chancellor, Administrative Files, Department of Physics, Meteorology Program, University of California, Los Angeles, University Archive, record ser. 359, box 136,/folder 2; *MCAG* 30 (1942), 67; Ernesto More, *Reportajes con radar* (Lima: Librería e Imprenta Minerva, 1960), 405-411. On the Bergen school, see Robert Marc Friedman, *Appropriating the Weather: Vilhelm Bjerkness and the Construction of a Modern Meteorology* (Ithaca, NY: Cornell University Press, 1989); Deborah Day, "Bergen West: Or How Four Scandanavian Geophysicists Found a Home in the New World," *Historisch-Meereskundliches Jahrbuch* 7 (1999). On Japan's growing scientific and technical prowess, see Tsutsui, *Manufacturing Ideology*, esp. ch. 2; James R. Bartholomew, *The Formation of Science in Japan: Building a Research Tradition* (New Haven, CT: Yale University Press, 1989); T. Wayland Vaughan listed 18 separate marine science research institutions active in Japan in the mid-1930s, compared to 43 for the United States, in *International Aspects of Oceanography: Oceanographic Data and Provisions for Oceanographic Research* (Washington, DC: National Academy of Sciences, 1937).

wrote an article on the ecology of the anchoveta and other economic fish species intended to provide baseline data for their "future industrial exploitation." In this article, he concluded that the "tropicalization" of coastal waters during the 1941 El Niño had caused the anchoveta to change their normal habits, which put them out of reach of the guano birds and led to the birds' "extraordinary" death. His observation that fish life flourished even during this "ecological depression" established the basis for his later opinion that the guano industry was moribund as a source of new wealth, while the fishing industry could be the fountainhead of untold riches. Like Lavalle, del Solar was an outspoken advocate for technocractic industrialization: "In fishing, *as in agronomy*, to obtain success it is indispensible that practical knowledge be subject to technicians."[6] In this spirit, he pushed for the establishment of a government Dirección de Pesquería y Caza and a biology program to train fishery scientists at the Universidad Nacional de San Marcos. As we saw in chapter 4, this led to the hiring of Hans-Wilhelm Koepcke, the German founder of university-based marine science education in Peru.

Del Solar's interest in the success of the Peruvian fishing industry was more than technical. He played an important role in the political organization of fishing industrialists, and with financial help from some old contacts in Japan, in 1953 he established a fish-products factory of his own. From the very beginning of industrialized fishing in Peru, del Solar was its foremost scientific defender. In line with his faith in the technocratic ideal, he steadfastly believed that his expert

6. Enrique M. del Solar C., "Ensayo sobre la ecología de la anchoveta," *BCAG* 18:1 (Jan. 1942), 3-7, 19, emphasis added.

training and technical understanding prevented his economic and political interests from compromising his expert authority. He continued to publish scientific articles--usually based on research voyages he paid for out of his own pocket--to aid the development of new fish resources and bolster his reputation as a scientist.[7]

The end of World War II freed shipping on the high seas which allowed Peruvian entrepreneurs to import ships and capital goods, especially from California, for its booming canning industry. Peruvian fishing exports increased markedly in 1946 to serve pent-up worldwide demand. They dropped just as quickly when Japan, Norway, West Germany, and other war-torn countries resumed fish production with aid from the United States. Peru's market for salted fish and fish livers dried up almost overnight. Fortunately for investors in Peru's new canning industry, their market did not disappear so readily. Nevertheless, rapidly changing commercial conditions after the war threatened a major shakeout among these new fishing concerns.[8]

Peru's fishing entrepreneurs had other reasons to feel anxious. The end of the war enabled long-distance fishing fleets to again set their sights on the productive waters off the coast of Peru. As early as 1936, the Van Camp Sea Food Co. of California had approached the Peruvian government for permission to enter Peru's three-mile territorial sea so its tuna clippers could catch anchoveta to use as

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7. Vegas Vélez, "La investigación oceanográfica en el Perú desde Humboldt a nuestros días," 146; Caravedo, *Estado, pesca y burguesía*, 23, 35; interview with Alfonso del Solar, 13 June 2001; Del Solar, "Adenda al catálogo de crustaceos del Perú," *Inf.Inst.Mar Perú* 38 (1972); del Solar, Jorge Sánchez R., and Alvaro Piazza L., "Exploracion de las areas de abundancia de merluza (*Merluccius gayi peruanus*) en la costa peruana a bordo del 'Bettina,'" *Inf.Inst.Mar Perú* 8 (1965).

8. See table 7; Tarnawiecki, "A Survey of the Development of Oceanic Fisheries in Peru," 129, 135.

bait. At that time, Francisco Ballén enunciated what eventually became CAG's party line, first for foreign fishing boats, than for industrialized fishing in general:

> In Peru, the exercise of fishing is intimately tied to the guano industry and the abundance of certain fish, especially the anchoveta . . . . Every method of fishing on a grand scale along the coast would thus be plainly inadvisable, all the more so taking into consideration that it will be impossible to exercise effective control over the fishing methods put into practice. It is also worth taking into consideration . . . that the fish obtained will be exported. The meager duties this firm offers will not compensate in the least for this waste.[9]

Peru was not the only country with such fears. Under intense pressure from U.S. oil and fishing companies who wanted to protect their offshore assets, in 1945 President Harry S. Truman unilaterally issued two proclamations claiming the "natural resources of the subsoil and sea bed of the continental shelf beneath the high seas but contiguous to the coasts as appertaining to the United States" and the right to establish fishery "conservation zones . . . subject to the regulation and control of the United States" beyond the traditional territorial sea. Mexico and Argentina soon made similar proclamations. But such claims made little sense for the extremely narrow continental shelf lining most of the Pacific coast of South America. Therefore, in 1947, first Chile, then Peru declared Exclusive Economic Zones (EEZs) extending 200 nautical miles (370.4 kilometers) from their coasts. In 1949, several Arab states claimed similar territorial rights to the petroleum and other resources located in the "submerged lands" extending from their shorelines. In 1952, Ecuador joined its two neighbors to the south by claiming a 200-mile EEZ and signing the Santiago Declaration on the Maritime Zone. It stated that "the

9. *MCAG* 28 (1937), 183-184.

geological and biological factors that condition the existence, conservation, and development of . . . maritime flora and fauna" had made "the ancient extention of the territorial sea . . . insufficient for the conservation, development, and exploitation of these riches to which adjacent coastal countries have a right."[10]

These moves backfired at first for Peru's fishing industry. The United States responded in a quite unneighborly way toward these declarations. The U.S. Congress passed retaliatory tariffs against Peruvian fish products in 1948, and the U.S. Food and Drug Administration conveniently banned the sale of bonito as "tuna" in 1949 based on the dubious scientific claim that these were entirely different classes of fish. (Peruvian fishery biologists love recounting stories of tricking U.S. technicians with taste tests and tissue samples comparing bonito with other tunnids. Their flesh is indistinguishable in practice, even under a microscope.) The Truman administration withdrew its own Fisheries Proclamation once its chaotic implications for international law became clear, but the United States could not close this Pandora's box.[11]

From the beginning, Peru carefully worded and defended these declarations using the rhetoric of conservation science. CAG's marine scientists jumped to the

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10. Quoted in Eduardo Ferrero Costa, "Evolución del derecho del mar," *Revista del Instituto de Estudios Histórico-Marítimos del Perú* (Lima) 3 (1980), 79; David C. Loring, "The Fisheries Dispute," in *U.S. Foreign Policy and Peru*, ed. Daniel A. Sharp (Austin: University of Texas Press, 1972), 62-67, 115-118; S. N. Nandan, "The Exclusive Economic Zone: A Historical Perspective," in *The Law and the Sea: Essays in Memory of Jean Carroz* (Rome: FAO, 1987), 171-188; D. P. O'Connell, *The International Law of the Sea* (Oxford: Clarendon Press, 1982), 1:552-558; McEvoy, *The Fisherman's Problem*, 192; see also Bobbie B. Smetherman and Robert M. Smetherman, *Territorial Seas and Inter-American Relations: With Case Studies of the Peruvian and U.S. Fishing Industries* (New York: Praeger, 1974).

11. Loring, 67-69; Caravedo, *Estado, pesca y burguesía*, 33; Roemer, *Fishing for Growth*, 80; interview with Aurora Chirinos de Vildoso, 11 June 2001.

defense of the 200-mile EEZ. Schweigger's estimate that the productive "green zone" of the Peru Current extended a maximum of 200-250 miles offshore provided a basic ecological rationale. At the First Latin American Congress on Marine Biology held in Chile in 1949, Enrique Ávila presented a paper on the biological and economic importance of South America's coastal waters. In direct response, this congress of scientists from eight countries voted unanimously to recommend the protection of anchoveta stocks from all exploitation (in order to protect Peru's guano birds) and the extension of jurisdictional waters up to 200 miles by all Latin American states. In this context, Ávila also introduced the neologism *bioma* (biome) to regional discourse to refer to the unique community of organisms typical of Schweigger's "green zone." These debates played into CAG's decision to extend its marine science capabilities during the early 1950s. CAG's scientific work provided the basis for what became known as the "biome" or "ecosystem" defense of the 200-mile EEZ.[12]

This battle of words and principles over the EEZ soon degenerated into a battle of blows. In 1947, the Peruvian navy seized its first U.S. tuna clipper for violating the EEZ. Late in 1954, Aristotle Onassis sent a whaling fleet from Hamburg explicitly to challenge the Peruvian 200-mile limit. After a lengthy game of cat and mouse, the Peruvian navy triumphantly seized five ships, the remains of 3,000 whales, and forced Onassis to pay a US$3 million fine. Buoyed by the defeat of this Goliath of international shipping and the nationalist frenzy it provoked, the

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12. Schweigger, *El litoral peruano*, 70-72; Ávila to Vogt, 18 July 1947, 16 Sept. 1949, 25 Oct. 1949, Vogt papers, box 1:1; Loring, "The Fisheries Dispute," 72, 86-87.

navy began to seize and fine U.S. tuna trawlers for violating the zone in search of CAG's sacred anchoveta with which to bait their hooks.[13]

International technocrats scrambled to find a rational solution to this conflict through a series of technical conferences. Peru refused to join the Inter-American Tropical Tuna Commission, a scientific research body established by the U.S. tuna industry and Latin American client states ostensibly to provide a technocratic regulatory apparatus for tuna fishing in the eastern tropical Pacific. Active hostilities off the coast of Peru came to a halt, for the time being, in 1956 when the American Tunaboat Association privately negotiated a licensing agreement in which Peru promised to use all licensing income for public marine science research. This agreement collapsed in the early 1960s, however, when tuna fishermen switched from long-line fishing (which requires bait) to drift nets as part of their never-ending quest for new fishing frontiers. From 1947 until 1974, the Pacific Tuna War, as this confrontation is known, resulted in the seizure of more than 250 ships belonging to the U.S. tuna industry and the payment of over US$6 million in fines to Ecuador, Peru, and four other Latin American states.[14]

Peru and its allies never backed down from their defense of the 200-mile territorial sea, even though this position hurt the export market for Peru's canning industry. Global opinion gradually turned in their favor, especially during the 1970s as more and more countries became embroiled in fishing wars of their own.

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13. Loring, "The Fisheries Dispute," 70-72.

14. *MCAG* 47 (1956), xviii; Loring, "The Fisheries Dispute," 72-73; Thomas Wolff, *In Pursuit of Tuna: The Expansion of a Fishing Industry and its International Ramifications: The End of an Era* (Tempe: Center for Latin American Studies, Arizona State University, 1980), esp. 53-54, 118.

Finally in 1982, after a decade of intense negotiations involving diplomats and technocrats from more than 150 countries, the Third United Nations Conference on the Law of the Sea adopted a 320-article convention designed to replace this chaotic situtation with the rule of international law. This convention enabled any coastal state to declare an Exclusive Economic Zone out to a maximum distance of 200 nautical miles. Thus, Peru and Chile's declaration became the arbitrary norm for divvying up 35 percent of the world's oceans. Though this new standard was intended to encourage environmental conservation, it was entirely devoid of the ecological significance CAG and its scientists had once tried to give it. It was also devoid of real authority: by the end of 1998, the International Year of the Ocean, 130 states had ratified this UN convention, but still not Peru and Chile's two main rivals for fishing preeminence in the Western Hemisphere: Canada (which declared a 200-mile EEZ of its own in 1977) and the Colossus of the North, the United States.[15]

This agreement demonstrates, yet again, the tremendous influence "peripheral" Third World countries have had on global environmental politics during the twentieth century. This controversy over the Exclusive Economic Zone had much in common with Peru's conflict over guano with the Peruvian Corporation of London during the 1910s. In both cases, Peruvian officials used universalizing scientific rhetoric and research to defend local, export-oriented

15. United Nations, General Assembly, *Final Act of the Third Conference on the Law of the Sea* (Montego Bay, Jamaica, Dec. 1982); World Commission on Environment and Development, *Our Common Future* (New York: Oxford University Press, 1987), 272-274, 287 n. 17; Barry Hart Dubner, *Recent Developments in the International Law of the Sea*, 33 The International Lawyer 627 (Summer 1999), [cited 11 Oct. 2000], available from http://web.lexis-nexis.com/universe/.

interests in the name of resource conservation. Nearly all the conflicting parties accepted the premise, at least rhetorically, that scientific knowledge should resolve these conflicts. Though marine science failed to resolve either disagreement, both controversies acted as a tremendous boon for the technocratic ideal in Peru. In neither case was the Peruvian economy as open to "imperialist penetration" as it has often been portrayed.[16]

Nevertheless, Peruvians' nationalistic resolve regarding the Law of the Sea had much to do with their perceived economic weakness. While Peru engaged in these diplomatic conflicts, the international competitive environment for Peruvian fish exporters deteriorated markedly. By 1948, when total world fish production had almost returned to prewar levels, Japan had reemerged as the world's largest fish-producing nation thanks to extensive economic aid and trading preferences granted by the United States after the war. Even then, Japan's production still fell far short of prewar levels. But Canadian, British, and Norwegian companies all sharply increased their levels of production to make up for Japan's shortfall. Struggling Peruvian entrepreneurs were increasingly locked out of the global market for preserved fish by both competition and discriminatory tariffs. Only an aggressive advertising campaign by Wilbur-Ellis that pitted Peruvian bonito against Van Camp Seafood's "Chicken of the Sea" and other tuna brands on the shelves of

16. Peru has often been held up as "the example par excellence in Latin America of that dream of orthodox development economists," a free and open economy ruled by a laissez-faire political economy: see Thorp and Bertram, *Peru, 1890-1977*, pt. 4, esp. 205-206; Cotler, *Clases, estado, y nación*, ch. 6.

the United States' new suburban supermarkets kept the Peruvian canning industry from going belly up in the early 1950s.[17]

By the end of 1953, because of intense international pressure to install new machinery to produce a higher quality product and declining market share, Peruvian fish canners began suffering from many of the same problems of overcapitalization that later beset the fishmeal industry. Almost all of Peru's 50 coastal canneries and 630 motorized fishing craft (mostly purse seine vessels [*bolicheras*] imported from the United States like the *Pacific Queen*) operated far below capacity, and many were completely inactive. Meanwhile, hundreds of small craft were forced out of fishing altogether by this boom-bust cycle, leading thousands of male artisanal fishermen to become wage workers--and now face unemployment. The expected rise in domestic fish consumption long predicted by the ideologues of fishery industrialization had not materialized: Peruvians only purchased a paltry nine percent of domestic canned-fish production, although this did substitute for what Peruvians had imported before the war. In an attempt to diversify their holdings, fishing entrepreneurs in Peru built several large-capacity refrigeration plants to freeze and pack whole tuna, swordfish, and shrimp. The Peruvian state, meanwhile, did its part to encourage production and domestic consumption by building modern market terminals in Callao and Lima and by vigorously defending Peru's Exclusive Economic Zone. Exports of whole frozen fish briefly surpassed canned fish, but then rapidly tailed off. This sector was also

17. See table 7; Tarnawiecki, "A Survey of the Development of Oceanic Fisheries in Peru," 130; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 12.

unevenly capitalized: The 19 refrigerated boats registered in Peru had a capacity 40 percent larger than the freezing capacity of local plants, not to mention the problem of finding refrigerated transport abroad. These woes--underutilization of equipment capacity, dependence on imported technology, flacid local markets--typified those facing industrialists in the so-called developing world. Economic barriers, not lack of entrepreneurialism, expertise, or state support, led to the failure of Peru's original food fish industry.[18]

Profit-hungry industrialists did have one thing in their favor: an unorganized, low-paid, predominantly female pool of factory labor. (As in the California industry, on which it was modeled, Peruvian canneries employed men only as technicians and managers.) But workers are only cheap if they produce something with a signficiant added value that their bosses can sell at a profit. Peru's first fishing boom had gone bust.[19]

Chicken from the Sea

Peru's fishery industrialists were always on the lookout for a new export opportunity. In the late 1940s they found it--fishmeal. Even though CAG held a monopoly over the production of fishmeal from anchoveta to protect the guano birds, nothing prohibited the production of fishmeal in Peru from other sources. In

18. Tarnawiecki, "A Survey of the Development of Oceanic Fisheries in Peru," 129-131; Fiedler, Jarvis, and Lobell, *The Fisheries and the Fishery Industries of Peru*, 53-55; Caravedo, *Estado, pesca y burguesía*, 39-41. Cf. Stephen Haber, *Industry and Underdevelopment: The Industrialization of Mexico, 1890-1940* (Stanford, CA: Stanford University Press, 1991), passim; Warren Dean, *The Industrialization of São Paulo, 1880-1945* (Austin: University of Texas Press, 1969), ch. 7.

19. Caravedo, *Estado, pesca y burguesía*, 39-41, 55.

1945, Peruvian fish canners began manufacturing fishmeal on a significant scale from spoiled bonito and canning waste; two years later, they started exporting it. Meanwhile, an "unnatural disaster" in the Northern Hemisphere created an uncommon opportunity for Peruvian entrepreneurs. Overfishing and climate change caused the California sardine industry, one of the world's largest fishmeal producers, to collapse. Despite elaborate attempts to manage the catch scientifically, total production of sardines crashed from 503,299 metric tons in 1944-1945 to 4,074 metric tons in 1953-1954 and never recovered. U.S. firms like Wilbur-Ellis suddenly had a mountain of surplus industrial machinery that they offered to enterprising Peruvians at bargain prices.[20]

But this supply-side market opening cannot explain how the Peruvian fishmeal industry grew to be ten times larger than the California industry it replaced. The growth of a global meat industry is one of the hallmarks of the ecological history of the late twentieth century (table 8).[21] On the demand side, the size and prosperity of human populations in the First World who wanted to indulge their taste for inexpensive meat grew rapidly after the lean years of World War II. This put the United States and future European Union way ahead of the rest of the world in terms of meat production and consumption in 1961 (except for a few countries with large herding economies such as Argentina, Australia, Mongolia,

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20. Tarnawiecki, "A Survey of the Development of Oceanic Fisheries in Peru," 129-131; Roemer, *Fishing for Growth*, 61. On the rise and fall of the California sardine industry and the role of scientists and bureaucrats in this process, see McEvoy, *The Fisherman's Problem*, ch. 6, 7, esp. pp. 146-147.

21. Inexplicably, J. R. McNeil entirely omits this undeniably new and important trend in global ecological history from *Something New under the Sun*; see esp. ch. 7, "The Biosphere: Eat and Be Eaten."

and Somalia). Since then, global meat production has more than tripled, per capita consumption nearly doubled, and the global meat trade has grown by almost seven times.

Contrary to the predictions of catastrophists like William Vogt, in recent years some "developing" countries have helped drive this trend in meat consumption. Aided by its status as a major soybean producer, Brazil has rapidly emerged since the 1970s as one of the world's largest meat producers and exporters. Per capita, Brazilians today eat three times as much meat as they did in the early 1960s. But the Chinese have changed their eating habits the most of all. Since the "Three Bad Years" of 1959-1961 killed 30 million people, the worst famine in history, meat consumption by the denizens of the world's most populous nation has increased by over 25 times. The Chinese now eat almost as much meat per capita as the European Union and United States, and they consume significantly more animal fat, practically all of which is produced within China's own borders. Thanks to such dense sources of food energy, the average citizen in these countries now consumes more than 2,900 calories per day making these the fattest human societies in the history of the earth.[22]

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22. American Association for the Advancement of Science, *AAAS Atlas of Population and Environment*, by Paul Harrison and Fred Pearce (Berkeley and Los Angeles: University of California Press, 2001), 55-62; *Fat*, dir. Antony Thomas, 54 min., PBS Video, 1998, videocassette. For contrasting opinions on China's mythic "food insecurity," see James Z. Lee and Wang Feng, *One Quarter of Humanity: Malthusian Mythology and Chinese Realities, 1700-2000* (Cambridge, MA: Harvard University Press, 1999); Vaclav Smil, *China's Environmental Crisis: An Inquiry into the Limits of National Development* (Armonk, NY: M. E. Sharpe, 1993), esp. ch. 6; Lester R. Brown, *Who Will Feed China?: Wake-Up Call for a Small Planet* (New York: W. W. Norton, 1995).

Of course, as Josué de Castro would be sure to point out if he were alive, national accounts tell us nothing of the enormous internal social inequality and shameful malnutrition that continue to beset rich countries like Brazil and the United States. But they do reveal some striking regional inequalities: Peruvians and Sub-Saharan Africans consume nearly the same amount of meat per capita that they did decades ago--and not by choice. In the meantime, peoples of the African Sahel have replaced Indians and Chinese as mass-media symbols of hunger and misery.[23]

Advocates of the "hamburger thesis" blame this worsening inequity, in part, on the systematic elimination of the world's tropical rainforests to create pasture for cattle and provide cheap beef to the global fast-food industry. Though there is a connection between cattle raising and tropical deforestation (tied mainly to land claims, at least in Amazonia and Central America), this has almost nothing to do with the vast global trade in "modern meat."[24] Unlike the days when beef cattle,

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23. On hunger and social inequality in northeastern Brazil and the United States, see Nancy Scheper-Hughes, *Death without Weeping: The Violence of Everyday Life in Brazil* (Berkeley and Los Angeles: University of California Press, 1992); Barbara Ehrenreich, *Nickel and Dimed: On (Not) Getting by in America* (New York: Metropolitan Books, 2001). For a general introduction to these issues, see David Arnold, *Famine: Social Crisis and Historical Change* (Oxford, UK: Blackwell, 1988); Vaclav Smil, *Feeding the World: A Challenge for the Twenty-First Century* (Cambridge, MA: MIT Press, 2000).

24. On the hamburger thesis, see Marc Edelman, "Rethinking the Hamburger Thesis: Deforestation and the Crisis of Central America's Beef Exports," in *The Social Causes of Environmental Destruction in Latin America*, ed. Michael Painter and William H. Durham (Ann Arbor: University of Michigan Press, 1995), 25-62; idem, *The Logic of the Latifundio: The Large Estates of Northwestern Costa Rica since the Late Nineteenth Century* (Stanford, CA: Stanford University Press, 1992); Susana Hecht and Alexander Cockburn, *The Fate of the Forest: Developers, Destroyers and Defenders of the Amazon* (New York: Verso, 1990). Noteworthy defenders of the hamburger thesis include Norman Myers, "The Hamburger Connection: How Central America's Forests Become North America's Hamburgers," *Ambio* 10:1 (1981), 3-8; the anti-McDonald's website McSpotlight, "Beyond Beef," [cited 13 Oct. 2002], available from http://www.mcspotlight.org/media/reports/beyond.html. See also Jeremy Rifkin, *Beyond Beef: The*

fed on the grand expanses of the Argentine pampas, U.S. Great Plains, and Australian Outback, were the lifeblood of the global meat trade, the post-World War II expansion in the global meat supply has been driven primarily by industrial production of pigs and fowl (table 9).[25] While world cattle production remained relatively stagnant, the number of chickens slaughtered each year has increased by over six times and the global trade in live chickens by over 15 times. Chickens alone account for 41.3 billion of the 47.7 billion animals killed for human and pet consumption each year, though they are still surpassed in terms of total weight by the annual global slaughter of over one billion pigs.

Rather than simply raising more hogs and chickens or focusing on the efficient use of land and labor, agro-industrialists in search of greater profits have looked to increase the intensity of animal production by directly manipulating the biology of livestock. To accomplish this, they engaged the world's increasingly vast technoscience complex to research and develop the "Chicken of Tomorrow" and other super-animals. Advances in nutrition, breeding, disease management, and other forms of environmental control--such as burning off the beaks of chickens so they cannot peck at themselves or each other in crowded enclosures--has allowed meat producers to increase dramatically the efficiency of their operations. (At least so far, genetic engineering of animals has had little to do with

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Rise and Fall of the Cattle Culture (New York: Dutton, 1992); Eric Schlosser, *Fast Food Nation: The Dark Side of the All-American Meal* (Boston: Houghton Mifflin, 2001).

25. The beef trade had a formative impact on early twentieth-century Argentine history, see Peter H. Smith's classic study, *Politics and Beef in Argentina: Patterns of Conflict and Change* (New York: Columbia Univeristy Press, 1969). On nineteenth-century Chicago as "the Great Bovine City of the World" and "Porkopolis," see William Cronon, "Annihilating Space: Meat," ch. 5 of *Nature's Metropolis: Chicago and the Great West* (New York: W. W. Norton, 1991).

these trends.) Because they are biologically predisposed to convert nutrient-dense foods to body mass with great efficiency, chickens and pigs have responded best to this manipulation. From 1945 to 1975 to 1995, in the clearest example of success, the average market weight of "young meat-type" broiler chickens in the United States increased from 1,360 to 1,720 to 2,130 grams (3.0 to 3.8 to 4.7 pounds), feed-to-meat conversion efficiency rose from 26 to 48 to a whopping 53 percent, and time-to-market maturity dropped from 95 to 56 to 47 days. Chicken, not beef, is the modern meat.[26]

As with input-intensive plant agriculture, these new forms of livestock raising have eliminated old systems of waste recycling associated with animal husbandry and replaced them with industrial throughput. These trends have turned a former benefit of livestock raising into an environmental scourge. The giant "animal factories" that produce all this meat simply cannot get rid of their animal waste fast enough. Rather than providing vital nitrogen fertilizer to plant agriculture as it did for millennia, today's animal manure has become one of the world's worst waterway pollutants and caused major changes in the nutrient supply and biodiversity of aquatic ecosystems all over the world. This epochal increase in human food production thus confirms a modern German saying:

> Life is like the ladder in a chicken coop,
> A person just can't get ahead because of all the poop.
> And when he finally reaches to the top of it,

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26. William Boyd, "Making Meat: Science, Technology, and the Industrialization of American Poultry Production," *Technology and Culture* 42 (Oct. 2001), esp. 636-637; unfortunately, in a fashion all-too-common among works in U.S. history, Boyd treats changes in the "industrial chicken" as if they were autochtonous to the United States.

Then he'll find he's stuck in the deepest shit.[27]

On a few farms where the "gospel of efficiency" is taken to an extreme, excrement is fed back to livestock, both to get rid of it and to put more meat on the table. In fact, the nutritional conditions of factory chickens are such that consuming their own excrement actually makes them healthier.[28]

The use of carefully balanced, high-protein feeds has been fundamental to the development of faster-growing, heavier livestock. This brings us back to the problem of producing enough nitrogen fertilizer for agriculture--the same problem that sent British and German farmers lusting after Peruvian guano and nitrates in the nineteenth century so they could grow enough root crops to feed livestock so Europe's ascendant bourgeoisie could eat a chop of meat at dinner each day. Circa 1950, with more and more new chemical plants using the Haber-Bosch nitrogen synthesis process coming into production, engineers were rapidly knocking down a fundamental barrier to human meat consumption (see table 2). But it took a while for industrial economies of scale linking agrichemicals, soybean growers, and meat producers to develop, especially in Europe. It took many years for China to install any of its vast network of small-scale "backyard" fertilizer plants. At least in the short term, it was simpler and more economical to extract high-protein feed directly from the sea as fishmeal, to rely on an unexploited realm of nature instead of

27. "Das Leben ist wie Hühnerleiter / vor lauter Dreck kommt man nicht weiter
und wenn man endlich oben ist / dan steckt man drinim tiefsten Mist." My translation; see Alan Dundes, *Life Is Like a Chicken Coop Ladder: A Portrait of German Culture through Folklore* (New York: Columbia University Press, 1984), esp. 9-10.

28. See Jim Mason and Peter Singer, *Animal Factories* (New York: Crown Publishers, 1980), esp. 48-49, 84-88; Michael A. Mullin, "Impacts of Industrial Animal Production on Rivers and Estuaries," *American Scientist* Jan.-Feb. 2000, 26-37; Richard P. Horowitz, *Hog Ties: Pigs, Manure, and Mortality in American Culture* (New York: St. Martin's Press, 1998); Orville Schell, *Modern Meat* (New York: Random House, 1984).

human artifice to do the work. (Fishmeal also had more nutrients and was known to accelerate livestock growth rates more than soybean meal.) Our capacity to eat so much meat was premised on our ability to master the nitrogen cycle.[29]

From 1948 to 1958, the crucial period when Peru's fishmeal industry took off, the total global market for imported fishmeal multiplied by over six times, from 111,000 metric tons worth US$15.3 million to 693,000 metric tons worth US$103.4 million. West German swine farmers and U.S. chicken raisers drove this early trend, followed by the United Kingdom and the Netherlands. Japan's consumption grew at the fastest rate, as affluent Japanese slowly adopted the meat-heavy diets of many Westerners. Rather than eating hamburger from Latin American rainforests, at least during these early years, U.S. and European consumers were eating chicken and sausage from the sea.[30]

A supply had to be found to meet this demand, of course. By the end of 1953, at least nine Peruvian canners had installed fishmeal reduction equipment, led by firms with ties to Wilbur-Ellis. But their ability to make fishmeal from factory waste was dependent on their production of canned fish, which had limited prospects. Peruvian fishermen had long coveted CAG's monopoly right to produce fishmeal from anchoveta. Not only were anchoveta much more abundant than bonito or any other fish off the Peruvian coast, they were also easier to catch and more economical to reduce to fishmeal because of their schooling tendencies and small individual size. With CAG's plant under political attack and still inoperable,

29. Smil, *Enriching the Earth*, ch. 7-10.

30. Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 111-112, 116-117, 120, 123-125, 131, 138-140, 142-143.

Manuel Elguera, a Peruvian fishing entrepreneur with both family and professional ties to the United States, began construction of a plant at Chimbote using equipment and engineers imported from California by Wilbur-Ellis. In 1950, the first Peruvian factory devoted solely to the reduction of anchoveta into fishmeal went into operation. This opened the door to the exploitation of anchoveta by others, but only a crack. By 1953, the Dirección de Pesquería y Caza recognized 10 fishmeal reduction plants devoted solely to anchoveta exploitation. Estimates of fishmeal exports from Peru vary widely for this early period. This statistical uncertainty is a reflection of both the tenuous legality and lack of state supervision over anchoveta production in Peru at the time.[31]

Partly with this in mind, Peru's fishing entrepreneurs reorganized themselves politically to protect their economic interests. They distanced themselves from the Aristocratic Republic's stodgy Sociedad Nacional de Industrias when it fell out of political favor after the 1948 military overthrow of populist José Bustamante. In 1952, they decided to establish a new, independent political association, the Sociedad Nacional de Pesquería (SNP). In recognition of Manuel Elguera's leadership in both the canning and fishmeal industries and his close ties to the powerful U.S. firm Wilbur-Ellis, its members named him as SNP president. Enrique del Solar, meanwhile, became its primary technical advisor.[32]

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31. See table 7; *MCAG* 44 (1953), 8-9; Tarnawiecki, "A Survey of the Development of Oceanic Fisheries in Peru," 135; Roemer, *Fishing for Growth*, 80-83; Abramovich, *La industria pesquera en el Perú*, 16-18; Portocarrero, Beltrán, and Romero, *Compendio estadístico del Perú*, 46, 138, 140. For criticism of CAG's fishmeal plant, see Lanatta, *Informe*, 14, 31-35, 83, 90-91.

32. Roemer, *Fishing for Growth*, 61, 80-83; Caravedo, *Estado, pesca y burguesía*, 35-37.

Through the SNP, Peru's fishing interest began to take sides against the guano industry, especially when CAG's managers again became vocal about their desire to regulate development of the fishmeal industry. To fishery industrialists, fishmeal production from anchoveta looked to be their salvation, so it had to be defended at all costs. And what better way to defend it than with the principles and findings of marine science?

Deciding the Fate of the Anchoveta

The 1953-1954 debate over the fishmeal industry in Peru soon became quite heated, the centrality of technocratic rhetoric to the arguments of both sides notwithstanding. In this sense, this contest was a preview of the rancorous disputes between pro- and anti-DDT scientists in the United States before and after the publication of Rachel Carson's *Silent Spring* in 1962. Remarkably, one scientist--Robert Cushman Murphy--played a starring role in both debates.[33]

As we have seen, CAG's managers had long recognized the danger "massive anchoveta fishing" posed toward the guano birds. In 1953, led by its general manager, agronomist Carlos Llosa Belaúnde, CAG began to lobby Peruvian officals to set a 100,000 metric ton annual ceiling on anchoveta production, since the state refused to ban it altogether. The SNP rejected these arbitrary limits on principle, noting that they lacked any explicit scientific justification. In response, CAG requested permission to use its own scientific

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33. See epilogue; Thomas R. Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton, NJ: Princeton University Press, 1981), 87-125.

apparatus to develop fishing regulations. If this was too much to ask, CAG at least wanted the state to set up an independent board of experts to develop "rational" fishing standards that would not threaten the "unstable equilibrium" of the marine ecosystem. The latter suggestion was acceptable to both sides, and the government's Dirección de Pesquería y Caza organized an adjudication board for this purpose in April 1953. CAG's delegation of experts, which included its scientific protégés Enrique Ávila, Mario Barreda, and Antonio Landa, explicitly pointed to the failure of the California sardine fishery in support of CAG's position regarding strict fishing quotas. Scientists from the Dirección de Pesqueria y Caza, led by Enrique del Solar, argued that the guano and anchoveta industries could develop safely in parallel. As a compromise, high-level state officials elected to limit the number of construction permits granted to fishmeal plants but refused to set any production limits. This pleased neither side. In an attempt to break this impasse, CAG invited two of the foremost conservation scientists in the world to study Peruvian marine production with "disinterest" and "affection for pure science."[34]

Frances Naomi Clark (1894-1987) was one of the world's preeminent experts on the California sardine (*Sardina caerulea*) and was at the peak of a remarkable scientific career that had been dogged by gender discrimination. When she was young, her prosperous father retired from farming in Nebraska and moved to California. There, both Frances and her older sister Laura attended Stanford

34. *MCAG* 44 (1953), 4-12, 49-51; *MCAG* 45 (1954), viii, 5-6, 7-9, 11; *BCNPN* 11:1 (1954), 11-13; Cary, "Report #7--September 5, 1953," 11 Sept. 1953, American Tunaboat Association Records, SIO Library, 28/1, pp. 8-9; Caravedo, *Estado, pesca, y burguesía*, 35.

University. Frances converted her interest in marine science into entry-level government jobs tied to the California fishing industry. Both daughters moved to the University of Michigan in the early 1920s: Frances to pursue a Ph.D. in ichthyology, Laura to support the doctoral work of her husband, Carl Hubbs, in the same field. After completing her Ph.D. in 1925 (illus. 41), Frances moved back to California where she passed a year as a junior-high school teacher looking for someone who would hire a woman scientist. The California Department of Fish and Game took her on as a fisheries researcher, but would not give her a supervisory post, even though for years none of the men she worked with had anything comparable to her formal scientific training. Finally, she was promoted to director of the California State Fisheries Laboratory at Terminal Island in 1941. Even then, she was given a bogus job title at first, and often gave her directives through a male assistant to avoid harming the masculine sensibilities of her underlings. She stayed in this position until her retirement in 1957. This made her the *only* U.S. woman scientist of any kind with an important policy-making post during the entire 1940-1972 period.

Such an exceptional achievement required sacrifices. Like Mary Sears, Frances Clark elected to forgo both the benefits and obligations of marriage and family traditionally imposed on women by society. Her mathematically adept sister Laura, in contrast, was banned by nepotism rules from receiving pay for her vital work as a scientific assistant to her husband at the Scripps Institution of Oceanography. But these sacrifices allowed Frances to be a productive researcher: From 1925-1962, she published 62 papers, most focused on the life history, population dynamics, and conservation of the all-important California sardine. She was also one of the few people with any knowledge of the California anchovy (*Engraulis mordax*), the Peruvian anchoveta's closest relative.[35]

CAG officials could not have chosen a more qualified nor a more outspoken critic of the unregulated development of a fishmeal industry if William Vogt had picked her himself. (In fact, Vogt may have had a hand in Frances Clark's selection. He introduced CAG officials to Clark's work in his 1942 report on the guano birds. He also knew her personally, and they corresponded regarding the Peruvian guano industry.)[36]

In 1939, Clark publicly predicted the collapse of the California sardine stocks and recommended strict limits on their harvest. All of her observations on these counts had important implications for the Peruvian fishmeal industry. She noted that the reduction of sardines to oil and meal had been the most lucrative phase of the California fishing industry from the moment that canners first started processing their canning waste. The California Department of Fish and Game had tried to limit the use of whole fish for direct reduction, but their regulations were circumvented during the 1930s by the introduction of floating reduction factories that did their work beyond California's three-mile territorial sea. (As we saw in

35. Frances N. Clark and J. B. Phillips. "The Northern Anchovy (*Engraulis mordax*) in the California Fishery," *California Fish and Game* 38:2 (1952), 189-207; Patricia Stocking Brown, "Early Women Ichthyologists," in "Women in Ichthyology: An Anthology in Honour of Et, Ro, and Genie," ed. Eugene K. Balon, Michael N. Bruton, David L. G. Noakes, *Environmental Biology of Fishes* 41:1-4 (1994), 23-24, 28; Rossiter, *Women Scientists in America: Before Affirmative Action, 1940-1972*, 301; McEvoy, *The Fisherman's Problem*, 200; *American Men and Women of Science: Physical and Biological Sciences*, 12th ed., s.v. "Clark, Frances N(aomi)"; Deborah Day, Scripps Institution of Oceanography Library, personal communication.

36. Clark to Vogt, 22 Mar. 1948, Vogt papers 1:1.

chapter 1, this was the same strategy mid-nineteenth-century fish-fertilizer producers had used to avoid local pollution regulations along the U.S. Atlantic seaboard. For good reason, the defenders of Peru's 200-mile EEZ feared this sort of invasion by foreign factory ships.) The response of regulators, however, was to relax restrictions against sardine reduction onshore, which led to a boom in the construction of shore plants. This was "a matter of grave consideration," Clark admonished, since it threatened the long-term survival of the entire industry from British Columbia to Mexico. She aggressively advocated government restrictions on the total yearly catch. A closed season was not adequate, in her view, because fishermen would simply raise the intensity of their effort during the open season. Closed reserves would not work, either, because the sardine is migratory and fishing grounds vary from year to year. A size limit was unfeasible because different-sized fish constituted the sardine schools; fishermen could not use nets with larger mesh to allow immature fish to escape because they would become clogged with gilled fish and quickly become inoperable. In Clark's opinion, the supply of sardines could not be maintained in California waters unless the state enforced a yearly quota not greater than 250,000 metric tons--half the catch at the time. Clark's warning went unheeded and, tragically, her prophecy came to pass. In the years that followed, she took on leadership of the faction of scientists who pointed to human harvesting as the primary cause for the dramatic decline of the sardine against those who blamed environmental changes.[37]

37. Clark, "The Sardine: International Aspects of its Life History and Exploitation," *Proceedings of the Sixth Pacific Science Congress of the Pacific Science Association Held at the University of California, Berkeley, Stanford University, and San Francisco, July 24th to August*

The defenders of the guano industry clearly expected Clark to decide in their favor. The technocratic ideal, however, requires the scientist to do some empirical research before making any authoritative statements, and the Peruvian fishing industry would have settled for nothing less. Clark arrived in Peru in October 1953 and had the good fortune to hook up with two Danish survey vessels. CAG's scientific team, especially Mario Barreda, worked closely with her during three survey cruises lasting until May 1954. As in the case of Mary Sears, crossing the North-South divide allowed Clark to have a level of access to shipboard research she was totally unused to in the United States. It also created an opportunity for Peruvian women scientists. With the aid of her closest Peruvian assistant, Luz Sarmiento, Clark produced substantial basic data on the anchoveta's biology. Most significantly, they confirmed that anchoveta schools concentrated in the surface layers, especially between five and nine meters, and only rarely descended below 18 meters--at least during the cool "La Niña" conditions of early 1954.

Clark also drafted a plan for systematic anchoveta research in Peru. Clark's experience with CAG's capable scientists and extensive facilities impressed her greatly. Her plan made CAG responsible for instituting systematic anchoveta research, although she recommended hiring a much larger scientific staff to do this adequately without slighting CAG's vital ornithological work. This was exactly what CAG's managers hoped to hear, but to their chagrin, she cautiously offered no

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12th, 1939 (Berkeley and Los Angeles: University of California Press, 1940), 3: 251-256; idem, "Can the Supply of Sardines Be Maintained in California Waters?" *California Fish and Game* 25:2 (Apr. 1939), 172-176; Rossiter, *Women Scientists*, 301; McEvoy, *The Fisherman's Problem*, 162.

explicit recommendations for the regulation of the fishmeal industry. Even worse, a Paita newspaper reported that she made the offhand comment that unregulated exploitation of anchoveta would have no detrimental impact in the short term in view of their "simple abundance."[38]

This could have been fatal to CAG's position, if not for the adamant support for strict regulation of the fishmeal industry provided by the other senior U.S. scientist CAG invited to Peru. As we have seen, Robert Cushman Murphy was already well known in Peruvian scientific circles, and he knew Peru's coastal environment as well as anyone--especially the Peruvian guano birds and the natural hazard posed by the El Niño phenomenon (illus. 42). For decades he had been an outspoken advocate of the reformed Peruvian guano industry, which he viewed as "an example to the world." By the early 1950s, Murphy had a nearly unparalleled international reputation as a scientist and conservationist to back up his opinions. Moreover, Murphy had already made public his negative opinions regarding "the beginnings of an 'artificial guano' industry . . . with the anchovy." In a review of Schweigger's *Pesquería y oceanografía del Perú* (1943), Murphy warned,

> many such undertakings have ended, sooner or later, in the exhaustion of the supply. There are strong indications that the Peruvians . . . would do well to concentrate on the betterment of their free, organic producers of irreplaceable wealth rather than sigh after short cuts.[39]

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38. Clark, "Biology of the Anchoveta," 25 June 1954, SIO Subject Files 17/25, translated as "Biología de la anchoveta," *BCCAG* 1:2 (1954), 98-132; idem, "Program for Anchoveta Investigations," 26 Apr. 1954, SIO Subject Files 17/25; "Panorama provinciano: La Anchoveta y las aves guaneras," *La Nación* (Lima) 26 Jan. 1954, clipping from American Tunaboat Association Records, SIO Library, box 103/folder "Peru"; Rodewald, "Die Anomalie der Wassertemperatur und der Zirkulation im Nordpazifischen Ozean und an der Küste Perus im Jahre 1955," 82.

39. *Who Was Who in American History--Science and Technology*, 1976 ed., s.v. "Murphy, Robert Cushman"; Graham, *The Audubon Ark*, 110, 117, 143, 155; Murphy, *Oceanic Birds*, 1:27-

CAG officials confidently expected Murphy to come down hard on the fishmeal industry.

He delivered. After a two-month, whirlwind survey of the Peruvian and Chilean coasts, Murphy made his report to the science faculty of the Universidad de San Marcos in January 1954, a major cultural event widely covered by the Lima press. In it, he utterly condemned the unlimited development of an industrial anchoveta fishery in Peru. Because of El Niño, he thought guano and fish production were both "equally subject to ecological depressions of irregular incidence." He reasoned that "stable production or populations probably do not exist" in the Peru Current. To build political support for his position, Murphy made a direct appeal to the agro-exporters who had long supported CAG and who dominated the current government that had been imposed by General Manuel Odría in 1948. He noted what should have been obvious to everyone from the beginning: Since fishmeal was so valuable as an exportable livestock feed, it would hardly benefit Peruvian farmers who grew plant crops. In short, they risked losing the "hen that lays the golden egg" by allowing a large industrialized fishery to threaten the guano birds.[40]

Murphy aggressively criticized the kind of science used to promote the interests of the Peruvian fishmeal industry. For example, he had nothing good to say about the crude 1941 guano production experiment by Luis Gamarra often cited

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29; idem, *Bird Islands*, 56; *BCNPN* 11:1 (1954), 4; idem, "More about Peruvian Fisheries," *The Geographical Review* 34:1 (Jan. 1944), 141-142.

40. "La visita de los doctores señor Robert Cushman Murphy y señorita Frances N. Clark," *BCAG* 30:1 (Jan. 1954), 31-32; Murphy, *El guano y la pesca de anchoveta*, 9-10, 14-16, 18; see *BCNPN* 11:1 (1954), 15-17, 20-21, for examples of positive and negative press coverage in *El Comercio* and *La Prensa*. Murphy later made a report of this sojourn to Peru on U.S. television.

by fishmeal advocates. Murphy also questioned the management value of the fishing industry's technical studies. He thought they put the anchoveta at *greater* risk, in fact, since they were designed to maximize productive efficiency within the industry, not to ensure the adequate reproduction of wild stocks. Nevertheless, Murphy was still a big believer in the technocratic management of natural resources. In accord with Baconian natural philosophy, Murphy deemed that proper science first involved observation, then understanding, then prediction, and finally control over nature. In his view, CAG had achieved the third stage and was on the verge of the fourth, but the Peruvian fishing industry had barely entered the first stage, and thus should bow to the interests of Peru's mature guano industry. Murphy took a tack quite different from Clark in the name of caution. He thought "wisdom" mandated that Peru strictly limit industrial fishing at least until "much more has been learned about the life cycle of anchoveta." Otherwise, "a new 'Saturnalia'" akin to Peru's Guano Age might result and lead the Peruvian fishing industry to the "calamitous" fate of the California sardine--or even the extinct passenger pigeon.[41]

Fishing industry representatives bristled at this challenge, and the SNP quickly rounded up its own "scientific circle," led by Enrique del Solar, to refute Murphy's assertions. These propagandists turned Murphy's position on its head. They made the guano birds into a threat to Peruvian national development. In an

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41. Murphy, *El guano y la pesca de anchoveta*, 17, 21-22, 30, 33-34, 36-39. For use of Gamarra's experiment by fishmeal industry advocates in this debate, see del Solar, "Los iniciadores de la industria de la harina de pescado," in *La anchoveta y la harina de pescado* (Lima: SNP, 1954), 52-53, originally published in *El Comercio* 14 May 1954.

illustrated article prominently featured on the front page of the arch-conservative Lima daily *La Prensa*, one SNP spokesman made the outrageous claim that the guano birds "eat more than they produce." This article claimed that "prestigious scientists affirm" that the guano birds were draining the seas of 18 million metric tons of anchoveta each year worth US$1.34 billion to Peru if converted to fishmeal, though without ever revealing who these unnamed experts were, much less the basis for these doubtful assertations. To try to win over the farming interest, this article kept pretending that fishmeal had "the same properties as guano" as a fertilizer, was available "at a lower cost" if produced on an industrial scale, and thus would finally save "the farmers of our coast and the indigenous paupers of our Andes from the sorrow of parched lands," despite over a decade of expert opinion to the contrary.[42]

A follow-up article by the same SNP spokesman claimed that the Peruvian guano industry was an anachronism instead of a model of progressive conservation science. "The exploitation of guano birds," he argued, "is a blunder on a grand scale that is putting the country at risk and is an index of the industrial backwardess of the nation." In other words, not only did the guano industry threaten the development of Peru's fishing industry, but it also prevented entrepreneurs from initiating a local petrochemical industry to produce fertilizer using the Haber-Bosch process. Modern Peruvians needed "neither guano birds, nor fishmeal as fertilizer

42. Pedro F. Cortázar, "¿Comen más de lo que producen?" *La Prensa* 29 Jan. 1954, p. 1, col. 5-7; for a similar pseudo-technocratic response, see "Fuente de riqueza nacional son ahora consideradas como 'aves dispendiosas,'" *La Prensa* 25 Jan. 1954, p. 2, col. 6-7.

[!], only the extended and *planned* protection of the national fishing industry as a productive source of excellent cheap food."[43]

In another publication, the SNP's experts crudely attacked Murphy's scientific credentials and his intellectual honesty. They accused CAG of violating the objective norms of scientific discourse by bringing a biased observer to Peru who lacked proper expertise. Since Murphy was an ornithologist, he "cannot be considered capable to carry out studies and arrive at solutions for problems related to marine fauna and biology." Furthermore, "no serious investigator" would dare present such "vague" pronouncements and "incongruous ecological examples."[44]

Fishing industry advocates also cynically comandeered some of Vogt's ecological rhetoric to use against Murphy's position. In their opinion, the record levels of guano production CAG attained in the early 1950s were a matter for criticism, instead of praise. This "indiscriminate multiplication" of the guano birds violated the ecological "equilibrium" of the ocean ecosystem and potentially led to their "overpopulation." In addition, by snatching away anchoveta from the bonito and fishmeal industries, the birds were supposedly stealing needed protein from the mouths of the world's exploding population. At any rate, CAG's unprecedented success self-evidently indicated that fears of overfishing were "alarmist and without scientific foundation," at least for the time being.[45]

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43. Emphasis added; Pedro F. Cortázar, "Ni guano, ni harina, sino protección a la pesca," *BCNPN* 11:1 (1954), 12-13, originally published in *La Prensa* 21 Mar. 1954.

44. SNP, *La anchoveta y la harina de pescado*, 3, 55.

45. Ibid., 1-5, 54-56; Cortázar, "Ni guano, ni harina, sino protección a la pesca," 12-13; idem, "¿Comen más de lo que producen?".

It is remarkably difficult to gauge whether the guano birds really did "consume more than they produced" in terms of Peruvian national wealth, as the fishing industry claimed. By 1954, the fishmeal industry was producing more than US$10 million in foreign exchange value a year from a product that went straight overseas to feed livestock and put meat, milk, and eggs on the tables of First World consumers. The majority of guano went to food plants grown and consumed by Peruvians, rather than to cotton and cane sugar production for export, as it once had.[46] Of course, the fact that CAG's guano production substituted for fertilizer imports partly made up for this difference. Since guano was sold at below-market prices to benefit Peruvian agriculture, it is unfair to compare its sale value to fishmeal. It is also difficult to compare the "conversion efficiency" of these two industries. As we saw in the last chapter, these estimates varied wildly. The best scientific estimate for the guano industry, 6.9 tons of anchoveta consumed for every ton of guano produced, came into play far too late to influence this controversy. The Peruvian fishmeal industry converted anchoveta to fishmeal at approximately a 5.5:1 efficiency, though this is not evident in official statistics because of the prevalence of cannery waste. Of course, fishmeal production also required significant investments in technology and energy which had to be recouped, while guano had long been harvested by brute, unskilled labor at a significant profit--something the fishing industry could not always claim. Since guano and fishmeal were put to such different uses, there is little point in making

46. See table 6, app. 5.

gross ecological comparisons between the food energy produced by guano versus fishmeal.[47]

Clearly there was a decision to be made: "to fish or not to fish."[48] It was obvious to both sides that the Peru Current could not support maximum production of both guano and anchoveta. If Murphy's caution carried the day, marine resource development in Peru would stagnate permanently where anchoveta were concerned. As with Vogt's declarations a decade earlier, few development-minded Peruvians, even CAG's own scientists, wanted to see this come to pass. Yet there were no clear grounds on which to make a rational choice whether guano or fishmeal was a more "efficient" use of nature, much less to decide how much anchoveta could be harvested without harming the guano industry. Out of respect for the technocratic ideal, all parties concerned decided to put the question to a new set of experts. CAG went in search of a foreign scientific consultant acceptable to the fishing industry to head this investigation.

The Triumph of Big Oceanographic Science

Through a complicated series of personal contacts orchestrated by the Scripps Insitution of Oceanography in California, CAG officials soon zeroed in on the perfect technocrat for the job: Milner Bailey Schaefer (1912-1970, illus. 43). This Wyoming native turned marine biologist had years of practical experience

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47. On the general issue of nutrient conversion efficiency by plants and animals, see Ricklefs, *Ecology*, 189-209, 220-223.

48. *BCNPN* 11:1 (1954), 15-16, original quote from *El Comercio*, a consistent supporter of strict fishing regulations, 20 Jan. 1954.

with state-run fishery management organizations in Washington State, British Columbia, California, and Hawaii. He also had relevant political skills. After completing a Ph.D. in fishery science at the University of Washington in 1950, Schaefer left government service to become director of investigations at the Inter-American Tropical Tuna Commission, a scientific research organization that was the U.S. tuna industry's answer to Chile and Peru's technocratic posturing over the EEZ. This position gave him immense responsibility for the study and management of the yellowfin and skipjack tuna fisheries in the eastern tropical Pacific Ocean. It also forced him to nurture collegial relationships with scientists and tuna producers in California, as well as scientists and officials in the Latin America states that bordered this region.[49]

Meanwhile, Schaefer had almost finished work on a vital tool for wildlife management. During the 1940s, he had been involved in the development of mathematical models to predict the population dynamics of the California sardine. The sardine industry collapsed before these could be put to practical use. While working for the Tuna Commission, Schaefer continued analyzing the California sardine data while turning his attention to the population dynamics of Pacific tunnids and the small bait fishes used to catch them. He soon developed an effective means to indirectly quantify the reproductive dynamics of an exploited

49. Schaefer to Ávila, 2 Aug. 1954, Schaefer papers, 17/54; W. M. Chapman to Harold F. Cary, 25 Dec. 1963, UC-IMR Records, 5/291, pp. 1-2; U.S., Foreign Operations Administration, Institute of Inter-American Affairs, Division of Agricultural Development, US Fishery Mission to Peru, "Proposal for a Fisheries Research Contract in Peru," 30 Oct. 1954, SIO Subject Files, 17/25; Deborah Cozort Day, ed., *Guide to the Papers of Milner Baily Schaefer (1912-1970), 1929-1970, in the Archives of the Scripps Institution of Oceanography*, SIO Reference Series 82-11 (La Jolla, CA: Scripps Institution of Oceanography, 1989), 3-9.

fish population using catch statistics. This "Schaefer model," as it became known, allowed him to quantify the "maximum sustainable yield" of a fishery and come to an objective, quantifiable definition of "overfishing." This was clear evidence of the progress of population ecology as a scientific discipline beyond Raymond Pearl's "law of population," the logistic curve. Once again, Peru could not have consulted a foreign scientist more qualified for the problem at hand.[50]

Schaefer carefully studied Frances Clark's typescript report before setting off for Lima in August 1954. Through his preliminary contacts, he was able to gauge quite accurately the contrary interests that divided scientists over the Peruvian fishmeal versus guano question. He identified lack of scientific organization, rather than lack of scientific knowledge, as the primary barrier to its resolution. Upon his arrival, he immediately convened a roundtable meeting that brought together representatives from the various sides. During their discussions, he identified a scientific problem shared by everyone that could form the basis for a compromise solution *based on scientific research*: What was the extent of oceanic fluctuations (i.e., the El Niño phenomenon) and their impact on biotic populations off the Peruvian coast? He suggested the formation of a scientific advisory committee to attack this problem with representatives from CAG, the SNP, the Hydrographic Office of the Peruvian Navy, and the Dirección de Pesquería y Caza.

50. Tim D. Smith, *Scaling Fisheries: The Science of Measuring the Effects of Fishing, 1855-1955* (Cambridge, UK: Cambridge University Press, 1994), 249-266; cf. Kingsland, *Modeling Nature*. See also Milner B. Schaefer, "Some Aspects of the Dynamics of Populations Important to the Management of the Commercial Marine Fisheries," *Inter-American Tropical Tuna Commission Bulletin* 1:2 (1954), 25-56; idem, "A Study of the Dynamics of the Fishery for Yellowfin Tuna in the Eastern Tropical Pacific Ocean," *Inter-American Tropical Tuna Commission Bulletin* 2:6 (1957), 245-285.

Schaefer also formulated an ambitious collaborative research plan to be executed mainly by CAG's scientific apparatus. This research was designed to determine the amount of anchoveta predation by the guano birds, the amount of anchoveta predation by the fishmeal industry, basic characteristics of the anchoveta population, and the effects of environmental variability on these characteristics. Under Schaefer's plan, all major groups with an interest in Peru's marine environment had a stake in both the creation and use of this scientific knowledge.[51]

Implicitly, his plan vindicated Clark's opinion that all regulations should be based on precise scientific knowledge and rejected Murphy's conservative, "better safe than sorry" approach. In fact, Schaefer turned exploitation of anchoveta by the fishmeal industry into a scientific virtue: as long as it was carefully documented in terms of fishing effort and yield, anchoveta fishing became the conservation technocrat's best source of knowledge for calculating the anchoveta's population dynamics.

Schaefer's recommendations led directly to the institutionalization of Peruvian marine science research under a single organization. In November 1954, President Odría established the Consejo de Investigaciones Hidrobiológicos (Council on Hydrobiological Investigations) under the Ministerio de Marina to "coordinate and support marine biological studies with a view to the greater utilization and control of natural resources." For some time, the Consejo continued

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51. Warren S. Wooster to SIO Director's Office, 2 Aug. 1954; Schaefer to Ávila, 2 Aug. 1954; Schaefer, "Cruises of the Pacific Queen," 29 Aug. 1954; U.S., Foreign Operations Administration, Institute of Inter-American Affairs, Division of Agricultural Development, U.S. Fishery Mission to Peru, "Proposal for a Fisheries Research Contract in Peru," 30 Oct. 1954, SIO Subject Files, 17/25. Schaefer, "Suggestions for Research on the Dynamics of the Anchoveta of Peru," 29 Aug. 1954, Schaefer papers, 4/216.

to exist in name only as CAG, the Navy, and the Dirección de Pesquería pursued their investigations independently. Then in 1956, with aggressive support from the Peruvian fishing industry, the American Tunaboat Association negotiated an agreement to buy licenses so that U.S. tuna ships could work within Peru's Exclusive Economic Zone--with the condition that payments would go straight to fund the Consejo.

This agreement led directly to the contracting of another North American expert, SIO oceanographer Warren S. Wooster (1921-), to provide the Consejo with some direction. Wooster already had experience working with Peruvian scientists thanks to SIO's 1952 "Shellback" expedition to the eastern equatorial Pacific and a scholarship program that brought Enrique Ávila and other budding Peruvian scientists to study at Scripps. As Director of Investigations, Wooster proceeded to implement, as best he could, a scientific program in accord with Clark and Schaefer's old research plans. He and his successor, the Romanian-Argentine oceanographer Zacarías Popovici Carpanu (d. 1991), organized important investigations of the 1957-1958 El Niño and made occasional policy recommendations. Most importantly, the Consejo began to gather reasonably good statistics from the fishing industry for the first time. Despite Wooster and Popovici's best efforts, the low-intensity, poorly funded scientific work organized by the Consejo was completely inadequate for the management task envisioned by Clark, Schaefer, and their Peruvian associates.[52]

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52. Wooster, "Preliminary Report, Shellback Expedition, 17 May to 28 August 1952," 28 Aug. 1952, SIO Subject Files, 7/3; *MCAG* 46 (1955), xviii, 13; SNP, *La anchoveta y la harina de pescado*, 5; Belaúnde, *La legislación pesquera del Perú*, 366-368, 376-377; Trygve Sparre,

Little by little, Peruvian marine science was becoming more dependent on outside funding and expertise as it become divorced from the guano industry. The strong El Niño of 1957-1958 accelerated this process dramatically. It caused guano production to fall by over two-thirds and CAG's real net earnings to fall by almost one half from their peak in 1955-1956.[53] This crisis forced CAG to dismantle its scientific apparatus: In 1959, it sold its Chimbote fisheries lab; in 1960, it mothballed the lab and much of the equipment on the *Pacific Queen*; and in 1961, it turned over the instruments from its ornithology station to the Peruvian state. Most of its biological staff took jobs elsewhere: Antonio Landa with the Inter-American Tropical Tuna Commission, Schweigger as the director of a new fishery science program at the Universidad Nacional Federico Villarreal.[54]

Some had trouble finding new work. In 1955, Enrique Ávila left CAG to take a research scholarship at the Scripps Institution of Oceanography. By the time he was ready to return, CAG did not have the money to rehire him. Ávila had to fall back on his family for support and ended up for a while back on his father's small ranch (now the site of a cement plant) near the bleak highland city of Juliaca. In the early 1960s, he acquired a position at the Puerto Rico Nuclear Center at Mayagüez where he pursued studies of ocean nutrient cycling using water samples sent from Peru. Ávila eventually returned as professor of oceanography to his alma

"Prólogo: El Instituto de Investigaciones de los Recursos Marinos," *Boletín del IREMAR* 1:1 (1963), iii-v; Chapman to Cary, 25 Dec. 1963, UC-IMR Records, 5/291, pp. 3, 5-8; Roger Revelle to Gillermo Tirado, 9 Dec. 1954, Luis Edgardo Llosa to Revelle, 7 June 1955, SIO Subject Files 17/25; University of California, La Jolla, news release, 13 Sept. 1960, SIO Subject Files 8/45.

53. See fig. 2, 7 and app. 2, 4.

54. *MCAG* 49 (1958), v-vi, xxiii, 18, 21; Anexos: Detalle de activo fijo," *MCAG* 46-54 (1955-1963); *Inter-American Tropical Tuna Commission Annual Report* 6 (1957), 4, 6, 9, 52; interview with Abelardo Vildoso, Callao, Peru, 11 June 2001.

mater, the Universidad Nacional de San Agustín in Arequipa. By the mid-1960s, only one marine scientist, Demosthenes Cabrera Quiroz, remained on CAG's payroll.[55]

Almost needless to say, acolytes of technocracy such as Ávila were becoming extremely frustrated with this "absurd" situation and the "unnecessary tension" it produced between advocates of the guano and fishmeal industries. In Ávila's view, both industries played

> a vital function in our country's economy. It is absurd because the first axiom of the Conservation of Renewable Natural Resources is not "to preserve without exploiting" but . . . "to exploit *rationally* for the benefit of man." . . . *"Rational exploitation"* implicitly mandates that . . . the object of exploitation should be studied exhaustively, . . . not only [to serve] the interests of present society, but also *those of generations to come*. . . . A healthy guano industry and a growing fishing industry . . . both must finance *to their completion* all such studies . . . that might be needed to determine *at what level and strength each of the industries can operate*.[56]

Rather than ask the Peruvian fishing industry to pay the bill, in 1959, with the vocal support of almost everyone else concerned, the second government of President Manuel Prado looked abroad for help. Peru asked the United Nations

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55. Schaefer to Ávila, 16 Dec. 1958, SIO Subject Files, 8/11; Vogt to Ávila, 1 Feb. 1967, 26 Feb. 1967, Vogt papers, box 1:3; interview with Basilia Díaz Viuda de Ávila, Lima, Peru, 13 June 2001. Ávila's works from this period include, "Investigaciones científicas conducidas por el autor en los laboratorios de biología marina de la Compañía Administradora del Guano, durante el período que va de 1940 a 1955" (Bachiller de Ciencias Biológicas thesis, Universidad Nacional de San Agustín de Arequipa, 1961); "On the Time and Spatial Distribution of the Properties of the Peru Current" and "On the Biological Aspects of the Peru Current," first and second reports to the Marine Biology Division of the Puerto Rico Nuclear Center (1963), typescript; "Radiation Physics," (Mayagüez, Puerto Rico, 1963), mimeographed typescript; "Nivel de radiactividad y tenores de radioisótopos en muestras de harina de anchoveta del Perú," *Revista de la Facultad de Ciencias de la Universidad Nacional de San Agustín* de *Arequipa* (1969), all courtesy of Basilia Díaz Viuda de Ávila.

56. Ávila's emphasis; Ávila, "Investigaciones científicas conducidas por el autor en los laboratorios de biología marina de la Compañía Administradora del Guano," 58-59.

Special Fund to finance an independent institute that would fully centralize marine science activity. Its goal: "the study and control of oceanographic, biological, economic, and technical factors" that determined "the degree of exploitation possible [for] the marine resources of the Peruvian coast, especially [the] anchoveta, without endangering the[ir] natural richness." In April 1960, the UN Special Fund provided US$756,300 matched by US$1,105,300 from the Peruvian state budget to found the Instituto de Investigación de Recursos Marinos (IREMAR).[57] This was the first grant of its kind ever given by the UN Special Fund, and it became a model for UN relations with fishing industries all over the Third World.

This new organization truly represented the arrival of Big Science in Peru. Key features of this model for organizing large-scale investigation of the marine environment include elaborate ocean-going vessels, instruments, and marine laboratories, all with substantial research staffs and funding under the management of a hierarchical bureaucracy. Thus, Peru joined in a trend that was revolutionizing science--especially marine science--on a global scale after World War II.[58]

Embracing Big Science meant that local scientists had to give up most of their control over marine science research to foreign scientists and UN-FAO bureaucrats. IREMAR's "*trust de cerebros*" was placed under the direction of Trygve Sparre (b. 1899), a Norwegian expert in fishing economics who had

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57. Sparre, "Prólogo," iii-vii.

58. See Susan Schlee, *The Edge of an Unfamiliar World: A History of Oceanography* (New York: Dutton, 1973), ch. 8; Peter Galison and Bruce Hevly, eds., *Big Science: The Growth of Large-Scale Research* (Stanford, CA: Stanford University Press, 1992).

operated his own food industry lab and consulting business in Argentina for 22 years before returning home to spend a decade as director of the Norwegian Institute of Fishmeal Research.[59] With the aid of Popovici, a managerial team of foreign experts, and several former CAG employees, Sparre instituted a broad-based research programs in physical oceanography, marine biology, and in fishing technology, economics, and administration--including guano bird research. To appease Peruvian fishing industry interests, IREMAR named Enrique del Solar as its principal scientific and technical advisor. By 1962, it employed 65 people, including 9 foreign FAO scientists, 22 Peruvian scientists, 10 advanced Peruvian students, and 19 administrators; it also operated three research labs and a research vessel donated by the Peruvian navy, the *Bondy*. This was a grand scientific institution by Latin American standards.

Peru's fishing industrialists eventually lived up to their rhetoric regarding the value of marine science, but for a price. IREMAR's programs were put at risk in 1964 when the original UN Special Fund grant ran out. Deft behind-the-scenes lobbying by del Solar, Manuel Elguera, and foreign scientists connected to the California tuna industry finally convinced fishing industrialists to pay for the expansion of IREMAR's work. (As we shall soon see, Peru's fishmeal entrepreneurs had acquired enormous wealth by this date.) As part of the deal, this scientific institution became a quasi-independent appendage of the Peruvian navy and everyday management passed into the hands of locals. By 1966, the renamed Instituto del Mar del Perú (IMARPE) employed 50 professional scientists (14 with

59. "La ciencia mira al mar," *Pesca* Jan. 1961, 11-17 [quote p. 12].

advanced degrees from foreign schools), and 23 technicians as part of a cadre totaling 126 employees. It also operated two brand-new research vessels, the *Explorador* and *Unánue*, and soon moved into a new, specially built headquarters in Callao (illus. 44). It was clear whose interests IMARPE was intended to serve: its scientists worked almost entirely on problems related to the anchoveta, particularly the definition of fishing quotas based on a theoretical maximum sustainable yield. Although the El Niño phenomenon remained an important research concern, guano bird research fell by the wayside. Finally, Peru had a marine science apparatus appropriate to its vast marine resources. A dream of CAG's founders finally came true. By all appearances, this triumph of Big Oceanographic Science was also a victory for the technocratic ideal.[60]

The Technology of Fishmeal

By supporting more scientific study and building bigger scientific institutions, Peruvian state officials, just like the managers of Peru's guano and fishing industries, hoped to find the "one right answer" that would prevent them from imposing arbitrary regulations and thus ensure the "rational exploitation" of Peru's marine environment "for the benefit of man." This is the essence of the technocratic ideal. In case after case all over the world, this quest for scientific

60. Del Solar, Elguera, and Edgardo Llosa, "Informe de la comisión nombrada para estudiar el plan tentativo presentado por el Consejo de Investigaciones Hidrobiológicas y presentar recomendaciones al Directorio de la SNP," (Lima, 23 Apr. 1964), UC-IMR Records, 3/174; Chapman to Cary, 18 Apr. 1964, UC-IMR Records, 3/174; IMARPE, "El IMARPE y sus principales investigaciones científicas hasta 1965," *Informe Especial* (La Punta, Callao) 5 (Mar. 1966), 1-4, 11-12; Belaúnde, *La legislación pesquera en el Perú*, 401; Pedro G. Aguilar Fernández, "Algunos apuntes sobre el desarrollo de la biología en el Perú," in *Estudios de historia de la ciencia en el Perú*, ed. Ernesto Yepes del Castillo (Lima: CONCYTEC/ SOPHICYT, 1986), 1:84-85.

principles of environmental management has provided an enormous boost to science, from yesterday's regulation of California's fisheries to today's interest in global climate change. At the same time, this cautious (some would say cowardly and blame-deflecting) strategy has paralyzed regulatory action too many times to count.[61]

The quest for the biggest possible profit from environmental exploitation is tied up with this search for the "one right answer." A fundamental tenet of the technocratic ideal is that improvements in scientific knowledge will inspire new technological applications that will have big economic payoffs. As we saw in chapter 5, perhaps the best-known proponent of this belief, Vannevar Bush, thought scientific progress would enable humanity to conquer an endless series of frontiers. To conclude his bachiller thesis, Enrique Ávila quoted U.S. President John F. Kennedy on the conquest of one such frontier, the ocean:

> Knowledge of the oceans is more than a matter of curiosity. Our very survival may hinge upon it. The seas offer a wealth of nutritional resources. They can provide many times the current food supply if we but learn how to garner and husband this self-renewing larder. To meet the vast needs of an expanding population, the bounty of the sea must be made more available. . . . Basic research is the cornerstone on which the successful use of the seas must rest.[62]

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61. On these points, see McEvoy, *The Fisherman's Problem*; Clark A. Miller and Paul N. Edwards, *Changing the Atmosphere: Expert Knowledge and Environmental Governance* (Cambridge, MA: MIT Press, 2001); Joseph E. Taylor III, *Making Salmon: An Environmental History of the Northwest Fisheries Crisis* (Seattle: University of Washington Press, 1999); Sheila Jasanoff, *The Fifth Branch: Science Advisers as Policymakers* (Cambridge, MA: Harvard University Press, 1990).

62. Ávila, "Investigaciones científicas conducidas por el autor en los laboratorios de biología marina de la Compañía Administradora del Guano," 61; cf. Vannevar Bush, *Science, The Endless Frontier: A Report to the President on a Program for Postwar Scientific Research* (Washington: United States Office of Scientific Research and Development, 1945).

It was hoped marine science would diffuse William Vogt's population bomb.

Both President Kennedy and Ávila had reason to be optimistic. During the decade that elapsed between the founding of the Consejo de Investigaciones Hidrobiológicos in 1954 and IMARPE in 1964, the Peruvian fishing industry changed beyond recognition. Anchoveta exploitation and fishmeal production experienced a boom without precedent thanks, in large part, to a series of technological advancements, some of which depended on basic scientific research produced elsewhere in the world.

This enormous expansion occurred before the institution of Big Oceanographic Science in Peru. Nevertheless, the Peruvian fishmeal boom depended on the local engagement of experts, both foreign- and Peruvian-trained. It required the design, organization, construction, and administration of a complicated technological system capable of converting live anchoveta into an easily transportable and lasting product. When CAG's managers built the first fishmeal reduction plant in Peru, they merely intended to supplement the biological conversion of fish into nitrogen fertilizer by the "living machinery" of the guano birds. But fishmeal production involved an entirely new set of ecological, economic, and technological relationships. These could not be instituted overnight, as CAG's managers found out. As a consequence of their false start during the 1940s, they lost control of the fishmeal industry to a new set of managers, a group that envisioned the fishmeal industry as a replacement for the guano birds as the main consumers of anchoveta. As the owners of the fishmeal industry ruthlessly competed with each other to maximize their share and control of the industry, the fishmeal manufacturing process itself changed over time in the direction of greater productive efficiency, greater ecological impact--and lower profitability.

Industrial anchoveta fishing began with the purse seine trawler, a technology that was transferred directly from the salmon and sardine fisheries of the western United States to Peru by the North American Fishery Mission in 1941. At first, Peruvian anchoveta fishermen simply motored along the coast and searched for surface schools by sight or by making an educated guess where they could be caught beneath the surface. They depended heavily on watching guano birds to locate schools of fish. They wasted little time and fuel in this effort, as long as fish were abundant near port, which they almost always were, at least during the austral summer. Once fishermen located a school, the vessel circled it while the crew unloaded by hand a heavy net made from locally produced cotton (illus. 45). When the school was surrounded on the surface, the crew used a winch to reel in the purse line attached to the weighted bottom of the net; this caused the bottom of the net to gather up and prevent fish from escaping. The fishermen then used hand nets to transfer the anchoveta from this watery “purse” into the ship’s hold--a slow, back-breaking process. They then chugged back to port to unload their catch before it degraded too much.

In this new system, the guano birds brought fishermen to the anchoveta, rather than bringing the anchoveta to a handful of guano islands where they and their chicks converted it to excrement. Even in the best conditions, this required about as much manual labor and much more skill, ship time, and fuel than CAG needed to extract guano--all factors that Luis Gamarra failed to include in his efficiency calculations.

The introduction of a series of technological innovations to Peru, many linked to military research in the Northern Hemisphere, made it much more cost effective to mine the seas for anchoveta on a large scale. In 1954, directional echo-locaters (SONAR) originally invented to pinpoint submarines below the surface at some distance away from a ship went on sale in Peru. When used to locate subsurface schools of fish, these high-tech instruments eliminated much of the trial-and-error nature of fishing. But few in Peru could afford these expensive, imported instruments without going into major debt. Moreover, they required a lot of skill to operate. IREMAR and IMARPE, led by Norwegian expert Gunnar Saetersdal, offered classes to enterprising fishermen who wanted to learn the art and science of echo-location.[63] The widespread adoption of SONAR during the 1960s substantially increased the efficiency as well as the geographical and seasonal range of Peru's fishing fleet. But this technological change helped drive poorer boat owners out of the industry. Echolocaters also made the guano birds entirely superfluous to the process of finding fish; in fact, they turned the guano birds into a pest.

In 1955, nets produced from nylon fibers first became available in Peru. The development of nylon fishing nets involved one of those remarkable

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63. On the crucial role of Norwegian scientists and engineers in the adaptation of military SONAR to fishing, see Vera Schwach, "An Eye into the Sea: The Development of Fisheries Acoustics in Norway, 1935-1970," paper prepared for presentation at Maury III Workshop on the History of Oceanography: "The Machine In Neptune's Garden: Historical Perspectives on Technology and the Marine Environment," Monterey, CA, June 2001.

"Connections" cherished by pop historians of technology that ultimately tied South American nitrate extraction and industrial nitrogen synthesis to Big Science and the eventual success of the Peruvian fishing industry. After World War I, the U.S. chemical company Du Pont, a long-time producer of nitrate-based explosives, sought to adapt its new-found success with high-pressure catalytic ammonia synthesis (the Haber-Bosch process) to consumer uses other than explosives and fertilizer. From 1927-1940, Du Pont's R&D complex developed a new, nitrogen-based polyamide polymer. Du Pont first mass marketed this new fiber in the form of women's fashion hosiery. Later, it adapted nylon for use in fishing nets (and the nylon model for organizing large-scale research to the development of other synthetic fibers and plutonium manufacture).[64] The mass production of nylon nets was entirely premised on the ability to synthesize nitrogen compounds on a large scale and the manipulation of these chemicals by Big Science in the Northern Hemisphere.

These imported synthetic nets were superior to Peruvian-produced cotton nets in almost every way: they were lighter, stronger, more durable, and also relatively inexpensive. They were also amenable for use with diesel-powered cranks. This new combination made it possible to manipulate enormous purse-seine nets, many of which reached deeper than the guano birds could dive and fish effectively. Their introduction eliminated a major factor that limited the size of purse-seine vessels and created economies of scale for owners of the largest boats.

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64. David A. Hounshell, "Du Pont and the Management of Large-Scale Development," in *Big Science: The Growth of Large-Scale Research*, 236-261; cf. James Burke, *Connections* (Boston: Little, Brown, 1978), and Burke's television series *Connections* and *Connections*^{2}.

By 1959, the use of cotton nets in Peru had almost disappeared. Because of their sheer size, besides sweeping the sea of the guano birds' food, these nets caught and drowned thousands of birds.

As with SONAR and nylon nets, the fishmeal industry imported most of its capital goods from the Northern Hemisphere in the beginning, especially from the defunct California sardine industry. But by the late 1950s, the Peruvian fishing industry had far surpassed the maximum size of its "parent," and the Peruvian economy rapidly developed its own manufacturing industries to supply large wooden- and steel-hulled ships, reduction equipment, plant buildings, and other capital goods to the fishmeal boom. By the early 1960s, for example, the Peruvian firm Textil Marítima (est. 1950) had given up manufacture of cotton nets--to the detriment of Peruvian cotton growers--and begun to produce a range of nylon nets using Du Pont filament on British- and French-built looms, many for export.

The fishmeal boom also inspired lucrative local innovations. Hidrostal was a firm founded by a Swiss hydraulic engineer who had immigrated to Peru years before the fishmeal boom. Martin Stähle got his start designing irrigation pumps for coastal agriculture. At the behest of a Peruvian fishmeal plant manager, in 1957 he designed a helical-impeller pump that could remove fish from pursed nets without mutilating them. This delayed their deterioration and extended the range of fishing fleets. More importantly, the use of these pumps greatly increased the efficiency of loading and unloading fish. Hidrostal's founders obtained an international patent for this superior pump and manufactured it and exported it to the world. This created an immense demand, in turn, for reinforced rubber hose to carry fish from net to ship to factory, most of which had to be imported from the United States or Great Britain.

Many economic factors drove entrepreneurial competition for anchoveta and the adoption of new fishing technologies to catch them. One of these, surely, was the well-known "tragedy of the commons," the drive to maximize individual profit from an ownerless and unregulated natural resource.[65] These new technologies also reduced much of the drudgery and dramatically increased the speed of the fishing process. On the other hand, they eliminated the need for many manual workers--who, unlike machines, required managerial discipline, could demand pay raises, or even go on strike. These were not major issues, however, as long as the industry kept growing.

Finding and catching anchoveta was only half the story. The conversion of wet, perishable fish into dry, inert fishmeal also required the direct transfer of reduction plant technology from the California sardine industry. This process took a couple of attempts and several years to complete. But the basic process of fishmeal manufacture in Peru was already set in the original plan for CAG's fishmeal reduction plant drafted by Luis Gamarra. Later plants incorporated some technological innovations, but not to the revolutionary extent that anchoveta fishing vessels did.

When purse-seine trawlers returned to port, they first unloaded their catch into lighter vessels or directly at the dock of a fishmeal plant (illus. 46, a, b). Initially this was done by hand; the later adoption of Hidrostal's helical impellers

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65. Garrett Hardin, "The Tragedy of the Commons," *Science* 13 Dec. 1968, 1243-1248.

greatly speeded up this process and reduced the need for manual workers on shore, as well. The fresh fish were then weighed and placed in large storage tanks (c), usually made of concrete. These measurements provided the basis for official catch statistics and did not account for fish already discarded by the trawlers. Mechanized conveyors and elevators (d, e) lifted the fish into a cooker (f) where they were steam-heated at 80 to 100 degrees Celsius. The cooked fish passed automatically to a press (g) that removed liquid which was then transferred to oil separators (h) and to a boiler (i) for further processing. The pressed solid cake passed to a disintegrator (j) where it was broken up and then lifted into a rotating, cylindrical hot-air dryer (k). A mill (l) broke up the resulting dried solid, while a centrifuge (m) removed insoluble solids from the remaining liquid and returned them to the dryer. Like guano, the fully processed meal was then packaged in jute sacks imported from South Asia (n, o) and lowered to a warehouse (p) for curing. Subsequent plants eliminated the warehouse which was necessary on the rainy U.S. West Coast but superfluous in extremely arid coastal Peru. In the late 1960s, one Peruvian company developed a chemical stabilizer that skipped the curing process altogether, while W. R. Grace & Co.'s Paramonga sugar complex established a local industry for producing paper sacks. By the mid-1960s, Peruvian plants as a whole produced approximately 1 ton of fishmeal from every 5.41 tons of anchoveta unloaded at the plant, quite a bit short of the 1:4 efficiency Gamarra originally claimed would replace millions of avian beaks, crops, gullets, stomachs, intestines, and cloacas.

These plants were not environmentally benign. They required immense quantities of energy from either Peru's stressed electrical network or on-site diesel generators--another element "externalized" from Gamarra's conversion efficiency calculations. Chimbote emerged as the fishmeal capital of the world in the 1950s for several reasons that had nothing to do with the biologically productive upwelling region close offshore. One of the few achievements of the industrial policy of Manuel Prado's first government during the early 1940s, other than the establishment of a fish-canning industry, was the development of a hydro-electric complex and steel mill in the Chimbote region. As part of this project, an international team of male engineers and hygienists drained over 225,000 square kilometers of wetlands surrounding Chimbote and installed potable water and sewage facilities, while female social workers kept a close watch over the local population to eliminate the threat of disease and encourage "healthy" urban growth.[66]

Peru's first fishmeal plants simply dumped their waste water into the ocean. This created an enormous marine pollution problem.[67] Effluent from these plants literally killed off artisanal fishing around the ports of Chimbote and Callao. Later plants (four-fifths by 1968) added cleaners that removed most solids from waste water in order to produce more fishmeal. A few advanced plants incorporated expensive, stainless-steel stickwater processers that obtained even more product,

66. Elba Tolentino Aguilar, "El impacto industrial en Chimbote," *Pesca* June 1961, 87-90, 93-94, 96-97; *Peru: Obra de gobierno del presidente de la República Dr. Manuel Prado*, 43-48.

67. Luis Arriaga M., "Contaminación en el Océano Pacífico Suroriental (Ecuador-Perú-Chile)," *Revista de la Comisión Permanente del Pacífico Sur* 5 (1976), 3-62.

reducing the amount of water pollution in the process. Plant managers adopted these innovations, however, not to reduce water pollution, but to increase the efficiency of their operations. Unfortunately, there was no purely economic reason to put a stop to the most notorious pollution problem caused by fishmeal plants: the production of noxious fumes. Immense public outcry in Lima against the horrible, fishy stench and smoke that pervaded even the richest neighborhoods of this rapidly growing metropolis led the Peruvian government to issue a series of decrees in the early 1960s regulating air pollution by fishmeal plants. Despite the strongest possible protests from industry executives, one such decree closed down all fishmeal factories in the Lima-Callao metropolitan area until they installed air-filtering equipment. Even though the government offered emergency low-interest loans to make this regulation easier to bear, many simply moved elsewhere or closed down altogether. This act farmed out Lima and Callao's pollution problem to provincial cities with less political influence in Peru, where the "smell of money" and fishing industry jobs was sweet enough to overcome the stench of pollution steaming from their smokestacks.[68]

All of these technological installations and improvements required money, of course--lots of it. Local capital markets played a crucial role in the fishmeal

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68. The above section on fishing and processing technologies is based on a detailed reading of the illustrated engineering and trade journal *Pesca* (Lima) 1:1 - 27:6 (Oct. 1960-Dec. 1973). Other sources include Roemer, *Fishing for Growth*, 22, 66, 83-84; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 60-61, 64-68; Thorp and Bertram, *Peru, 1890-1977*, 244; Tarnawiecki, "A Survey of the Development of Oceanic Fisheries in Peru," 129-131; Belaúnde, *La legislación pesquera en el Perú*, 82-83, 159-159, 181-182; Gamarra, "La industria de la fabricación de harina de pescado en el Perú," passim; idem, "Relación entre la cantidad de alimento ingerido por las aves guaneras y el guano aprovechable que producen," in Lanatta, *Informe*, 65-74.

boom. With international demand and prices for fishmeal so high, Peruvian petty capitalists discovered that they could rapidly recoup their investments in nets, motorized craft, and plant facilities, so they were willing to pay extraordinarily high rates of interest to local lending institutions. Peruvian banks, encouraged by the loose fiscal policy established by the second Prado administration in 1956, pumped vast amounts of capital into the industry with short-term, renewable loans. This rapidly created an immense vested interest in the industry's short-term financial success that pushed long-term considerations of industry welfare--and the health of Peru's marine environment--to the sidelines of political debate.[69]

New technology, easy credit, and profit margins as high as 90 percent per year helped to create enormous fortunes for a few lucky investors. Luis Banchero Rossi (1929-1972) was the golden boy of the fishmeal boom. He began his working life at the small liquor store of his Italian-Peruvian parents in the southern city of Tacna. His mother envisioned better things for her son but feared sending him to the predatory metropolis Lima, and so arranged for him to live with her family in Trujillo where he matriculated at the local university. While he studied chemical engineering in order to raise his social standing by becoming a technician, Banchero worked as a salesman with ties to the local cane sugar industry. In 1951, after finishing his classwork, he put his technical career on hold to devote himself full-time to the sale of petroleum lubricants. In 1955, Banchero traded this interest in this business for a small bonito cannery in Chimbote. He quickly converted it to fishmeal production and bought his first motorized vessel and nylon purse-seine

69. Thorp and Bertram, *Peru, 1890-1977*, 245.

outfit. Like Manuel Elguera, Banchero got expert assistance along the way. In 1957, he and Wilbur-Ellis entered a partnership to build the gigantic Pesquera Humboldt fishmeal plant in Chimbote. Banchero rode the wave of the fishmeal boom to the top. By 1960, he was the second biggest fishmeal producer in the world (after the U.S. Gulf Coast's "king of menhaden" and chicken feed Harvey Smith) and said to be the richest man in South America. He was widely considered to be one of the oligarchs who ruled Peru, and his company as the definition of "a technified industry, with plans, with trained men." His rags-to-riches story heightened the mystique of entrepreneurship and managerialism and became a rallying point for proponents of developmentalism in Peru.[70]

Contrast Banchero's success as the definitive "self-made man" to the fate of the Graña brothers, well-born sons of the Aristocratic Republic. A member of their family had been present at the very first meeting of CAG shareholders in 1909 and unsuccessfully stood election to its board of directors. The Graña's Huando estate had been one of CAG's biggest guano customers. In 1961, these agribusinessmen took a big risk and sold out their interest in cotton cultivation to buy into the fishmeal boom. Within two years, they owned the third largest fishmeal company in Peru--only to go bankrupt a year later as Chancay, the fishing city they helped build overnight, became the first coastal boomtown to suffer the downside of overly rapid expansion.[71]

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70. "El magnate de la pesca peruana," *Pesca* Oct. 1960, 22-26; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 62; Gilbert, *The Oligarchy and the Old Regime in Peru*, 342; *Diccionario histórico y biográfico del Perú*, s.v. "Banchero Rossi, Luis."

71. See table 5; "Otro agricultor de la pesca," *Pesca* Sept. 1961, 39; "Los 15 grandes," *Pesca* Apr. 1963, 51; "Quiebran empresas de Graña," *Pesca* Sept. 1964, 32; "Chancay tuvo su bonanza," *Pesca* Feb. 1966, 12-16; "Información comercial: Banco Alemán Transatlántico [sic, see

In sum, experts played a pivotal role in the initiation of the Peruvian fishing industry, both during its initial, food-fish producing phase (1942-1953), and the fishmeal boom that succeeded it. In Luis Banchero's case, a chemical engineer became Peru's biggest fishing tycoon. During the decade that followed the 1954 guano-versus-fishmeal controversy, Peruvians industrialists maintained a semblance of control over the production and use of new, more efficient fishing technologies. Though they required the help of a variety of technicians, their success did not depend on marine science. In the process, Peru's coastal environment became integrated into a new transnational economy involved, not only in feeding chickens and hogs in the Northern Hemisphere, but also in supplying capital goods to the world's other burgeoning industrial fisheries. In many aspects, the Peruvian economy appeared to have "taken off" on a developmental trajectory of its own, just as historian and presidential advisor Walt Rostow's "non-communist manifesto" predicted would happen when underdeveloped economies reached the right "stage of growth."[72]

But the fishmeal boom always had its downside. Peru never came close to self-sufficiency in supplying the fishmeal industry, as proponents of import-substituting industrialization during this era would have liked. More troublingly, the fishmeal boom was fueled almost entirely by enormous debt. It was never as efficient as its boosters claimed it would be, especially taking into account the vast

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correction "Información comercial: Compañía Administradora del Guano," 12 Apr. 1909 (morning ed.) p. 1, col. 6]," *La Prensa* 11 Apr. 1909 (morning ed.), p. 2, col. 1.

72. See W. W. Rostow, *The Stages of Economic Growth: A Non-Communist Manifesto* (Cambridge, UK: Cambridge University Press, 1960), esp. ch. 4.

amounts of energy it consumed and pollution it produced. Meanwhile, a new vested interest came into being. It grew larger with every sol lent, every fish caught, every dollar garnered for processed meal, every dollar paid to a worker or capital-goods manufacturer. Most importantly, technology transformed the very nature of fishing in Peru's coastal waters: from a labor-intensive to a capital-intensive endeavor, from a relatively innocuous industry that depended on the guano birds to catch anchoveta, to a potent ecological force that could outcompete the guano birds for fish--and potentially destroy the fishery itself.

In the midst of all this, high-level government planners consciously decided to put the guano industry at risk in the name of national economic development while they waited for science to rule on the "highest use" of Peru's marine environment. CAG could not produce hard evidence that a large-scale fishing industry threatened the well-being of the guano birds--which, until the 1957-1958 El Niño, were flourishing better than they had in human memory. The guano birds paid the price for this delay, just as Robert Cushman Murphy had warned.

Chapter 8

Replacing the Guano Birds

As a result of the intervention of man, . . . it would not be surprising if the extinction of the guano birds were closely followed by the extinction of the anchoveta.

--*El Comercio* editorial (1966)

Technocrats were never able to reconcile all the conflicts associated with exploitation of Peru's marine environment, yet Peru's rulers never gave up their faith in the technocratic ideal.

In the late 1950s, during yet another moment of economic and environmental crisis, Peruvian state officials decided to place their trust in a different kind of technocrat, an economist, who thought the free market should be allowed to resolve the guano versus fishmeal controversy. This allowed the fishmeal industry to grow unabated at a criticial juncture.

Others put their trust in state-managed import-substituting industrialization. By the late 1950s, the guanay and piquero had clearly lost their position as "the most valuable birds in the world" to the industrial North's new super chickens. Most of Peru's agro-exporters had long since lost interest in the guano industry and were looking for new cheap sources of fertilizer. Though they supported free-market economics in some realms, they campaigned for the development of an import-substituting chemical industry that could produce nitrogen fertilizer via the Haber-Bosch process.

The Peruvian guano industry could have produced fertilizer in perpetuity for Peru, but its future prospects for growth were limited. It was also sensitive to environmental change. The El Niño phenomenon initiated two big crashes in the guano bird population in 1957-1958 and 1965. The guano birds failed to recover from the second crash--a clear indication that the Peruvian fishmeal industry, as long feared, had grown so large that it was stealing the birds' food. This inspired immense public outrage against an industry already responsible for polluting a number of Peru's coastal cities with noxious-smelling effluent and fumes. Peruvians were also well-aware that this industry existed solely to provide First World consumers with as much cheap pork and chicken as they wanted, while Peru's poorest children starved.

Any grounds for coexistence that had once existed between the guano and fishmeal industries had long since eroded away. Too many vested interests liked "the smell of money" emanating from the fishing industry's smokestacks to put controls on the industry merely to save Peru's poor marine birds. So Peru's rulers--with the support of key experts--consciously allowed the guano industry to pass into oblivion. They hoped Peru's nascent chemical industry would soon be able to replace the guano birds as fertilizer manufacturers.

By the mid-1960s, all this industrial "progress" had begun to threaten public order. Peru's lower classes, especially rural peasants pouring into Lima, Chimbote, and other industrial cities looking for work, became increasingly restive about the paltry benefits they were receiving from economic growth. In a few regions, guerrilla *focos* sprang up that sought to overthrow the "oligarchy" that continued to monopolize wealth and power in Peru. These popular movements, as they had so often done, served to reinforce Peru's technocratic tendencies. In fact, they paved the way for reformist military officers to seize control of the Peruvian state in order to establish a redistributive "bureaucratic-authoritarian" government premised on the technocratic ideal.[1]

By the time the Revolutionary Government of the Armed Forces took power in 1968 to put a lid on social unrest, the internal momentum of the fishmeal industry was so great that not even the military could control it. Nevertheless, they thought they could. By the 1960s, experts had repeatedly proven their ability to manage production from Peru's marine environment, and there was good reason to believe that this success would continue. But Peru's marine environment turned out to be much more variable and unpredictable than even experts on the El Niño phenomenon imagined. In 1972-1973, a strong El Niño event came along that put the anchoveta population to its first severe test since the fishmeal industry had reached truly gargantuan size. The anchoveta fishery collapsed.

But this was hardly a natural disaster. Well-informed officials advised by the world's best marine scientists made conscious, deliberate decisions that carried Peru to the brink of ecological cataclysm. Peru's economic planners carried their country over the brink, as they tried to manage a series of simultaneous economic crises. Misplaced faith in technocracy, not technology run amok, ultimately doomed the fishmeal industry. It took two decades for Peru's marine industries to recover. Peru's guano birds never did.

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1. See Cotler, *Clases, estado y nación*, esp. ch. 7, esp. pp. 347, 353, 365; Stepan, *The State and Society*, pt. 2.

Steps toward an Ecological Disaster

The fortunes of fishmeal entrepreneurs like Luis Banchero notwithstanding, a few powerful men never forgot the dire warnings of William Vogt and Robert Cushman Murphy. Even though state credit policies were driving the fishmeal industry's growth, President Manuel Prado attempted to rein in its uncontrolled expansion by other means. In December 1956, he suspended licensing plant expansions and construction of new plants, claiming that the fishmeal industry potentially threatened "the equilibrium of the biological chain" of the Peru Current ecosystem. In other words, Peru's guano birds, bonito, and lobos del mar needed state protection. This decree was issued, however, only as a precautionary measure while scientific studies continued. Like so many regulations of this type, it included a grandfathering clause for plants under construction and allowed the licensing of new construction as long as the builder promised to refrain from using anchoveta--a requirement that was obviously difficult to enforce. It was also motivated as much by the "not in my backyard" advocacy of influential coastal citizens who did not want to live with the putrid fumes and effluent of fishmeal plants as it was by any desire to regulate the factories' productive capacity. Government corruption and the speculative sale and transfer of licenses further undermined the Prado administration's attempts to regulate the fishmeal industry in this manner, much less protect the guano birds.[2]

2. *MCAG* 48 (1957), 25-26; Belaúnde, *La legislación pesquera en el Perú*, 141; Caravedo, *Estado, pesca, y burguesía*, 47-48, 142-143; Thorp and Bertram, *Peru, 1890-1977*, 246.

Then came the "ecological depression" CAG had long dreaded. In 1957-1958, a strong El Niño event struck Peru after years of cooler than normal oceanic temperatures and a decade of CAG's policy of creating artificial guano "islands" at several coastal points. This event devastated the guano bird population (fig. 9). Under the careful watch of CAG's marine scientists, the estimated nesting adult guanay population, which had peaked at 33.5 million in August 1955, plunged to a low of 3.1 million in January 1958 (normally prime nesting season). The nesting adult piquero population in Peru, meanwhile, fell even more precipitously from a high of 4.2 million in December 1956 to only 160,000 in July 1957. The nesting alcatraz population suffered most of all, declining from as many as 1.3 million in March 1955 to as few as 20,000 in August 1957. A substantial part of these abrupt downswings can be ascribed to migration, but many of these birds never returned--having died of starvation, disease, or predation somewhere along the South American coast. Where they went mattered little, of course, to the millions of chicks they left behind to die and the humans who stood to profit from their excrement. Production of guano *rico* plummeted accordingly from an all-time high of 332,223 metric tons in 1956 to 108,919 metric tons in 1959. Both CAG and Peruvian farmers sought to make up for this short-fall by increasing their imports of Chilean nitrates and manufactured fertilizers from abroad.[3]

CAG officials desperately tried to make sense of this catastrophe. In 1957, they sent six of CAG's scientific cadre on a series of oceanographic cruises and

3. See app. 2; Tovar, Guillén, and Nakama, "Monthly Population Size of Three Guano Bird Species off Peru," 208-218; *MCAG* 50 (1959), x, anexos; Robertson, *The Peruvian Fertilizer Industry*.

tours of the guano islands. After hundreds of bird autopsies and a brilliantly conceived experiment that revived several moribund birds, they definitively proved that lack of food was the root cause of this disaster. But to cover all its bases, CAG directed its workers in 1958 to intensify their "prophylaxis" of the islands, eliminating bird cadavers and destroying the areas favored by bird ectoparasites in the futile hope that disease prevention might stem this holocaust. CAG's scientists even tried using Aldrin, benzene hexachloride (BHC), and other persistent pesticides to try to get rid of these parasites. Luckily, these wrong-headed experiments failed, as these chemicals are now known to cause egg-thinning, breeding failure, and direct poisoning in the very birds CAG was trying to protect. On the regulatory side, CAG called for "more energetic methods" against the "frenetic" fishmeal industry, including size limits, a closed season, even a ban against use of the purse seine. "The dynamic equilibrium between the guano bird and anchoveta can be broken by man, leading to the extinction of both species," CAG's managers pleaded. "Man is capable of exhausting any natural resource, and we [must] remember that . . . sea lions, conches, and oysters were nearly exterminated from our coast" by human mismanagement. To pacify CAG, the Ministry of Agriculture held a roundtable meeting of experts in September 1957, but little came of it.[4]

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4. *MCAG* 49 (1958), vi-vii, 7, 10, 12-14, 18, 21; *MCAG* 50 (1959), v; Barreda, "Recuperación de guanayes (Phalacrocorax bougainvillii) caquecticos en cautividad"; Rómulo Jordán to Luis Massa Giuffré, "Informe sobre experimentos con garrapaticidas," 15 Apr. 1960, ACAG-Isla Don Martín.

This El Niño event had little effect on Peruvian fishermen, who besides following the guano birds to schools of fish could use two-way radio, echolocation, deep-reaching nets, and airplanes in their search for anchoveta. By most appearances, it looked like El Niño benefited them: anchoveta production and fishmeal exports increased by *over 600 percent* from 1956 to 1958. In fact, Peruvian fishermen caught more fish than was good for them: their export income only increased by 20 percent during these boom years as Peru glutted the world protein market. This uncontrolled expansion for so little financial gain, as much as the sufferings of the guano industry, inspired President Prado to issue strict regulations against the fishmeal industry in December 1958. Prado restricted the time, season, location, and net size of anchoveta fishing, particularly around the guano islands, and prohibited the transfer of production licenses from old to new reduction plants (although not to floating plants, the scourge of the California sardine). Lawbreaking fishermen and plant owners were threatened with fines and confiscation, albeit small ones: for plant owners S/.1,000 (US$36) on the first offense, S/.10,000 (US$360) on the second, temporary closure on the third, and permanent confiscation on the fourth. These laws would remain in place while "biological studies . . . determine the maximum yield possible that will protect the national economy."[5]

Meanwhile, larger forces worked in tandem to undo this attempt at a state fishery conservation policy. The El Niño-Southern Oscillation cycle did not hurt

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5. See app. 9; *MCAG* 50 (1959), 14-17; Belaúnde, *La legislación pesquera en el Perú*, 372-375; Caravedo, *Estado, pesca y burguesía*, 47-48.

just the guano industry. The one-two punch of a severe “La Niña” event in 1955-1956 followed by a strong El Niño warm event in 1957-1958 depressed crop production all over Peru. Generalized drought conditions in much of the Sierra were topped off by massive food-crop failures and near famine on the altiplano around Lake Titicaca in 1957. Export crops were also affected. Sugar cane yields per hectare harvested in 1957 were their worst, by far, since 1938.[6]

Peruvian agribusinessmen could not simply blame the weather for these problems. As we have seen, as part of the drive to maximize Tangüis cotton production, most of the central Peruvian coast had been converted to an almost continuous, year-round monoculture. This created ideal conditions for an insect plague. Problems started in the late 1930s, but widespread use of arsenical dust, crop rotation, reduced wartime planting, and a resurgence of the pests’ natural enemies caused the problem to die down in the early 1940s. After the war, high crop prices led cotton planters to choose a new strategy to maximize crop production: beginning in 1946, they applied vast quantities of two brand-new insecticides, DDT and BHC, both products of the Northern Hemisphere’s vast military-chemical complex.[7] Cañete Valley cotton planters were among the first in Latin America, or anywhere in the world, for that matter, to use chlorinated organic pesticides on a large scale. They enthusiastically served as experimental guinea pigs for this powerful, but flawed new technology.

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6. Thorp and Bertram, *Peru, 1890-1977*, 278-279; Portocarrero, Beltrán, and Romero, *Compendio estadístico del Perú*, 40, 42.

7. See Russell, *War and Nature*, esp. ch. 7-9.

Not everyone was a convert to these new insecticides. The cotton bollworm (*Heliothis virescens*) soon developed resistance to these poisons. The German-Peruvian entomologist Johannes Wille, a long-time friend of Erwin Schweigger and student of the guano birds' parasites, became increasingly concerned with these chemicals' adverse impact on the natural insect predators of crop pests. Cotton productivity actually fell during the late 1940s. But by steadily increasing their applications of chemicals, cotton growers were able to boost productivity in the early fifties, only to see it fall precipitously in 1956 and 1957 due to insecticide resistance and a sudden plague of secondary crop pests encouraged by abnormal weather conditions and the extermination of their natural enemies. Export income fell precipitously. Wille's philosophy of "integrated pest management" eventually won over Peruvian cotton farmers, as a consequence.[8]

In short, the economic crisis of the late 1950s was partly an ecological crisis affecting input-intensive agriculture. But to high-level economic planners, these problems paled in comparison to those created by the sharp recession that hit the international economy in 1957. As a consequence, the Peruvian economy suffered its worst balance-of-payments shortfall of the 1950s and its worst trade deficit since before the turn of the century, partly because the loose credit policies that had been

8. See fig. 3, 5 and app. 6-7; Wille, "Biological Control of Certain Cotton Insects and the Application of New Organic Insecticides in Peru," *Journal of Economic Entomology* 44:1 (Feb. 1951), 13-18; Edson J. Hambleton, "*Heliothis virescens* as a Pest of Cotton, with Notes on Host Plants in Peru," *Journal of Economic Entomology* 37:5 (Oct. 1944), 660-666; Teodoro Boza Barducci, "Ecological Consequences of Pesticides Used for the Control of Cotton Insects in Cañete Valley, Peru," in *The Careless Technology: Ecology and International Development*, ed. M. Taghi Farvar and John P. Milton (Garden City, NY: Natural History Press, 1972), 423-438; Douglas L. Murray, *Cultivating Crisis: The Human Cost of Pesticides in Latin America* (Austin: University of Texas Press, 1994), 15, 37.

driving the expansion of the fishmeal industry had allowed purchases of imported consumer goods to rise.[9]

Late in 1957, Prado called out for help. Foreign economists from the International Monetary Fund (IMF), the world's "money doctors" of the late twentieth century, gave Peru's central bank a substantial line of credit to defend the sol on foreign currency markets with the understanding that Prado would impose austerity measures on the Peruvian economy and wait for export income to recover. Prado balked at their suggestions: On the one hand, if he put the squeeze on wages and salaries, he risked losing the support of APRA and stirring up massive labor unrest. On the other hand, if he imposed direct currency exchange controls, he would take away the ability of rich men like himself to protect their wealth by converting it to foreign currency and removing it from the country. Prado's government instead tried to compensate with increased deficit spending, but this only worsened the balance-of-payments situation and plunged Peru into an even deeper recession and political crisis. In 1959, the Peruvian Congress gave a vote of no-confidence and Prado's democratically elected coalition government nearly fell to pieces.[10]

In July 1959, Prado appointed a well-known technocrat to clean up this mess. This decision had dire long-term consequences for Peru's entire marine ecosystem. Pedro G. Beltrán Espantoso (1894-1979, illus. 47) was an outspoken representative of the far right in Peru. He was fiercely dedicated both to the free-

9. Bertram, "Peru, 1930-60," 8:443, 446; Portocarrero, Beltrán, and Romero, *Compendio estadístico del Perú*, 168, 170.
10. Bertram, "Peru, 1930-60," 8:442-444, 446-447.

market principles of classical economics and the protection of wealthy interests, and he felt no compunction against using authoritarian means to ensure a laissez-faire climate for business in Peru. His basic remedy for every social problem was increased per capita production, based on his emphatic belief that increased wealth would somehow trickle down to Peru's poorest. He was a true forerunner of the Chicago Boys and other neoliberal technocrats of the late-twentieth century, and his life personified the convergence of many strands of Peruvian history since CAG's foundation.

Beltrán was born into one of Peru's most powerful agro-exporting families and went to school with the sons of key members of the Aristocratic Republic. He earned an economics degree at the London School of Economics in 1918, but opportunities were few for an economist in Peru, even one with such prestigious training, so he took up cotton farming in the Cañete Valley south of Lima upon his return. During the 1920s, Beltrán totally transformed the management of his 490-hectare Montalván estate. He personally established a regional experimental agronomy station for this center of Tangüis cotton cultivation, hired agronomists and plant breeders to manage his plantation, mechanized its cultivation, and was reputedly the first Peruvian to employ a crop duster to apply arsenical insecticide to his crops. Beltrán benefited as much as anyone from CAG's services: Under his tenure, Montalván quickly rose to the ranks of CAG's top 25 guano customers of all time.[11] Beltrán was a model scientific farmer.

11. See table 5.

While he engaged in these endeavors, Beltrán began his rise as one of the supreme spokesmen of the agro-exporting class in Peru: first as the founder of a local farming association for the Cañete Valley, then as president of the Sociedad Nacional Agraria, then as a founder of the ultra-conservative Partido Nacional Agrario with agronomist Gerardo Klinge. But Beltrán never gave up his identity as a British-trained economist. By the time he took control of Peru's political economy in 1959, Beltrán had a long record when it came to the technocratic management of Peru's monetary system under authoritarian governments, first as director of the Banco Central under Luis Sánchez Cerro's Depression-era military government, then as a big supporter of General Manuel Odría's 1948 military takeover. As director of the Banco Central de Reserva under Odría, with the encouragement of a team of U.S. economists known as the Klein mission, Beltrán oversaw the shift to a laissez faire economic policy--with the obvious exception of vast government spending in irrigation works. An unprecedented agro-exporting boom ensued that went a long way toward reconstituting Peru's old oligarchy.[12]

Beltrán turned into a vocal critic of Odría's regime, however, when his superior (with the IMF's support, in this case) stopped supporting his monetarist prescriptions. Beltrán countered by inviting Austrian economics professor Ludwig von Mises, one of the founders of neoliberalism, to stand by his side when he stepped down as Peru's central banker in 1950. Latter-day technocrats routinely used this tactic to recruit support for their economic prescriptions. Beltrán had other propaganda tools at his disposal. Since 1934, he had owned a large share of

12. See fig. 3-6 and app. 5-6.

the Lima daily *La Prensa* and frequently used it to broadcast his political and economic doctrines. He ended up in prison in 1956 for his negative press campaigns. Thus, this agent of authoritarian governments unjustly became an international icon of freedom of the press in Latin America.

In stark contrast to Odría, Manuel Prado in 1959 gave his prime minister free reign over state economic policy. Beltrán immediately hatched a plan designed to please the IMF and to make his idol von Mises proud. Among his many stabilization procedures in 1959, Beltrán devalued the sol markedly, raised fuel prices, and established special tax exemptions for business. But his most significant act for the subject at hand was his decision to revoke all laws limiting the growth of the fishmeal industry in order to "stimulate the commercial development of the country on the basis of free enterprise." To serve the ideology of this new breed of technocrat--the neoliberal macroeconomist--the Peruvian government jettisoned policies designed to protect the guano industry, thus setting the stage for the rapid growth of the fishmeal industry. The international economy cooperated with Beltrán's designs: the recession passed. Anchoveta production and income from fishmeal exports mushroomed. The planting and production of cotton and sugar cane also went up sharply, pest and fertilizer supply problems notwithstanding.[13] This export boom turned into a general economic boom. Beltrán looked like an economics genius, though his policies benefited the rich far more than the poor who were in the process of creating vast, unplanned shantytowns (*barriadas*) on the outskirts of Lima, Chimbote, and other cities.

13. See app. 6, 9.

In 1962, Beltrán tried to use his technocratic achievements to springboard to the presidency, but he had an entirely misplaced sense of his own popularity. He failed to recognize that the general populace, most of whom benefited little from his economic reforms, hated him more than any other figure on the Peruvian political scene, particularly for his unending attacks on "wage inflation." Beltrán often accused Peru's "overpaid" workers, like the guano birds, of "consum[ing] more than they produce." This producer of export cotton also shamelessly appropriated the overpopulation rhetoric of William Vogt to oppose any sort of government land reform--since it might threaten agricultural productivity, lead to "mistreated land," and threaten the world's food supply. Many in Peru's political elite disliked just as much Beltrán's haughty belief that he held a monopoly on economic truth. He quickly dropped out of the race and government, but left behind a legacy that contributed significantly to later social unrest and political instability in Peru. Years before the triumph of Friedrich von Hayek and Milton Friedman's Chicago Boys under Augusto Pinochet, much less the rise of Jeffrey Sachs and other neoliberal economists at the end of the Cold War, this free-market technocrat fundamentally changed the course of his country's ecological history by "liberating" Peru's marine environment from state intervention.[14]

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14. This biographical section is based on the following: Arturo Salazar Larraín, introduction to *Pedro G. Beltrán: Pensamiento y acción (selección de textos)* (Lima: Instituto de Economía de Libre Mercado, 1994), 7-21; see also selections of Beltrán's own writings, pp. 26-33, 50-51, 94-97, 157-161, 214-216, 218-220, 226-229, 373-378, 445-452; César Hildebrandt, *Cambio de palabras: 26 entrevistas* (Lima: Mosca Azul Editores, 1981), 96-98; Belaúnde, *La legislación pesquera en el Perú*, 144-145; *MCAG* 51 (1960), 25-27; *MCAG* 54 (1963), 21-24; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 81-86; Bertram, "Peru, 1930-60," 8:420-422, 436-447; Pike, *The Modern History of Peru*, 273-274, 296-299; Gilbert, *The Oligarchy and the Old Regime in Peru*, 342, 352-358; Malpica, *Los dueños del Perú*, 87;

Of course, the Peruvian fishmeal boom was not all one man's accomplishment, even if some of Beltrán's worshippers liked to think otherwise. In fact, it was as much a product of the formation of an international cartel--the antithesis of the free-market economy--as it was of the liberalization of the political economy of the Peruvian state. In 1959, a serious slump in the global price of fishmeal stimulated by the rapid rise in fishmeal supply and speculation in fishmeal contracts threatened to end Peru's fishmeal boom. Several fishmeal exporting countries got together to form a cartel. Peruvian fishmeal entrepreneurs held out at first, in the belief that they could run their international competitors into the ground by underselling them. But the slump continued, and in October 1960, led by Elguera and Banchero, Peru joined most of the world's other major fishmeal producers in a Fishmeal Exporters Organization. To ensure their participation, Peruvian producers obtained a generous quota, a guaranteed 60 percent of world production. Conservation rhetoric played into Peru's strategy: Banchero, Peru's biggest producer, claimed he would only accept limitations "that come from a biological-technical study. . . for conservation purposes, . . . not for the convenience of international markets," but he eventually gave into the cartel. With the notable exception of Gildemeister & Co., which marketed its fishmeal exports through its vast agribusiness headquartered in Bremen, Germany, practically all of

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Diccionario histórico y biográfico del Perú, s.v. "Beltrán Espantoso, Pedro"; *Enciclopedia ilustrada del Perú*, s.v. "Beltrán, Pedro."

Peru's major producers joined the Consorcio Pesquero del Perú, S.A., a national cartel with the sole power to market Peru's export quota.[15]

In a remarkable convergence between the guano and fishmeal industries, Roque Romero Cárdenas (b. 1912) was recruited to head the Peruvian Fishing Consortium. He was a lawyer by training who spent many years working his way up through the ranks of CAG's management hierarchy. He left CAG to become the bureaucratic head of the Odría regime's new health and social security program. In October 1954, he returned to replace Carlos Llosa Belaúnde as CAG's general manager in the midst of the guano vs. fishmeal controversy, and he took over CAG's campaign against the unregulated growth of the fishmeal industry. Romero left CAG in 1957 when offered the number-one post in Coca Cola's Peruvian operations. As head of Peru's new cartel, arguably the most powerful fishmeal trader in the world in the early 1960s was a former Lord of Guano.[16]

With the institution of this cartel, the international fishmeal price recovered rapidly, and the Peruvian fishmeal boom barely wavered, at least in terms of brute production. By 1964, the vested interest in the Peruvian fishmeal industry was immense. In that year, Peru caught what was then a record 8.863 million metric tons of anchoveta and exported 1.566 million metric tons of fishmeal (99 percent

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15. "El magnate de la pesca peruana," 26; "Paris: Conferencia de productores," *Pesca* Oct. 1960, 33; "Triunfó la anchoveta en París," "Cuotas de exportación," *Pesca* Nov. 1960, 29-31; "Se formó Consorcio Pesquero," *Pesca* Dec. 1960, 37; Roemer, *Fishing for Growth*, 75, 84-85, 182 n. 29; Thorp and Bertram, *Peru, 1890-1977*, 249-250.

16. Ingeniero Agrónomo Armando Rivera Calle, second in command at PROABONOS, the Peruvian guano industry's present-day manager, was present when his uncle Roque Romero received news of the Coca Cola offer, personal communication, June 2001; "El consorcio y su gerente," *Pesca* Dec. 1961, 35-36; *MCAG* 46 (1955), xxix; *MCAG* 48 (1957), 22-26; "Nombramiento de gerente de la Compañía," *BCAG* 30:11 (Nov. 1954), 1; "Cincuentenario de la fundación de la Cía. Administradora del guano," *BCAG* 35:4 (Apr. 1959), 2-4.

derived from anchoveta) worth US$165.7 million. Peru had already passed Japan in 1962 as the number-one producer by tonnage of live fish in the world. By 1964, Peru's catch represented one-fifth of total world production, and its fishmeal supplied two-thirds of global trade in this commodity. In 1965, Peru's fishmeal export income surpassed the value of all its agricultural exports combined, even though the recent kings of Peru's coastal economy, cotton and sugar cane, were bigger than they had ever been. Fishmeal provided more than 28 percent of Peru's foreign exchange, second to mineral exports. The fishing industry as a whole composed more than four percent of Peru's gross national product. To the satisfaction of Peruvian economic nationalists, foreign companies only had dibs on one-quarter of the industry's investments. Peru's industrial working class also had a major interest in the fishmeal industry; it directly employed around 38,000 well-organized, politically active workers whose demands and strikes fundamentally influenced fishery management in following years once the fishing sector stopped growing so rapidly. Ancillary industries employed tens of thousands more. Many ideologues of Third World development came to perceive the Peruvian fishing industry as one of the great industrialization success stories of the age. Some foreign experts--most notably Benny Schaefer--began to promote it as a model for other underdeveloped nations to follow so they could experience their own economic "take-off" and feed the Third World's exploding population.[17]

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17. Key proponents of the idea that ocean products could feed the world include Milner Schaefer, "The Potential Harvest from the Sea," *Transactions of the American Fisheries Society* 94:2 (Apr. 1965), 123-128; C. P. Idyll, *The Sea against Hunger: Harvesting the Oceans to Feed a Hungry World* (New York: Thomas Y. Crowell, 1970), esp. 12, 121-123. For a dissenting (and somewhat inaccurate) view by one of the main "structuralist" ideologues of planned economic development in Latin America, see Celso Furtado, *Economic Development of Latin America: A*

But all was not well with the fishing industry. By 1963, total industry debt was estimated to be as high as S/.3 billion (US$112 million), although no one knew exactly how large it really was. By this time, the fishmeal industry, like the canning industry it replaced, was on the verge of overcapitalization. Its fleet of 1,848 motorized fishing craft and 150 or so fishmeal plants had an estimated capacity to catch and process 13 million metric tons of anchoveta per year, roughly four million tons beyond what it needed. From the time of the price slump of 1959 until the Peruvian state expropriated the industry in 1973, smaller, less efficient producers were constantly on the verge of bankruptcy, especially since larger producers kept upping the ante by upgrading their fishing fleets and refining equipment to get an edge over their rivals. It is testimony to the growing power of the industry--and its continuing state of crisis--that the new civilian government of Fernando Belaúnde Terry lowered taxes on fishmeal to the minuscule level of other export industries when he took office in 1964. Belaúnde's government also created a special subsidiary of the Banco Industrial del Perú to provide credit to keep the boom going, though fishery industrialists were compelled to buy shares in the Banco Industrial as part of the bargain.[18]

This contradiction between incredible prosperity, productivity, and power, on the one hand, and the constant threat that this behemoth would collapse under its own weight and take down Peru's entire social order, on the other, made it all but

Survey from Colonial Times to the Cuban Revolution, trans. Suzette Macedo (Cambridge, UK: Cambridge University Press, 1970), 184-185.

18. See app. 9; Contreras and Cueto, *Historia del Perú contemporáneo*, 292; PESCA-PERU, *Qué ha hecho y adonde va PESCA-PERU* (Lima, 1982), 26; Macera, "El guano y la agricultura peruana de exportación," 497.

impossible to bring the fishmeal industry under control. It had far too much momentum. This did not stop Peru's rulers from looking for a technocratic solution to these problems. But it was already too late to save the guano birds from the wrath of Mother Nature and to prevent the guano industry's sacrifice to the God of National Development.

"Perhaps We Should 'Lose' Guano?"

While the Peruvian fishmeal industry was approaching its high-water mark, the Peruvian guano industry withered away under its onslaught. The guano bird population recovered after the 1957-1958 El Niño, a clear indication that its initial decline was mainly related to environmental conditions and that CAG's bird management policies were still performing their intended function. But their numbers leveled off far short of their recent glory (see fig. 9). Direct competition with anchoveta fishermen was cutting into the carrying capacity of the marine environment for the birds.

Guano production also recovered somewhat, but with the booming agro-export economy of the early 1960s, CAG never could fulfill more than a quarter of national demand. Because of this shortfall, Peruvian farmers came to rely more and more on expensive imported fertilizers (fig. 10). They bought the lion's share from West Germany, partly because Peru still had a special relationship with the German chemical industry thanks to Gildemeister & Co.'s long influence, partly because German companies packaged their fertilizer in sacks made from South Asian jute, just as CAG had been packaging guano for over five decades. (U.S.

manufacturers shipped fertilizer either in unfamiliar paper bags or in bulk.) Of course, these imports cut into the profits of Peruvian agribusiness and hurt Peru's balance of trade. Many farmers could not afford them at all. CAG's managers realized the guano industry's days might be numbered, so they directed their agricultural chemists to investigate ways to commercially derive uric acid and other marketable chemicals from guano. CAG completed a uric acid production plant in 1959, but to keep its balance sheet from going into the red, CAG had to export substantial quantities of guano. Since it could no longer supply Peru's fertilizing needs, the Peruvian guano industry was losing its reason for existence as a state development project, especially from the point of view of Peru's agro-exporters.[19]

For the time being, few Peruvians with political clout showed much concern for the guano industry's plight, though CAG's management kept up its incessant criticism of the fishmeal industry, and that old symbol of Peru's decaying oligarchy, the Sociedad Nacional Agraria, kept voicing its lukewarm support. In 1960, the law granting CAG its formal existence was allowed to expire once the foreign loan that Leguía's government had contracted back in the 1920s on the basis of future guano receipts had finally been paid off.[20]

As time passed, more and more people began to agree with the fishmeal industry's position that the time was right to *replace* the guano industry with a modern domestic industry that would eliminate the need to import manufactured

19. See app. 2-6; *MCAG* 46 (1955), xix; *MCAG* 50 (1959), xii; Robertson, *The Peruvian Fertilizer Industry*, passim.

20. "La futura estructuración de la Compañía Administradora del Guano o de la entidad que la suceda, de acuerdo con las necesidades actuales del país," *BCAG* 38:11 (Nov. 1962), 3-5.

chemical fertilizers. A handful of local entrepreneurs attracted by the easy credit and tax advantages offered under the Prado administration elected to start a synthetic fertilizer industry in Peru. In 1957, the first calcium superphosphate manufacturer opened. Three years later, FERTISA started producing ammonium nitrates and ammonium sulfates using the Haber-Bosch process at an expansive chemical manufacturing complex at the mouth of the Rímac River in Callao. But these private companies barely made a dent in fertilizer imports.[21]

Political change accelerated this switch toward import-substituting fertilizer manufacture. After three years of Pedro Beltrán's controversial policies, the presidential election of 1962 ended in a virtual three-way tie--clear evidence of the deep political and social fissures that were threatening to plunge Peru into civil disorder. Presaging the revolutionary events of 1968, a reformist group of military officers took control of the Peruvian state rather than allow a devil's bargain between the populist APRA party and a reactionary right-wing decide who would be Peru's next executive. These officers tentatively embraced state-led developmentalism, a philosophy of government diametrically opposed to Beltrán's laissez faire. As we have seen, this approach had deep roots in Peruvian history, whether under Manuel Prado's first administration, Augusto Leguía's "Nueva Patria," or Manuel Pardo's "Practical Republic." In 1962-1963, this military junta cautiously instituted a series of technocratic commissions, including an Instituto de

21. Robertson, *The Peruvian Fertilizer Industry*, passim.

Planificación (Planning Institute), to consider how the Peruvian state organism could lay out a reformist course for the rest of Peruvian society.[22]

This sort of intervention should be immediately recognizable to those familiar with the "bureaucratic-authoritarian" approach to rule in Latin America. Two years after Peru's reformist military coup, a right-wing junta of military officers seized control of the Brazilian state. They brutally repressed dissent and proceeded to install an elaborate science and technology sector to guide Brazil's national development. Its pharaonic projects helped engineer Brazil's "miracle" of the 1970s. International institutions and programs such as the IMF, World Bank, Inter-American Development Bank, U.S. Alliance for Progress, FAO, even the Economic Council on Latin America (ECLA), legitimated this authoritarian approach to development. It promised to eliminate many barriers to foreign aid programs, while offering a powerful bulwark against the spread of communism.[23] It should be noted, however, that technocratic planning was also a feature of communist Cuba and Latin American governments that did not fall under military rule, particularly Peru's neighbor Colombia where Canadian-born economist

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22. See Contreras and Cueto, *Historia del Perú contemporáneo*, 296-299; Pike, *The Modern History of Peru*, 299-302.

23. Schwartzman, *A Space for Science*, ch. 9; Martins, *Tecnocracia e capitalismo*; Thomas E. Skidmore, *The Politics of Military Rule in Brazil, 1965-85* (New York: Oxford University Press, 1988), passim. For comparative perspectives on the ties between bureaucratic-authoritarianism and developmentalism during the 1960s-1970s, see Kathryn Sikkink, *Ideas and Institutions: Developmentalism in Brazil and Argentina* (Ithaca, NY: Cornell University Press, 1991); Emmanel Adler, *The Power of Ideology: The Quest for Technological Autonomy in Argentina and Brazil* (Berkeley and Los Angeles: University of California Press, 1987); David Collier, ed., *The New Authoritarianism in Latin America* (Princeton, NJ: Princeton University Press, 1979); and the great classic that focused this discussion, O'Donnell, *Modernization and Bureaucratic-Authoritarianism in South American Politics*.

Lauchlin Currie (1902-1993) and his brainchild Planeación Nacional de Colombia (est. 1968) did so much to determine the course of national development.[24]

One thing these approaches to state-led development shared was a dedication to import-substituting industrialization. This was the overarching intent behind the National Fertilizer Plan promulgated early during Peru's new military regime. In 1963, it reorganized CAG as the Corporación Nacional de Fertilizantes (CONAFER) and directed its management to work with a series of foreign technical consultants and a tripartite government commission to build a fertilizer plant close to the oil fields along Peru's northern coast. The Lords of Guano were thus given the charge to develop a new agroecological system for Peru based on domestic production of synthetic fertilizers powered by Peru's natural gas resources and using imported expertise. As is so often the case with technology-transfer projects, the technology of fertilizer manufacture was changing so fast that this unwieldy planning apparatus could not keep up. CONAFER's managers were caught in a classic bind of "underdevelopment": New plans became obsolete almost as soon as they were written, but the cost and complexity of these projects--as well as the influence of foreign funding organizations--was so great that this planning procedure could not be skipped. CONAFER was not allowed to think small. Even the cheapest project under consideration would have built a plant with

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24. See Henderson, *Modernization in Colombia*, esp. ch. 9; Arturo Escobar, *Encountering Development: The Making and Unmaking of the Third World* (Princeton, NJ: Princeton University Press, 1995), passim; Roger J. Sandilands, *The Life and Political Economy of Lauchlin Currie: New Dealer, Presidential Adviser, and Development Economist* (Durham, NC: Duke University Press, 1990); Lauchlin Currie, *The Role of Economic Adivsers in Developing Countries* (Westport, CT: Greenwood Press, 1981); Angel Israel Rivera-Ortiz, "The Politics of Development Planning in Colombia," (Ph.D. diss., State University of New York-Buffalo, 1976).

a daily output capacity of 200 tons of ammonia and 340 tons of agriculturally stable urea for US$20.9 million. Peru's National Fertilizing Plan called for the construction of facilities that were capable of manufacturing, year after year, twice as much nitrogen as the mercurial guano birds did during their most successful season under CAG's management.[25]

Meanwhile, Peru's military government gave another state-owned company the go-ahead to build a fertilizer synthesis plant at Cachimayo in the highlands near Cuzco. This regional company took over CAG's old duty to promote input-intensive agriculture among farmers in Peru's southern Sierra. Its struggles to make a profit illustrate the sort of dilemmas that face these projects once they reach the implementation stagem, and it underscores the tragedy of discarding a proven project such as CAG.

The Development and Reconstruction Corporation of Cuzco wanted to expand a hydroelectric plant on the Urubamba River within sight of the famed archaeological ruin Machu Picchu, but it needed a big electricity consumer in the area to justify the "need" for this power plant. An energy-intensive nitrogen manufacturer fit the bill nicely. But why choose Cuzco over Puno, Ayacucho, Cajamarca, or any other highland department without an industrial sector or input-intensive agriculture? La Convención province on Cuzco's Amazon slope (*montaña*) happened to be the focus of one of several left-wing guerrilla *focos* that

25. "Créase la Corporación Nacional de Fertilizantes: Decreto Ley No. 14502," *BCONAFER* 1:1 (July 1963), 3-4; *MCONAFER* 2 (1965), 9-14; "Informe del Presidente del Directorio al Sr. Senador Fernando Noriega Calmet," *BCONAFER* 4:1-4 (Jan.-Apr. 1966), 13-23; Robertson, *The Peruvian Fertilizer Industry*, 14-17, 32, 55. On the rapid development of ammonia synthesis technology during this period, see Smil, *Enriching the Earth*, ch. 6.

sprang up in rural Peru in the wake of the Cuban Revolution. This one had a significant rural following in a region clamoring for agrarian reform. In accord with the United States' Alliance for Progress in Latin America, Peru's reformist military felt compelled to meet this threat, not with military force, but with a land redistribution and development program.[26] This fertilizer plant became central to its plans for agrarian reform in the Cuzco region. The military junta's civilian successors made sure these projects went forward.

The result was a fiasco. A German contractor completed the Cachimayo plant for the enormous sum of S/.647.5 million (US$24.1 million). When it opened in 1965, it had a production capacity *ten times* greater than the total demand for nitrogen fertilizer in all of southern Peru at the time. Of course, state planners hoped that area farmers would scramble over each other for this new product and pull the Peruvian highlands into the modern world of input-intensive agriculture and high-technology industry in the process. Things did not work out that way. The Cachimayo plant almost immediately filled its warehouse with unsellable fertilizer. It soon ran out of capital and shut down in May 1967. Plant managers made a deal to distribute their wares on the far-away coast, but when they reopened they could not meet their production goals. Even if they had, the plant still would have barely covered the interest on its loans. Nevertheless, the state kept this big money loser going.

26. See Contreras and Cueto, *Historia del Perú contemporáneo*, 298-299; Tony Smith, "The Alliance for Progress: The 1960s," in *Exporting Democracy: The United States and Latin America: Themes and Issues*, ed. Abraham F. Lowenthal (Baltimore, MD: Johns Hopkins University Press, 1991), 71-89.

Today, travelers to Machu Picchu can still see this monument to state developmentalism. It is the only industrial complex of any significance on the rail line from Cuzco. It is surrounded by fields still cultivated by the ancient Andean digging stick (*taki chaclla*). Unfortunately, tourists can no longer continue down the line past the Machu Picchu hydroelectric plant to Quillabamba, the capital of La Convención province. A huge landslide (*huaico*) caused by torrential rains during the 1997-1998 El Niño buried the plant under 28 million cubic meters of rock, water, and mud. It destroyed, probably forever, the only railroad ever built in Peru that connected the Pacific coast to the Amazon Basin. Thus, El Niño interred a dream of generations of Peruvian progressives under tons of mud. Against the advice of financial and technical experts, the Peruvian state dug out and rebuilt the 90-megawatt Machu Picchu hydroelectric plant at a cost of US$53 million. It reopened to great fanfare in 2001, proving that Peru could recover from natural disaster, even if it could never recoup the millions of dollars lost on these projects intended to replace the guano birds as engines of progress.[27]

These failures were not due to lack of training and expertise. CONAFER's new state-appointed board of directors, now representing corporatist interests like the National Federation of Chemical Engineers rather than share-holding agro-exporters and state creditors, included five engineers and two licensed economists out of nine members. Four of CONAFER's top managers, including its general

27. Robertson, *The Peruvian Fertilizer Industry*, 18-19, 22-25; *MCONAFER* 4 (1967), 14; Bernabé Calderón, "Machu Picchu vuelve a dar luz," *El Comercio* (Lima) 25 May 2001, p. A11, col. 1-6. For early images of Andean plowing, see Rolena Adorno, *Guaman Poma: Writing and Resistance in Colonial Peru* (Austin: University of Texas Press, 1986), 100-102.

manager, were also engineers. This reflected the "technocratic consensus" that swept President Fernando Belaúnde Terry, a University of Texas-trained architect and long-time professor at Peru's national engineering school, to power when Peru returned to civilian rule in 1964. CONAFER consulted a series of experienced U.S. and Japanese experts to help it implement its manufacturing plans. Such projects were not doomed to failure: Indonesia, India, and many other post-colonial countries built successful ammonia-urea plants with the aid of foreign engineers during this period. The transfer of five complete plants from Great Britain and the Netherlands to China in the aftermath of the 1959-1961 famine set the world's most populous country on the road to becoming the globe's largest nitrogen fertilizer consumer and producer--and a big meat consumer. Moreover, Peru's newest Lords of Guano were still following the technocratic model that had brought so much success to the guano, bonito canning, and fishmeal industries.[28]

By this time CONAFER had already dismantled its version of Salomon's House. In 1963, as a sign of this brain drain, the military government excluded CONAFER from the advisory board it formed to develop new fishing regulations after IREMAR's scientists sternly warned that anchoveta production was nearing its natural limits. But this did not mean that CONAFER's managers gave up their technocratic pretensions to manage Peru's entire marine environment. In fact, Luis Gamarra, still CONAFER's *gerente técnico* after all these years, belatedly

28. Cotler, *Clases, estado y nación*, 345-347; Contreras and Cueto, *Historia del Perú contemporáneo*, 296; Pike, *The Modern History of Peru*, 294; Smil, *Enriching the Earth*, 116-117, 124-125, 167-170. See also Pedro-Pablo Kuczynski, *Peruvian Democracy under Economic Stress: An Account of the Belaúnde Administration, 1963-1968* (Princeton, NJ: Princeton University Press, 1977).

converted to Vogt and Murphy's cause. He upbraided Peru's fishmeal magnates for destroying the "equilibrium" and "climax state" of the guano birds. Unless they adopted strict conservation policies such as a 20-mile "safe zone" around the guano islands, Gamarra warned, their wanton acts "could lead to the practical extinction of the species."[29]

His prediction nearly came true. In 1965, yet another El Niño event--although only a moderate one--hit the Peruvian coast, this time under unprecedented supervision by marine scientists. Once again, this event had a devastating effect on the guano birds. Ávila's former assistant Rómulo Jordán (now at IMARPE) closely followed their decline. Using monthly charts provided by CONAFER's island guardians, he estimated that starvation caused the total guano bird population to fall from 17.3 million in February 1965 to three or four million the next year. (More exact studies have concluded that the total breeding bird population on the guano islands recovered *briefly* to a post-1957 high of 28.2 million in May 1964, slid to 12.3 million in March 1965, and then plunged to a low of 610,000 in September 1965.) Although Jordán and his collaborators made no explicit policy recommendations, they faulted the fishing industry for this situation and made a general plea for conserving the guano birds as "a necessary and valuable resource," at least until Peru's nascent synthetic fertilizer industry had fulfilled its promise.[30]

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29. Belaúnde, *La legislación pesquera en el Perú*, 17, 563-565; Gamarra, "Las fluctuaciones de la población de palmideds marinas productoras del guano del Perú," *MCONAFER* 2 (1965), 13, 33-37.

30. See fig. 9; Jordán and Fuentes, "Las poblaciones de aves guaneras y su situación actual," 9, 29; Tovar, Guillén, and Nakama, "Monthly Population Size of Three Guano Bird Species off Peru, 1953 to 1982," 208-218. On the oceanography of the 1965 El Niño, see Merritt R.

Diehard defenders of the Peruvian fishing industry were not necessarily predisposed to accept these hard facts of the guano industry's crisis. In 1964, the engineering journal *Pesca* published a snide article that dismissed the entire foundation for scientific understanding of the guano bird population. "As the source for its 'statistics,'" *Pesca*'s publisher chided, CONAFER "has indicated that its figures have been procured by the guardians of its guano islands and points, which gives one an idea of how much 'science' said work contains." *Pesca* used the kind of image CAG once used to promote its accomplishments to make sure its point was clear (illus. 48). Its caption read: "Any one of these workers, the majority illiterate, can become a guardian, and [CONAFER] considers the figures they gather on bird numbers to be data of great scientific and technical value." Peruvian fishery engineers were just as adept at deploying ethnic and class animosity to belittle the science of others as William Vogt had been.[31]

But people living in Lima and Callao did not need scientists to tell them something terrible was going on. The guano birds' plight was so severe that thousands of starving birds descended on these cities' open markets in search of food. This created an enormous public uproar. News of this "disaster" even provoked the United Kingdom's Prince Philip, a friend of Peruvian conservation activist Felipe Benavides and a prominent conservationist in his own right, "to call

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Stevenson, Oscar Guillén G., and José Santoro de Ycaza, *Marine Atlas of the Pacific Coastal Waters of South America/Atlas de las aguas costaneras del Océano Pacífico en la América del Sur* (Berkeley and Los Angeles: University of California Press, 1970).

31. "Nunca hubo 40 millones de aves," *Pesca* Mar. 1964, 39-43. *Pesca* was edited and published for most of its run by the Peruvian-born, University of Washington-trained fishery engineer Alejandro Bermejo; see "El profeta de la escasez," *Pesca* Nov. 1960, 32-33.

for emergency action. . . to safeguard this unique Peruvian asset."[32] Peru's world-famous guano industry quite literally died on the streets of its capital.

The guano birds' very public demise breathed new life into the conservationist cause in Peru. In fact, the disastrous events of 1965 led directly to regulation of the fishmeal industry. In September 1965, Belaúnde's government reinstated the three- to five-mile reserves around Peru's guano islands that Beltrán's policies had abolished. It even gave CONAFER the right to issue fines to trespassing fishing boats, though CONAFER still lacked a Policía Pesquera to do this effectively. In November, after IMARPE's scientists and the fishing industry had their say, the Peruvian state issued even more stringent regulations and formed a Guano Bird Study Commission to decide what to do next.[33]

Like the first two rounds of debate between scientists during the early 1940s and mid-1950s regarding the fate of the guano birds, this expert commission failed to come to an agreement. Representatives from CONAFER, the Ministry of Agriculture's Servicio de Pesquería, and the government's new Instituto de Planificación all agreed that the guano birds needed greater protection. Luis Gamarra testified that the 95 percent decline in the guanay population since 1956 was "symptomatic of a species on its way to extinction." Countering the fishing industry's cost-benefit rhetoric, he claimed that guano was (once) responsible for S/.1 billion (US$37 million) in Peruvian agricultural production every year. The

32. Philip to Benavides, 5 Apr. 1966, Biblioteca Municipal, Pueblo Libre, Lima, Peru, special exhibition [27 Apr. 2001].

33. "Disposiciones legales y documentos relacionados con estos," *BCONAFER* 4:1-4 (Jan.-Apr. 1966), 77-82.

Lima daily *El Comercio*, an outspoken advocate for environmental protection during this controversy, gave Gamarra a platform to speak to the Peruvian public directly. CONAFER's directors saw to it that Carlos Llosa Belaúnde was appointed as company president to speak out on the guano birds and save the guano industry, as he had done as CAG's general manager from 1945-1954.[34]

The Sociedad Nacional de Pesquería's representatives Manuel Elguera and Enrique del Solar issued an independent report--with IMARPE's tacit support--thrashing the "emotional" arguments of the defenders of the guano birds. Elguera and del Solar tried to take the scientific high ground. They criticized the guano industry's "inexact scientific appreciation for the oceanic cause of the avian crisis." Echoing Erwin Schweigger's old contention, they argued that the El Niño phenomenon established "a natural factor limiting the bird colonies" (which could only fish some ten meters below the surface), but not for the anchoveta fishery. Why should Peru's fishermen (who could reach down to 50 meters) be stopped from targeting fish flourishing at depths out of reach of the guano birds? Elguera and del Solar countered the contention that the fishmeal industry was violating a "virgin stock" with a laughable cornucopian definition of ecological balance: Based on the anchoveta population's well-known ability to reproduce itself every two years or so, they claimed: "Self-renewable resources, like anchoveta, have to

34. "Medidas recomendadas al Supremo Gobierno en relacion con las aves guaneras: Informe presentado por la Sub-Comisión 1: Decreto Supremo No. 67 de 12 de noviembre de 1965," *BCONAFER* 4:1-4 (Jan.-Apr. 1966), 94-108; Gamarra, "Texto de la exposición del Ingo. Luis Gamarra Dulanto ante la comisión creada para contemplar las medidas por adoptarse para la protección de las aves guaneras, Febrero 11 de 1966," *BCONAFER* 4:1-4 (Jan.-Apr. 1966), 57-60; idem, "Comentarios sobre 'la acción con respecto al ave guanera como depredadora,'" *BCONAFER* 4:1-4 (Jan.-Apr. 1966), 67-69; "Nombramiento del Ing. Carlos Llosa Belaúnde como Presidente del Directorio de la Corporación Nacional de Fertilizantes," *BCONAFER* 4:9-10 (Sept.-Oct. 1966), 1-3.

maintain a certain dynamic balance. If for some reason the population decreases, the rate of renewal increases, so that the population recovers its balance." They also pointed out the arbitrariness and inefficacy of the state's fishing restrictions: The size of the "safe zones" around the guano islands not only had "no scientific basis," but such zones were nearly impossible to patrol and enforce (as CAG had discovered years before). Such restrictions, moreover, threatened the closure of fishmeal factories and the loss of thousands of jobs and billions of soles in lost wages, tax income, and invested capital. Finally, Elguera and del Solar renewed their criticism of the "inconsistent, obsolete, anti-economic guano industry." In its stead, modern Peru needed a "chemical fertilizer industry," preferably one that took advantage of large, undeveloped natural gas and phosphate deposits in the Amazon--an industry that could expand "at a rate compatible with population increase and just expectations of the elevation of food needs."[35]

Meanwhile, the defenders of the Peruvian fishing industry had made a habit of using *both* the neo-Malthusian arguments of William Vogt and anti-hunger rhetoric of Josué de Castro against the guano industry. Of course, they were extremely vulnerable to the criticism that practically every fish taken from Peru's marine environment ended up in the belly of a chicken or hog in the rich countries of the North, rather than feeding the world's poor. The Sociedad Nacional de Pesquería had given its support to a couple of projects to head off this criticism.

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35. Peru, Comisión de Estudio sobre las Aves Guaneras, *Informe singular de la Sociedad Nacional de Pesquería, integrante de la comisión nombrada por Decreto Supremo no. 67 de 12 de noviembre de 1965* (Lima, July 1966), passim; SNP, *Memoria, 1964-1965* (Lima, 1965), 27-30, 43-44; SNP, *Memoria, 1965-1966* (Lima, 1966), 25-28.

With several countries involved in a race to develop technologies to refine fishmeal for direct human consumption, in 1960 the SNP, U.S. National Institute of Health, and Clínica Anglo-Norteamericana in Lima initiated a program to test the nutritional attributes of fishmeal. Medical outposts in Lima's impoverished shantytowns provided a couple hundred malnourished children as guinea pigs. They were fed soup, bread, and pasta fortified with fishmeal provided by an experimental South African refinery. One dangerously underweight infant, "Isabelita," was fattened up on fishmeal and turned into the poster child for the Peruvian fishing industry's food from the sea campaign (illus. 49). Pedro Beltrán even served a slice of fishmeal bread to visiting U.S. dignitary Adlai Stevenson. But in 1962, the U.S. Food and Drug Administration (FDA) determined fishmeal to be unfit for human consumption because it could not meet its high standards for purity in animal products. Peruvian fishmeal producers dropped this project once this huge potential market was lost--thus revealing their real intention, to enter the U.S. processed-food industry.[36]

In the midst of the controversy over the demise of the guano birds, the Belaúnde administration's Minister of Agriculture, agronomic engineer Rafael Cubas Vinatea, lambasted the Peruvian fishing industry for its utter failure to provide food to Peruvians. Fishing industry representatives responded cynically that it was the government's duty to make sure Peruvians consumed enough

36. "La tragedia de la abundancia," *Pesca* Oct. 1960, 5-8; "Una realidad: Harina para consumo humano," *Pesca* Aug. 1961, 13-17, 19-21; "¿Y la ética periodística?" *Pesca* Sept. 1961, 16-17; "Harina Vio Bin, rechazada," *Pesca* Mar.-Apr. 1962, 43; "La polémica de la harina comestible," *Pesca* July-Aug. 1962, 23-28; Carlos Collazos, "Perú fabricará harina comestible de pescado," *Pesca* Oct. 1962, 57-59; "Guerra a la desnutrición," *Pesca* Sept. 1964, 14-20.

protein. To deflect such criticism, the SNP had already established a small food-fish company to supply Peruvian coastal consumers; meanwhile, Enrique del Solar briefly returned to the life of a field scientist when he personally funded and supervised research into the industrialization of a *merluza* fishery.[37]

Some of these projects were well-intentioned, and they did draw public attention to the Peruvian hunger problem, "the taboo of our time." But as the industry's reaction to the FDA's decision to ban fishmeal for human consumption in the United States makes clear, most of this was pure propaganda designed to forestall government intervention in the fishing industry, not to furnish malnourished children like Isabelita with unlimited food from the sea.[38]

Fortune Strikes

The intervention of fishery population biologist Milner Schaefer brought a final end to the fishmeal vs. guano controversy. Under his influence, Peruvian officials made a consicious decision to trade away the continued existence of the guano industry for a chance to place the fishmeal industry under meaningful regulative control. Despite the best efforts of Peru's marine scientists, these plans failed miserably. During the next strong El Niño event, the world's largest industrial fishery collapsed. The story of the role of experts in this second

37. "Declaraciones de Cubas," *Pesca* Sept. 1966, 21-23; "Las doce verdades," *Pesca* May 1966, 37-40; "Proteinas, higiene y calidad," *Pesca* Apr. 1965, 22-24; del Solar, Sánchez, and Piazza, "Exploración de las areas de abundancia de merluza (*Merluccius gayi peruanus*)."

38. *Pesca*'s series on Josué de Castro and the hunger problem was picked up by a number of Lima dailies and television programs: "El tabú de nuestro tiempo," *Pesca* Oct. 1962, 26-30; "Hambre en el mundo," *Pesca* Oct. 1962, 22-23; "Hambre en el Perú," *Pesca* Oct. 1962, 24; "Iniciativa de PESCA causó impacto," *Pesca* Nov. 1962, 67-69; "Más pescado para la alimentación!" *Pesca* Nov. 1962.

ecological disaster is too rich to recount here in full. But it is worth outlining some of its features in order to demonstrate how CAG's legacy as a successful conservation organization--and faith in the technocratic ideal--affected the tragic fate of the anchoveta.

Anchoveta producers in Peru had begun to experience some difficulties finding fish in 1962 and 1963, leading to the decline of Chancay as a major fishing port. This directly influenced the fishing industry's decision to fund IMARPE. But not until the moderate El Niño of 1965 did the industry experience a noticeable drop in brute anchoveta production, although a major strike by fishermen in February 1965 and the ease with which some boats continued to locate stocks masked the ill effects of this environmental hazard on the fish population. Popular reaction to the collapse of the guano bird population forced Peruvian state officials to take a stand: During the 1965-1966 fishing season, they issued several limits to the fishmeal industry reminiscent of the conservation policies that originally protected the guano industry. Based on recommendations by IMARPE scientists (acting independently of the fishing industry, for the moment), the Peruvian state stopped issuing licenses to expand fishmeal plant capacity, established a minimum-size limit for individual fish caught (calculated as an average per catch), prohibited fishing during the peak months of anchoveta spawning (June-August, when fishing activity was at a minimum, anyway), and most importantly, mandated a seven million metric ton anchoveta production quota based on theoretical calculations of the fishery's maximum sustainable yield (MSY). It even expanded the closed oceanic reserves around the three most important guano island groups to ten miles.

For the 1966-1967 season, IMARPE recommended slightly more stringent regulations, including an additional six-week closed season (*veda*) early in the year to protect the new year-class of anchoveta fry (*peladilla*) and a five-day work week for the entire industry. Of course, most of these regulations were crafted to minimize their economic impact rather than to conserve anchoveta stocks. By preserving the *peladilla*, the industry maximized the standing crop of adult anchoveta that could be converted to fishmeal, leading to greater yields. By adopting a restricted work week, the industry spread out the work year and provided time off for fishermen, thus providing a concession to labor syndicates that were agressively opposing a long *veda*--and work stoppage--of several months. Of course, these regulations meant that factory and boat owners could not operate their machinery at anything close to full capacity, and it meant smaller incomes for industry workers.[39]

The fishing industry lobby did not take these "drastic measures" lying down. As CAG had done 12 years earlier, the Sociedad Nacional de Pesquería recruited Milner Schaefer to check IMARPE's math, so to speak. As we saw in the chapter 7, Schaefer was widely respected as the world's "*experto número uno*" when it came to fish population dynamics because of the mathematical model he had developed to track variations in the Pacific yellowfin tuna. Fishing industry executives, both North and South, liked Schaefer because he was a major

39. IMARPE, "La Pesquería en la anchoveta," *Inf.Inst.Mar Perú* 1 (1965); idem, "Efectos de la pesca en el stock de anchoveta," *Inf.Inst.Mar Perú* 7 (Oct. 1965); idem, "La pesquería de la anchoveta," *Inf.Inst.Mar Perú* 14 (Dec. 1966); Antonio Landa to Inter-American Tropical Tuna Commission Director of Investigations, "Information Report," 17 June 1966, UC-IMR Records 4/178; Alejandro Bermejo to Schaefer, 31 Jan. 1967; Schaefer to Bermejo, 7 Feb. 1967, 22 Feb. 1967, UC-IMR Records 4/188.

proponent of increasing the production of "food from the sea" and sensitive to their economic complaints, even if he was acutely aware of the stakes of these measures, and the need to prevent what happened to the California sardine.[40] Nor did he carry the haughty pretense that many northern experts--William Vogt, for example--brought south as part of their cultural baggage.

In April 1966, Schaefer traveled to South America and did a reanalysis of Peru's 1964-1965 fishing data. His calculations were slightly more optimistic than IMARPE's. Rather than surpassing the maximum sustainable yield of the anchoveta fishery in 1965, Schaefer concluded that the Peruvian fishing industry had almost exactly equaled the "long-term" MSY (7.5 million metric tons) of the fishery. In short, the fishing industry was not engaged in "overfishing" where its own interests were concerned, even if it was killing off the guano birds. Nevetheless, Schaefer thought Peru needed to curtail fishing effort since the fishery was so close to its maximum sustainable yield. He thought a closed season (*veda*), one of the main policies used to protect the guano birds, was the best way to accomplish this. It was easy to enforce, and he thought it would encourage fishing entrepreneurs to redirect their unused equipment to other underutilized species from Peru's coastal waters. Perhaps this would finally lead to industry diversification and produce food for Peruvian consumers. Schaefer had high hopes for these measures. Based on his frustrating experience trying to manage tropical tuna fishermen, he believed "the leaders of the [Peruvian] industry are much more

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40. See Bermejo, "El profeta de la escasez," *Pesca* Nov. 1960, 32-33; "Estimación del potencial del mar," *Pesca* Oct.-Nov. 1964, 23-29.

enlightened and rational than in most parts of the world" and "quite willing to accept regulation of the fishery if it is really required." Moreover, Peru's biggest fishmeal producers, in accord with the gospel of efficiency, were quite enthusiastic about fishery conservation.

Meanwhile, Schaefer started to include estimates of the guano birds' consumption in his anchoveta population estimates. This changed everything. It allowed him to raise his tentative estimate of the *combined* maximum sustainable yield of the anchoveta fishery involving both human and avian predation to around ten million metric tons. His interpretation: the massive decline in the guano bird population during the 1965 El Niño had created a windfall for the fishmeal industry. A much smaller guano bird population meant that the "long-term" MSY available to humans was around 9.5 million metric tons per year in perpetuity. Unlike the fishing industry's shrill critics, he did not think the total extinction of the guanay, piquero, or alcatraz was at stake if Peruvian fishermen upped their exploitation to these levels.

Peruvians had a clear choice to make, in his view. They could decide to maximize either guano or fishmeal production. "Such a choice cannot be avoided, the only question is whether it will be made on the basis of objective analysis or through . . . emotional arguments," Schaefer told CONAFER officials. Yet Schaefer would not recommend a specific course of action. In his view, this was a decision for the Peruvian people, not a foreign technocrat, to make. But privately, Schaefer did not think it would be much of a tragedy if "perhaps we should 'lose' guano."[41]

Schaefer's new quantitative approach to overfishing could not have come at a better time for the Peruvian fishing industry. When Schaefer arrived in Peru in April 1966, the impasse between the members of the the Guano Bird Study Commission was nowhere close to being resolved, and the SNP had become embroiled in a vicious polemic with Minister of Agriculture Rafael Cubas over its patriotic duty to supply Peruvians with sufficient food. Most importantly, the anchoveta catch was rapidly approaching the 7 million metric ton quota that IMARPE had set, and government officials had already agreed to workers' demands to limit the length of the closed season to June to September. Practically everyone breathed a sigh of relief when Schaefer announced at a press conference that the anchoveta fishery's true MSY for 1965-1966 was 10 million metric tons, only half a million tons of which was going to be eaten by the depleted guano birds, so the true MSY for anchoveta fishermen was around 9.5 million metric tons. Even though anchoveta fishermen reached their original quota three weeks early, regulators were able to keep a clear conscience while allowing fishing to continue for a total season of 222 days worked. Schaefer's innovation made the decision to

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41. Sources for this section: Carlos Otero Lora to Schaefer, 20 Apr. 1965, 9 Nov. 1965, 10 Nov. 1965; Schaefer to Otero, 20 May 1965, 15 Nov. 1965, UC-IMR Records 4/181. Schaefer to Garth I. Murphy, 18 May 1966; Schaefer to Alfonso Elejalde, 19 May 1966; L. K. Boerema to Schaefer, 20 May 1966; Schaefer to Boerema, 2 June 1966, 29 June 1966, UC-IMR Records 4/178. Schaefer, "Progress Report to the Sociedad Nacional de Pesquería and the Instituto del Mar del Perú Concerning Analysis of the Dynamics of the *Anchoveta* Fishery," 30 June 1966; Alfredo V. Freyre to Schaefer, 26 Aug. 1966; Schaefer to Freyre, 6 Oct. 1966, UC-IMR Records 4/179. Manuscript marginalia by Schaefer in William W. Warner, "Preliminary Proposal for a Conference on Peruvian Marine Research," 2 June 1966, UC-IMR Records 4/187. "¡Veda! Protección a la anchoveta ven industriales pesqueros," *Pesca* Dec. 1964, 36.

implement the first closed season in the history of the Peruvian fishing industry much easier to accomplish, and it went a long way toward increasing his influence with industry executives.

In following years, Schaefer helped IMARPE develop a procedure to estimate the maximum sustainable yield for the year in the middle of an ongoing fishing season. These calculations were based on early returns and fish recruitment estimates. This was supposed to allow regulators to act on the best possible information when they set a cut-off date for the year's fishing. Most importantly, it allowed them to adjust the MSY for the year upward if the year's *peladilla* crop was abundant. What it meant, in practice, was progressively shorter fishing seasons: from 166 days in 1966-1967 down to 116 days in 1971-1972, with increasing yields in most years. These actions were extremely unpopular, especially among wage workers and small, indebted, inefficient producers. Every day state officials shortened the fishing season, they risked forcing another plant into bankruptcy, further reducing orders for new fishing craft and equipment, throwing a few hundred more proletarians out of work, and depleting Peru's precious export income and foreign exchange. In one sense, the Peruvian fishmeal industry's association with another kind of expert, the industrial engineer, had become self-defeating. The ease with which companies incorporated new technologies to increase their efficiency was pushing this perilously overcapitalized industry toward a shakeout.[42]

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42. "No más de 10 millones," *Pesca* May 1966, 9. SNP, Circular no. 1397, "Veda para la pesca de anchoveta en el litoral peruano, Decreto Supremo Nº 16 de 10 de Febrero de 1967," (Lima, 11 Feb. 1967); Otero to Schaefer 21 Feb. 1967, 25 Feb. 1967; Schaefer to Otero, 2 Mar. 1967, UC-

The decision to establish the veda system as the fishing industry's main control therefore sealed the fate of the guano birds. No regulator could bring himself to shorten the fishing season in order to reserve additional fish for the guano birds and take food away from the families of fishery workers or close down another small businessman. Moreover, open fishing corresponded with the guano birds' prime breeding season when the anchoveta was easiest to catch. One overwhelming fact, basic lack of food, made all other bird protection policies irrelevant, just as William Vogt, Robert Cushman Murphy, and now Luis Gamarra predicted.

With this intense ecological competition, the guano birds failed to recover from the 1965 El Niño. From 1966 to 1970, the annual mean breeding population hovered around 3.8 million adults--an undeniable indication that fishing pressure, not environmental conditions, was the ultimate cause for their decline. Guano production fell to its lowest levels since the formation of CAG. Significantly, the average alcatraz population remained fairly stable during this period. It only declined slightly from 270,000 breeding adults during the period 1957-1964 to 240,000 during the period 1965-1971. This was a clear indication that the alcatraz occupied a distinct ecological niche from the guanay and piquero and did not require anchoveta for subsistence. Moreover, this stability contradicts the notion promoted by some defenders of the fishing industry that persistent pesticides were the main cause for the guano birds' decrease. In marked contrast, DDT exposure

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IMR Records 4/184. Caravedo, *Estado, pesca y burguesía*, 63, 123-124; Abramovich, *La industria pesquera en el Perú*, 86.

depleted the North American population of the brown pelican (*Pelecanus occidentalis*), the Peruvian pelican's closest relative, so severely during this period that it came to be classified as an endangered species. Its population recovered rapidly after the U.S. government banned the use of DDT and similar chemicals in 1972.[43]

Meanwhile, the Peruvian state struggled to replace the guano birds with a fertilizer manufacturing industry. In the short term, fertilizer imports skyrocketed with the decline in guano production. Even though the Cachimayo plant near Cuzco was barely surviving, CONAFER became involved in an even grander project, a Gran Complejo Industrial Petro-químico del Norte combining the interests of a half-dozen state and private companies. Of course, it took several more years to plan and build this huge industrial complex--and CONAFER had ceased to exist by the time it went into operation. This project turned out to be a success. For a brief period from the mid-1970s to late-1980s, Peru had its own import-substituting fertilizer industry. Of course, this chemical industry had a number of environmental drawbacks that the guano industry did not, especially its great thirst for energy produced from fossil fuels. To keep things in perspective, Peru's fertilizer factories produced almost exactly the same amount of nitrogen over a 16-year period (918,225 metric tons from 1975-1991) as Peru's guano birds provided during the entire 57-year period from CAG's foundation until the final crash of the guano industry in 1966 (917,517 metric tons). Peruvian agriculture

43. See fig. 9; Tovar, "Areas de reproducción y distribución de las aves marinas en el litoral peruano"; Tovar, Guillén, and Nakama, "Monthly Population Size of Three Guano Bird Species off Peru, 1953 to 1982," 208-218. Cf. Dunlap, *DDT*; idem, *Saving America's Wildlife*.

finally escaped from the limits inherent to extracting nutrients from Peru's marine environment. But a decade of economic crisis, renewed foreign competition during the late 1980s, followed by President Fujimori and economist Carlos Boloña's neoliberal "shock therapy," all led this once-protected industry to the same demise as the guano birds. Both were discarded as obsolete by a new generation of developmentalists. In 2000, Peru's chemical industry produced *zero* metric tons of nitrogenous fertilizer. Except for organic farmers who use guano and other animal manures, Peruvian agriculture now, for the first time in its entire history, depends entirely on nitrogen imports.[44]

It took much less time than this for the fishmeal industry to meet with misfortune. The owners of the largest, most profitable companies such as Luis Banchero stood behind the Peruvian government's technocratic regulations, as promised. From their point of view, there were several benefits to the shorter fishing seasons of the late 1960s. IMARPE's standards reduced labor costs and mainly hurt less-efficient competitors in the short term. In the long term, these conservation regulations promised to protect their immense, underutilized investments in technology and provide them with the opportunity either to gobble up their smaller competitors or force out them out of business. In short, these technocratic standards helped lead to concentration of ownership in the fishing industry, not unlike the concentration in coastal agricultural holdings

44. See fig. 10 and app. 3; *MCONAFER* 4 (1967), 13-14; Empresa Nacional de Comercialización de Insumos, *ENCI y la comercialización de fertilizantes en el Perú* (n.p.: Valverde, [1978]), 6, 12-14; fertilizer statistics from FAO Statistical Databases, [cited 8-13 Oct. 2002], available from http://apps.fao.org/.

unintentionally promoted by the technocratic administration of irrigation water and guano. By 1968, Luis Banchero had come to own nine subsidiary companies, including the giant Pesquera Humboldt factory in Chimbote, and control 15 percent of the fishmeal industry's producing capacity. This made him the number one fishmeal producer in the world. Manuel Elguera and his partner Arturo Madueño, the founding fathers of the SNP and Peruvian fishmeal industry, owned five subsidiaries and another six percent of the industry's producing capacity, making them the third-largest producers in Peru. By 1968, two U.S. corporations, International Proteins of New Jersey (owning factories recently bought from Ralston-Purina) and Star Kist Foods of California (an H. J. Heinz subsidiary), owned between them eight fishmeal companies and over 11 percent of the industry's producing capacity, making them the second- and fourth-largest producers in Peru, respectively. Major beneficiaries of the Aristocratic Republic all owned significant shares of the industry--Gildemeister & Co. (no. 10), W.R. Grace & Co. (no. 13), the Graña, Pardo, and Lavalle families--as did Enrique del Solar and Mariano Prado. Three other U.S. companies, the Minneapolis-based giant Cargill (no. 9), Gold Kist (no. 22, a Georgia cotton-marketing cooperative, now the United States' second-largest chicken processor), and General Mills (no. 24) represented the gradual infiltration of transnational agribusiness into Peruvian fishing. But economic nationalists and enemies of Peru's old oligarchy alike could take solace in the fact that a new class of fishmeal capitalists dominated by

Banchero, Elguera, and Madueño owned as much of the fishing industry as foreign companies and Peru's "traditional elite" put together.[45]

During the late 1960s, most IMARPE scientists felt no need to clamor for stricter production limits because its conservation policies seemed to be working. The Peruvian anchoveta kept producing good year-classes of new fish. The population models Schaefer IMARPE implement said it was okay for production to surpass the long-term average annual MSY during a good season. Schaefer's new calculations kept telling him that this long-term average for the total anchoveta fishery (humans + birds) was between 9.9 and 10.3 million metric tons. Moreover, it was thought an industry shakeout would eventually remove pressure on the fishing stocks.[46]

A handful of fishery scientists, both Peruvian and foreign, were not as confident as the fishing industry's "*experto número uno*," especially in view of what had happened to the guano birds. They worried that the Peruvian anchoveta fishery was headed for a similar collapse. But Schaefer was unimpressed by such "predictions of doom." For one, the guano birds' loss meant the fisherman's gain. He had great confidence in Peru's fishery management system. He felt IMARPE kept good statistics on catch and fishing effort. Even though he was concerned about the progressive improvement in fishing vessel efficiency--which meant Peru's fishing fleet posed a greater threat toward the anchoveta every year--he

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45. Abramovich, *La industria pesquera en el Perú*, 44-66; "Cuatro super grandes; 22 grandes y medianos," *Pesca* Feb. 1969, 28-29; "Gold Kist History," [cited 22 Oct. 2002], available from http://www.goldkist.com/company/history.asp.

46. Schaefer, "Interim Report on Investigations of Ecology and Population Dynamics of the Anchoveta *Engraulis ringens* in Peru," 15 May 1969, Schaefer papers 4/220, pp. 7-12, 14-16; Day, *Guide to the Papers of Milner Baily Schaefer*, 3-9.

thought it would be possible "to detect any marked overfishing" well ahead of time. He firmly believed, from repeated conversations, promises, and actions by Peruvian government and fishing industry officials, that the right people were "in a position to do something about" marked overfishing "when and if it occurs." Unlike William Vogt, Schaefer had immense faith in Peru's conservation technocracy.

But IMARPE's vaunted statistics had a major flaw: they did not go back very far. They did not even include the 1957-1958 El Niño year. This did not concern Schaefer much. From his work at the Inter-American Tropical Tuna Commission and close association with the world's foremost Pacific oceanographers and meteorologists, he had as good an understanding of the El Niño phenomenon as any other scientist in the world at the time. He helped organize the international "El Niño Project" of the mid-1960s. In fact, Schaefer was personally responsible for turning meteorologist Jacob Bjernkes to the study of the El Niño phenomenon: During the 1960s, as the last major act of a phenomenal career, Bjerknes developed a physical model connecting sea-surface and atmospheric changes in the equatorial Pacific. It remains the basis of our present-day understanding of the El Niño-Southern Oscillation. Schaefer played a role as important as anyone in the "discovery" of ENSO. Based on these observations, he firmly believed that El Niño's effect on Peruvian fish "stocks is small--and perhaps even favorable," especially since it put a virtual stop to predation by the guano birds.[47]

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47. A. C. Burd to Schaefer, 19 June 1969; Schaefer to Burd, 9 July 1969, Schaefer papers 4/224; L. K. Boerema, "FAO Indicative World Plan for Agricultural Development: Area Review on Living Resources of the World's Oceans: Draft for Comment: Southeast Pacific," FAO Fisheries

As it turned out, this was the perfect recipe for disaster. In 1968, the Revolutionary Government of the Armed Forces overthrew President Belaúnde's financially beleagured, gridlocked, and scandal-ridden government. Taking over where Peru's previous military regime had left off, it established a reformist bureaucratic-authoritarian state run by technical experts--many with training at Peru's Centro de Altos Estudios Militares--in order to forestall an even more radical revolution à la communist Cuba. Under General Juan Velasco Alvarado's leadership, this center-left government gradually took control of the means of production in Peru, starting with foreign-owned companies such as the Peruvian Corporation of London and its railroads. In many cases it created worker cooperatives to run these institutions, only to replace them with trained technicians when it became obvious that worker control usually led to sharp decreases in economic output. Beginning in 1969, the Revolutionary Government launched a radical agrarian reform that sought to reverse a situation in which less than one percent of landowners owned a whopping four-fifths of all agricultural land in Peru. Most importantly, it instituted a political economy in line with the latest

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Circular no. 109.18 (Rome: Food and Agriculture Organization of the United Nations, Nov. 1969), with manuscript comments by Schaefer, Schaefer papers 4/233.

On Schaefer and Bjerknes's powerful influence on El Niño studies after 1957, see Gregory T. Cushman, "Choosing Between Centers of Action: Pacific Buoys and the Marginalization of El Niño-Southern Oscillation Studies, 1957-1975," in *The Machine in Neptune's Garden: Technology and the Marine Environment*, ed. Helen Rozwadowski and David van Keuren (New York: Science History Publications, forthcoming). On Bjerknes as one of the fathers of modern, physics-based meteorology, see Friedman, *Appropriating the Weather*. For a brief historical commentary on "Bjerknes and the ENSO paradigm," see Davis, *Late Victorian Holocausts*, 230-234; cf. Glantz, *Currents of Change*, passim.

"dependency theory" enunciated by ECLA technocrats that was designed to reduce Peru's economic "enslavement" to the Northern Hemisphere.[48]

The military rulers of the Peruvian state possessed great power and expertise. But Peru's fishing industry possessed even greater inertia as a technological system. Meanwhile, the military was the avowed defender of Peru's small entrepreneurs and workers against big, foreign companies, and it was embroiled in a series of major economic reforms. This created a situation in which it was extremely difficult, if not impossible, to balance conflicting interests within the fishing industry and the reformist goals of the military government with the well-being of the anchoveta.

The technocratic ambitions of Peru's military rulers notwithstanding, they failed to enforce IMARPE's fishing quotas consistently, even after a special panel of foreign scientists reviewed Peru's system of fishery management in January 1970 and legitimated IMARPE's regulatory regime. This panel set an MSY of 9.5 million metric tons for the 1969-1970 season. The productive power of the Peruvian fishing industry's 20,000 fishermen and 1,400-plus purse seiners was so vast by this time that they reached this quota on 28 April 1970 after less than five months of work. Over the next ten days, they landed an additional million metric tons. The military government shut down the bigger companies, but caved in to a petition by smaller producers for an extension, and they hauled in another 300,000 metric tons. All told, the industry officially landed more than 11 million metric

48. Cotler, "Peru since 1960," in *CHLA* (1991), 8:465-469; Stepan, *The State and Society*, pt. 2; Contreras and Cueto, *Historia del Perú contemporáneo*, 304-319.

tons of anchoveta before the government decreed the end of the fishing season for good after 151 days of work. Because of systematic under-reporting of the *peladilla* catch, due in part to the fact that official production statistics were only taken at the point that anchoveta entered the plant, Peru may have caught more than 14 million metric tons of anchoveta. This required the deaths of around ten trillion (10^{13}) individual fish in order for Peru's 125 operating fishmeal plants to manufacture less than two million metric tons of chicken and hog feed for consumption in the First World.

In macroeconomic terms, Peru's technocrats had little room for maneuver. Fishmeal exports brought in a little over US$300 million to the captains of a vastly overcapitalized industry. This represented more than a third of Peru's total export income, and the fishing industry as a whole produced about two percent of Peru's entire gross domestic product (GDP). Peru's military leaders were desparate to maintain this income. They could not afford to return to the huge balance-of-payments and balance-of-trade deficits accrued by the government they had overthrown, and they had to make up somehow for the loss of export income in other areas. For example, real export income from agricultural products like sugar and cotton had fallen by almost half from the levels of the early 1960s, as the Revolutionary Government pushed forward agrarian reform in the countryside.

Fishing industry workers, meanwhile, were desparate to work as many days as possible during the year (and pressured the government to make this possible) because so little of this income reached their pockets. An unskilled, full-time fisherman made less than US$1,300 on average for the entire season. Although "good" for a country where per capita GDP was US$548, this meant that 60 percent of the fishing industry workforce shared in less than eight percent of the industry's gross earnings, even though their labor produced a whopping 5,500 metric tons of fish per man. The situation was not much different in the fishmeal plants, where unskilled wage laborers made an average of US$1,200 per year, while managers and skilled workers on salary got by on US$2,900; this third of the workforce shared in less than six percent of gross earnings, even though their labor produced more than 180 metric tons of fishmeal per person. The owners of the fishmeal industry pleaded that they were too financially stretched to afford to pay their workers anything more, though they consistently refused to open their books to the gaze of government technocrats to prove this, probably because they feared expropriation if their true financial mismanagement was discovered.[49]

Inevitably, a strong El Niño event put this overextended system to a test. The events of 1972-1973 proved that the anchoveta population *was* vulnerable to disruptions in deep-water upwelling and plankton production caused by this phenomenon--much more vulnerable, in fact, than even pessimistic scientists expected. Catch levels went into a freefall. Increasing numbers of ships came back to port without encountering any fish at all. Things happened faster than Peru's

49. See app. 5, 9; IMARPE, Panel de Expertos, "Informe sobre los efectos económicos de diferentes medidas regulatorias de la pesquería de la anchoveta peruana," *Inf.Inst.Mar Perú* 34 (1970); Paulik, "Anchovies, Birds and Fishermen in the Peru Current," 156-158, 172-176, 181-182; PESCA-PERU, *Qué ha hecho y adonde va*, 26; Edmonds, "Reasons Underlying Development of the Peruvian Fishing Industry," 17-18; Abramovich, *La industria pesquera en el Perú*, 86; Portocarrero, Beltrán, and Romero, *Compendio estadístico del Perú*, 168-170; Peru, Instituto Nacional de Estadísticas e Informática, *Peru: Series estadísticas, 1970-91* (Lima: Dirección Técnica de Indicadores Económicas, 1992), 168; idem, *Peru: Series estadísticas, 1970-94* (Lima: Dirección Técnica de Indicadores Económicas, 1995), 77-78, 85-86.

technocrats could react. Peruvian state officials finally tried to stop the carnage by imposing strict catch quotas, but the damage had already been done. Catch-per-unit-of-fishing-effort statistics clearly show that the Peruvian *bolichera* fleet was so efficient in its destructiveness that it removed nearly all available anchoveta from the sea during these two years. Dozens of fishmeal companies failed, throwing thousands out of work, as anchoveta production plunged from over 10 million metric tons in 1971 to 1.5 million in 1973--far less, in fact, than the quota allotted by IMARPE. That year, fishmeal export income bottomed out at US$138 million, the lowest in real terms since the formation of the fishmeal cartel in 1960. This was a devastating blow to Peru, both economically and socially.[50]

Fishing executives could no longer look to either Schaefer or Banchero for help in finding a solution--both were deceased. The military government used undeniable evidence of industry mismanagment to nationalize the 84 surviving Peruvian fishmeal companies on 7 May 1973. But it paid a large indemnity for the expropriated companies under the circumstances (equal to US$102 million). It also took on the industry's huge debt (equal to US$273 million), plus its nearly worthless "excess of factories and craft, as well as personnel." The state--and ultimately, Peruvian taxpayers--bailed out the failing fishmeal entrepreneurs. When it established PESCA-PERU in 1973 and took over the barren remains of the guano industry in 1975, the Peruvian government briefly made real the state monopoly and comprehensive management of marine production envisioned by CAG technocrats decades before. Envisioning an even greater future for these

50. See app. 5, 9; Idyll, "The Anchovy Crisis," 22-29.

industries, the Peruvian state financed a concrete skyscraper on Lima's eastern periphery to house its fishery technocrats.[51]

But to what end? PESCA-PERU, in consultation with IMARPE scientists, continued trying to maximize the anchoveta catch over the next few years in order to pay for this expropriation and to produce scarce export income during an accelerating balance of payments crisis. In fact, the worst "overfishing" of anchoveta stocks probably happened during the mid-1970s when the fishmeal industry was under total state management. As a consequence, the anchoveta population failed to recover from the El Niño of 1972-1973. By the beginning of 1982, when an El Niño super-event forced the anchoveta fishery to shut down entirely, PESCA-PERU only operated 37 fishmeal plants and still owed a US$245 million debt. The entire fishing sector only employed 7,000.[52]

In fact, Peru's "anchovy crisis" was just one aspect of a global disaster during 1972-1973. This powerful ENSO event influenced similar climate anomalies in many parts of the world. Of course, none of Peru's fish made it to the African Sahel where thousands, primarily pastoral peoples, were starving due to an intense drought. In the USSR, a huge grain production shortfall forced Soviet planners to import massive quantities of food. These combined disasters once again drew the world's attention to the El Niño phenomenon and the world's population problem. This is the context that made people so receptive to the Club

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51. PESCA-PERU, *Qué ha hecho y adonde va*, 4-5, 17; Caravedo, *Estado, pesca y burguesía* 79-85.

52. See app. 5, 9; PESCA-PERU, *Qué ha hecho y adonde va*, 41-50; Alonso Aguilar Ibarra, Chris Reid, and Andy Thorpe, "The Political Economy of Marine Fisheries Development in Peru, Chile, and Mexico," *JLAS* 32 (2000), 512-513; Portocarrero, Beltrán, and Romero, *Compendio estadístico del Perú*, 170.

of Rome's famous report on *The Limits to Growth* that were facing humankind. Cornucopians stopped talking in ecstatic tones about an untapped wealth of food from sea. Thus, events affecting Peru's marine environment again influenced environmental consciousness in the rest of the world. The oil price shock of 1973 only made these problems much worse. It took longer for observers to realize that decades of ill-conceived development projects were responsible for some of the worst examples of ecological destruction and human suffering caused by this climate disaster. Unfortunately, some of these patterns were repeated during the more powerful ENSO event of 1982-1983.[53]

In ecological history, every major change produces winners as well as losers. Some organisms benefited from the decline of the anchoveta. It reduced grazing pressure on many plankton species, all of which recovered after upwelling resumed. A local sardine species (*Sardinops sagax*) increased markedly in abundance once it no longer had to compete with the anchoveta for plankton. After General Velasco's death in 1975, Peruvian government planners allowed private companies to gradually build a new fishmeal industry based on the sardine. This sardine fishery never came close to approaching the size of the anchoveta fishery, however. More encouragingly, the failure of the anchoveta finally inspired Peruvian fishermen to turn their attention toward exploiting other species for local, human consumption.[54] Of course, these endeavors put other marine species at risk

53. Donella H. Meadows, et al., *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books, 1972); Richard W. Franke and Barbara H. Chasin, *Seeds of Famine: Ecological Destruction and the Development Dilemma in the West African Sahel* (Totowa, NJ: Rowman & Allanheld, 1980); Glantz, *Currents of Change*, 39-41, 84-97.

54. See app. 9; Portocarrero, Beltrán, and Romero, *Compendio estadístico del Perú*, 46-47.

of overexploitation. But fishery economics and careful supervision by IMARPE have prevented this, at least so far.

Peru's misfortune also created an enormous opportunity and windfall for its neighbor Brazil. The collapse of Peru's fishmeal industry brought a permanent end to the wild growth of world fishmeal production and caused the price for high-protein feeds to skyrocket. This led to a fundamental shift in the agroecological system that supplied the world's meat industry with protein feed (fig. 11). Worldwide, farmers increased the area planted in soybeans by a quarter from 1971 to 1974. Almost half of this increase was in Brazil, where the military government provided major incentives to turn the vast tropical savannas of Mato Grosso into mechanized, input-intensive soybean plantations. By 1977, Brazil was producing 12.5 million metric tons of soybeans on 7.1 million hectares of land and exporting 7.9 million metric tons of soybeans and soycake worth US$1.86 billion. In real dollars, this was five times more than Peruvian fishmeal exports brought in during their best year, 1969. Ever since, Brazilian agribusiness has controlled one quarter of the global soybean export market, and it has emerged as the world's third-largest meat producer. Of course, this agricultural expansion required vast quantities of nitrogen fertilizer and land. By the year 2000, a total of 75 million hectares (268,000 square miles) was planted in soybeans worldwide, an area roughly equivalent to Peru's vast Amazon basin, or the United Kingdom and Spain, but much smaller than Peru's 114 million hectare territorial sea.[55]

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55. Soybean and fishmeal production data from FAO Statistical Databases, [cited 8-13 Oct. 2002], available from http://apps.fao.org/.

Meanwhile, Peru's guano bird population reached a new low. In July 1972 the total breeding population in Peru bottomed out at around 560,000 adults, and the average total breeding population for all of 1973 only amounted to 1.63 million adults, a 90-plus percent decline from the mid-1950s. As always, the guanay population was hit the hardest. In fact, this catastrophe hit them so hard that the piquero population in Peru outnumbered the guanay almost continuously from April 1972 until March 1979. The 1982-1983 El Niño event caused Peru's guano bird population to decline even further. None of these bird species has since returned to anything like its former abundance. The fishmeal boom engineered a profound and persistent change in the Peruvian marine environment.[56]

The anchoveta fishery eventually recovered from human mishandling after a hiatus lasting two decades. But the guano birds joined the California sardine, great whales, fur seal, sea otter, sea turtles, North Atlantic cod, herring, and oysters--and nearly joined the extinct great auk and Steller's sea cow--on a long, long list of valuable marine species ruined by human ecological greed.[57] Peruvian planners *consciously* sacrificed the guano industry to the god of national development, although not without some hand-wringing. Whether in the guise of service to the free market or state-managed economic nationalism, they did so believing that alternative plans could better engineer social and political stability and rapid economic growth in Peru. These plans proved to be far more difficult to

56. Tovar, Guillén, and Nakama, "Monthly Population Size of Three Guano Bird Species off Peru, 1953 to 1982," 208-218; cf. Daniel de la Torre Ugarte, *El desarrollo económico del Perú y sus consecuencias sobre la ecología* (Lima: Conaplan, 1982).

57. See Ray Hilborn, "Marine Biota," in *The Earth As Transformed by Human Action*, 371-385; Mowatt, *Sea of Slaughter*.

accomplish than expected, even under technocratic-authoritarian rule. Environmental management had its limits.

Conclusion

Who has made the decision that sets in motion . . . this ever-widening wave of death? . . . Who has decided--who has the *right* to decide--for the countless legions of people who were not consulted that the supreme value is . . . a sterile world ungraced by the curving wing of a bird in flight? The decision is that of the authoritarian temporarily entrusted with power; he has made it during a moment of inattention by millions to whom beauty and the ordered world of nature still have a meaning that is deep and imperative.

--Rachel Carson (1962)

It is convenient (and probably appropriate) to blame the military technocrats who managed PESCA-PERU for the failure of the anchoveta fishery. Years later, economists such as Jeffrey Sachs certainly found it expedient to fault statist economic management for the intense economic problems that beset most of Latin America during the 1980s: they wanted to ensure the triumph of neoliberal regimes all over the region during the 1990s. At least superficially, the recovery of the anchoveta fishery and Peruvian fishmeal industry under private ownership in recent years would seem to support this conclusion: in 1992, the year after Carlos Boloña took over as finance minister, the fishing industry processed over four million tons of anchoveta for the first time since the El Niño of 1972. In 1997, fishmeal exports brought in over US$1 billion, and by 1998, the entire industry had passed back into private hands.

Meanwhile, Peru's newest generation of technocrats have learned from past mistakes: In 1997-1998 during the most powerful El Niño event of the twentieth century, scientists at IMARPE set conservative quotas for the anchoveta fishery. These were strictly enforced by Alberto Fujimori's authoritarian government, neoliberalism's laissez-faire rhetoric and opposition from the fishing industry, notwithstanding. Many fishmeal producers targeted sardines and other fish species in order to hold their heads above water during this crisis. As a consequence, the anchoveta population recovered rapidly, and in 2000 Peru's fishing industry caught 9.372 million metric tons of anchoveta and exported 2.344 million metric tons of fishmeal, the fifth- and second-largest yearly totals in Peruvian history, respectively.[1]

Peru's newest fishmeal plants also emit relatively few pollutants, thanks to new technologies that maximize processing efficiency. However, anyone who has suffered the agony of breathing the caustic exhaust produced by Lima's chaotic, privatized public transportation system or the mineral concentrating plants situated along the Central Andean Railway--all tangible products of neoliberal reforms during the 1990s--knows that Peru's new-fangled technocrats have done little to provide their compatriots with a clean, healthy environment in other realms. Whether this second fishmeal boom will continue remains to be seen.

Many environmental activists now fault science, technology, and expertise for enabling the unprecedented destructiveness of humanity during the past two centuries. Some even see science as "the civics of [a] Hobbesian world."[2] Others continue to seek the earth's salvation in science, particularly ecological science.

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1. See app. 9, other Peruvian fishmeal statistics from FAO Statistical Databases, [cited 8-13 Oct. 2002], available from http://apps.fao.org/; Zapata and Sueiro, *Naturaleza y política: El gobierno y el Fenómeno del Niño en el Perú, 1997-1998*, 17-31, 85-98; cf. Meier Cornejo, *El futuro de la pesquería: Corrigiendo los errores del pasado*.

2. Visvanathan, "On the Annals of the Laboratory State," 277; Harry M. Collins and Trevor Pinch, *The Golem: What You Should Know About Science*, 2d ed. (Cambridge, UK: Cambridge University Press, 1998); idem, *The Golem at Large: What You Should Know About Technology*.

Meanwhile, no amount of scientific knowledge can decide whether it is the technocrat's primary moral duty to promote economic development for human benefit or to protect other species.

This concluding chapter takes a moderate position on these questions. It highlights several ways in which science enabled the successful management of Peru's marine environment for human benefit--albeit, for a privileged few--and a few ways in which science contributed to the failure of these endeavors. It should be clear by now that economic development and wildlife conservation can coexist. If the idea of "sustainable development" guided by scientists is ever to have any practical meaning between these dystopian and utopian extremes, historians must provide examples of relatively stable and lasting human ecosystems in the past that can serve as models for emulation.[3] The lifecycles of the Peruvian guano and fishing industries indicate that such schemes are possible, but quite fragile.

The Frontiers of Environmental Management

The revived Peruvian guano industry, for most of its history, was an extraoridinarily successful case of environmental management that served as a model to the world, its tragic fate notwithstanding. The Compañía Administradora del Guano's triumph as a scientific development program was crucial to its longevity. This success was premised on the remarkable quality of scientific talent --on the Lords of Guano--Peru has been able to recruit over the years: Rehr,

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3. On the need for empirical studies of successful cases of environmental management, see Worster, *Nature's Economy*, 428-433.

Unanue, Humboldt, Haenke, Rivero, Piérola, Raimondi, Malinowski, Carrillo, Vanderghem, Klinge, Coker, Forbes, Lavalle, Murphy, Gamarra, Schweigger, Vogt, Ávila, Sears, Llosa, Clark, Jordán, Rojas, Schaefer, Bjerknes. Their involvement in the management of Peru's marine environment is testimony to the importance of science in Peruvian history. The centrality of science and technology to the Peruvian fishmeal industry may have contributed to its demise, however, because it created the false appearance of a robust environmental management program.

The management of Peru's marine environment for human benefit had obvious ecological limitations. Peruvians discovered the hard way that the anchoveta were much less amenable to technocratic control than the easily "domesticable" guano birds. This was largely due to the different ecological roles humans played in exploiting these creatures. When extracting guano, humans played the role of scavenger. CAG took advantage of an unoccupied niche in Peru's marine ecosystem as consumers of excrement, although not without adversely affecting several other species in the process of shepherding the guano birds. In stark contrast, when catching schools of anchoveta to convert into fishmeal, humans acted as predators. Not only did the fishmeal industry compete ruthlessly against the guano birds for this limited resource, it negatively affected the inherent capacity of the anchoveta population to reproduce itself, even under the best conditions.

Today's marine experts have come to a consensus that environmental unpredictability makes marine fish "notoriously resistant to traditional resource management approaches."[4] Organisms, humans included, tend to experience life in terms of extremes. True environmental extremes happen at irregular intervals, sometimes beyond the living memory of an organism. This is especially true off the coast of Peru where the El Niño phenomenon makes the reproduction of marine organisms extremely variable from year to year, and where each El Niño event is quite different from the last.

In order to make sense of this uncertainty, investigation of this climate phenomenon has been a centerpiece of scientific research in Peru since the 1890s. Contrary to expectations, even after decades of study, experts still found it difficult to come to an agreement on the meaning of ecological change. On the one hand, William Vogt and Robert Cushman Murphy believed that uncertainty compelled caution, lest humans upset the "balance of nature" and destroy Peru's marine resources. On the other hand, the belief that Peru's marine ecosystem tended toward some "balanced" albeit oscillating state, encouraged scientists to try to manipulate and predict this variability. This had tragic consequences once Milner Schaefer legitimated the Peruvian fishing industry's attempts to manage the anchoveta fishery to produce a *maximum* sustainable yield for human benefit. Unfortunately, the rise of the Peruvian fishmeal industry happened between two severe El Niño events, and so was never put to an early test, and the anchoveta population proved to be more variable than even pessimists expected.

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4. Robert Costanza, et al., "Principles for Sustainable Governance of the Oceans," *Science* 10 July 1998, 198-99. On the problems facing Latin American fishing industries since the 1970s, see Aguilar, Reid, and Thorpe,"The Political Economy of Marine Fisheries Development in Peru, Chile, and Mexico."

Social relations of production from Peru's marine environment also impinged on this management regime. CAG's conservation experiment worked well initially because it stayed within preexisting traditions of property tenure. After the Peruvian state dealt with the Peruvian Corporation, CAG effectively owned and controlled the land and usufruct of the guano islands. The guano birds were wild and ownerless and their primary product easy to control. CAG's managers routinely used both conservation science and the technocratic ideal to defend their domain. They soon extended their technocratic realm to include the workers who harvested guano and the coastal farmers who used it, though not without resistance. From this solid base, the Lords of Guano were able to exercise autonomy of action in several realms.

In contrast, fish are highly mobile and not amenable to traditional forms of property administration developed on land. Fishermen are just as mobile and difficult to control, as CAG's managers found out in their futile attempts to police Peru's artisanal fishermen. Nevertheless, CAG's success dramatically strengthened the political authority of marine science in Peru, so much so that Peru's fishing industrialists continually pledged allegiance to the technocratic ideal, even to the point of funding IMARPE and submitting to its regulatory regime.

This authority had its limits, however, when marine experts failed to meet their superiors' lofty expectations. Modern industrial systems and state budgets are not designed for booms and busts; they are premised on constant growth. CAG eventually lost its reason for being when it failed to keep up with the expansion of input-intensive agriculture in Peru. The guano birds were sacrificed by Peruvian developmentalists in the belief that engineers could build a profitable chemical fertilizer industry based on the Haber-Bosch process that was not subject these limits. In a similar vein, the Revolutionary Government of the Armed Forces thought technocrats could do a far more efficient job managing the Peruvian economy for the benefit of all social classes once Peru's mining, agro-export, petroleum, railroad, and fishing sectors were placed under state ownership (after paying indemnities to their owners). This proved to be far more difficult than expected, especially when the vagaries of the anchoveta population and the international economy conflicted with the military's developmental vision.

As this last point indicates, the ecological history of Peru's marine environment cannot be understood merely in local terms. Besides that fact that foreign scientists were so often engaged in its management, production along the Peruvian coast has been subject to our changing role in the global ecology of the planet over the last two centuries, particularly our conquest of the nitrogen cycle. The "discovery" of Peruvian guano and nitrates by Humboldtian scientists during the early nineteenth century, followed by the invention of the Haber-Bosch process for synthesizing nitrogen compounds during the early twentieth century, not only affected the birth and demise of CAG and Peru's Guano Age, but also enabled input-intensive agriculture to become the conventional way most of the world's food is produced. Today, these practices make it possible for just less than half of the world's population (76 percent in the Americas) to live in cities far removed from the farming way of life. Meanwhile, nitrogen compounds are accessories in the annual deaths of trillions of fish (caught by nylon nests), billions of birds and mammals (fed on protein-rich feed and killed for meat), and millions of humans (by gunfire, conventional bombs, and cardiovascular disease from overconsumption of food and lack of exercise). Our manipulation of nitrogen has been as important as fossil fuels, and much more important than our ability to split the atom, in driving the ecological and social changes of the last two centuries. It will also shape the twenty-first century. Flatulence from all the meat- and milk-producing animals fed on these nitrogen compounds contributes to global warming.[5]

It is important to recognize that scientific innovation often took shape on the periphery, rather than at the core, of the global economic system built on this conquest of nitrogen. The cultural boundaries of science are vital to creativity, for at its margins, social conventions are brought into tension, even turned upside down. Preexisting mental categories turn out not to work, no matter how hard we try to force reality to fit our prejudices and classificatory schemes, so new paradigms have to be created. Locale is fundamental to this creative process. This was true among nineteenth-century Humboldtian scientists in the tropics, not only for Charles Darwin and Alfred Russel Wallace, who independently formulated the theory of evolution by natural selection based on their travels, but also for Jean Baptiste Boussingault, who devoted his life to researching the fertilizing importance of nitrogen after his encounter with guano in Peru. During the twentieth century, modern, physics-based meteorology was born, not in the

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5. On these points see Smil, *Enriching the Earth*, passim; idem, "Nitrogen and Phosphorus"; McNeil, *Something New under the Sun*, esp. ch. 7; *AAAS Atlas of Population and Environment*, 47-50, 55-62, 91-102.

scientific capitals of Europe, but in Bergen, a Norwegian fishing port. Likewise, the science of the El Niño-Southern Oscillation was born in Peru, Indonesia, India, and California (a one-time scientific backwater).[6]

Fundamental changes in environmental consciousness have also taken place on these cultural frontiers. The encounter with degradation in the "Edenic" tropics starting in the sixteenth century was vital to the development of modern environmental thought, as was the closing of the North American frontier at the end of the nineteenth century. During Peru's "ecological depression" of the early 1940s, William Vogt's encounter with the guano birds sparked his interest in the linkage between subsistence and human population growth, with far-reaching consequences for environmentalism in the Americas.[7]

It is wrong to conclude that the vast ecological transformations of the last two centuries were primarily "the unintended consequence of social, political, economic, and intellectual preferences and patterns."[8] Some of the worst travesties, such as the collapse of Peru's anchoveta fishery, indeed were "accidental." Even the best-laid plans sometimes created problems bigger than the ones they were trying to resolve. But many environmental changes, as with the final demise of

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6. Thomas F. Gieryn, *Cultural Boundaries of Science: Credibility on the Line* (Chicago: University of Chicago Press, 1999), esp. ch. 5, "Hybridizing Credibilities: Albert and Gabrielle Howard Compost Organic Waste, Science, and the Rest of Society," a study of the construction of the agricultural science of compost within the British empire; idem, "A Space for Place in Sociology"; Stepan, *Picturing Tropical Nature*, esp. ch. 1-2; Friedman, *Appropriating the Weather*; Davis, *Late Victorian Holocausts*, pt. 3.

7. Besides Grove, *Green Imperialism*, and other studies listed in ch. 5, see Patricia Jasen, *Wild Things: Nature, Culture, and Tourism in Ontario, 1790-1914* (Toronto: University of Toronto Press, 1995); Lee Clark Mitchell, *Witness to a Vanishing America: The Nineteenth-Century Response* (Princeton, NJ: Princeton University Press, 1981).

8. McNeil, *Something New under the Sun*, xxii; cf. Charles Perrow, *Normal Accidents: Living with High-Risk Technologies* (New York: Basic Books, 1984).

Peru's guano birds, were accomplished by experts who knew exactly what they doing and accomplished much of what they set out to do.

This fact is clearest when we examine whom these projects were intended to serve. The Lords of Guano enriched and empowered a new ruling class for Peru. The fat became fatter as a consequence of their actions on both sides of the North-South divide. Even if experts often presumed to use their "objective" knowledge to reconcile conflicting interests in order to serve the common good, in case after case, experts accomplished these changes explicitly to benefit those who already possessed power and capital. For this exact reason, some critics of the "dangerous liaison" that has developed between environmentalism and developmentalism consider "sustainable development" to be nothing more than the ancient worship of growing GDP under a new brandname and logo. Meanwhile, thanks to the catastrophist rhetoric of Vogt and his intellectual descendants, the "eco-technocratic elite" who manages the natural world for the rest of us are portrayed as the managers of our survival, when often times, they are really servants of the old regime. Experts have gained so much importance over the last two centuries for one major reason: They have been called on to manage uncertainty (if not to conquer it) for those who have the most to lose.[9]

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9. On the historical origin and meaning of the phrase "sustainable development," see Wolfgang Sachs, "Environment and Development: The Story of a Dangerous Liaison," *The Ecologist* 21:6 (1991), 252-257; idem, "The Archaeology of the Development Idea," *Interculture* 23:4 (1990), 1-37; idem, ed., *The Development Dictionary: A Guide to Power as Knowledge* (London: Zed Books, 1993); Worster, "The Shaky Ground of Sustainable Development," in *The Wealth of Nature: Environmental History and the Ecological Imagination* (New York: Oxford University Press, 1993), 142-155. Experts have most clearly served vested interests in the case of freshwater management: see Reisner, *Cadillac Desert*; Worster, *Rivers of Empire*; Perlo, *El paradigma porfiriano*.

Epilogue: Silent Spring on Isla Don Martín

Many environmental scientists envisioned something very different for ecology, "the subversive science." In Europe, "ecology" even became a codeword for Green politics. In 1962, at the exact moment when a movement of bird enthusiasts metamorphosed into an international environmental crusade, two former Lords of Guano brandished ecological science as a weapon to protect "the ordered world of nature" and humanity from the "ever-widening wave of death" reserved for them by the short-sighted "authoritarian."[10]

During the late 1950s, economic entomologists working for the U.S. Department of Agriculture oversaw the spraying of the insecticides DDT and dieldrin over vast areas of the eastern United States. Such sprayings were intended to control mosquitos, an old foe, as well as some new biological invaders: the gypsy moth, Dutch elm disease (by killing bark beetles), and the fire ant. These authoritarian actions unintentionally killed countless untargeted animals. As we now know, they also began to interfere, via a process known as bioaccumulation, with the ability of many fish-eating birds to produce viable eggs. In May 1957, Robert Cushman Murphy and a group of prominent Long Island residents filed suit seeking an injunction against spraying over private property. In 1959, Murphy brought his continued interest in the Peruvian guano industry to bear on this

10. See epigraph, Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin, 1962), 127. On ecology as the "subversive science," see Paul B. Sears, "Ecology--A Subversive Subject," *BioScience* July 1964, 11-13; Worster, *Nature's Economy*, esp. pt 6; Bramwell, *Ecology in the 20th Century*; Thomas Søderqvist, *The Ecologists, From Merry Naturalists to Saviours of the Nation: A Sociologically Informed Narrative Survey of the Ecologization of Sweden, 1895-1975* (Stockholm: Almqvist and Wiksell, 1986).

controversy. He wrote yet another article about CAG for *National Geographic Magazine* implicitly chastising North Americans for lacking the respect for marine birds that Peruvians had regained "out of the wreckage of the past, out of lessons bitterly earned."[11] Murphy lost the case, however, and the Supreme Court declined to review the decision in 1960.

But this ruling set the stage for the most important moment of the budding U.S. environmental movement. Murphy's wife, Grace E. Barstow Murphy, organized a grassroots movement, the Citizens Against Mass Poisoning, in protest. Meanwhile, one of Murphy's friends, a government scientist turned popular writer, Rachel Carson (1907-1964), developed an avid interest in the ecological impact of these chemicals. She had a long-standing relationship with Murphy, Vogt, and Mary Sears as both a bird enthusiast and a professional marine biologist with graduate training from Johns Hopkins (M.A., 1932) and Woods Hole. On 24 September 1962, when prominent *limeños* were marching to protest the pollution caused by Callao's fishmeal plants, both Murphy and Vogt were invited by Houghton Mifflin to attend a party at Carleton House in New York City to celebrate the official publication of Carson's newest book, *Silent Spring*. It quickly surpassed *Road to Survival* as a best-seller and now ranks as the most important environmental book ever written in any language. Carson argued forcefully with multiple examples and crystalline prose that North Americans would soon face a "silent spring" devoid of bird life and all that is beautiful if they did not curtail their use of poisonous synthetic "biocides." When Carson died of breast cancer only

11. Murphy, "Peru Profits from Sea Fowl," 413.

two years later, Murphy helped carry her bronze casket up the aisle of Washington Cathedral as a pallbearer. By this time, Peruvian state officials were actively considering ways to replace what Murphy still proclaimed as "the most impressive bird sanctuaries of their kind in the world."[12]

Like Murphy and Vogt, Carson challenged orthodox faith in technological progress and expert planning during this Golden Age of developmentalism. Like these Lords of Guano, Carson turned the ideology of progressive industrialism on its head. Her standard of value became our ability to adapt to the limitations of nature rather than to conquer them. Much like Vogt's *Road to Survival* and Murphy's 1954 report on *El guano y la pesca de anchoveta*, Carson's book was ruthlessly attacked by chemists, agronomists, entomologists, physicians, and other technical experts because she lacked the proper scientific training to speak authoritatively on the impact of pesticides on animal and human health. Many others condemned her as anti-progressive. Social inequalities were also involved in this treatment. Unlike in Peru, where female marine scientists were welcomed, Carson was treated with great condescension for her gender in the United States.[13]

Vogt, a self-proclaimed "admirer of Miss Carson and her writings," joined some of this critique. In a prominent review of *Silent Spring* and Murray Bookchin's first book *Our Synthetic Environment* (1962), Vogt gently admonished Carson for "a tendency to exaggerate and an occasional, uncritical acceptance of

12. Ibid.

13. Dunlap, *DDT*, ch. 4-5; Linda Lear, *Rachel Carson: Witness for Nature* (New York: Henry Holt, 1997), esp. 74, 120-121, 154-155, 180-182, 276, 305-307, 319, 422, 481, 516 n. 6, 555 n. 65

data," for her neglect of the scientific literature on population ecology, and her failure to use scientific names. In contrast to Carson's other critics, Vogt did not think Carson had gone far enough to provide "an ecological approach" to "these problems . . . in which our economy is embedded." Carson's more cynical opponents could have used such statements to claim that "prominent conservationists" dismissed the scientific basis of her argument.

Of course, Vogt agreed with Carson's basic claims. He knew exactly where the main battle for the world's environmental future was being fought: on the almost *lifeless* fields that modern, input-intensive agriculture was creating to maximize global food production. In this quest:

> Man . . . has fouled not his own nest but his entire environment--the air he breathes, the water he drinks, the soil that produces his food, the very food itself. He has reduced almost infinitely varied nature to the uniformity of pure stands of food and fiber that are even more ideally suited to his insect enemies than to himself.

These agricultural fields "destroyed more beauty than will ever be accumulated in all [our] galleries. Perhaps [our] major stupidity has been . . . to give the pernicious laws of the market place precedence over the most compelling laws of biology."

Like his old friend Aldo Leopold, and any good technocrat, Vogt was interested in acting on this knowledge, in developing viable solutions to humanity's problems based on a holistic view of the biosphere. But Vogt also realized how dependent humanity had become on synthetic pesticides and other technologies of input-intensive agriculture:

> What part do such substances play in trying to feed three billion world-wide, adding about another billion each decade? What would the control or

> abolition of such materials on our . . . farms do to their social structure, and to the cost and availability of food? . . .
>
> If Miss Carson and Mr. [Bookchin] are substantially correct in their facts and interpretations, and I believe that on the whole they are, a return to health and sanity will probably be roughly as complex and difficult as would have been the establishment of control over numbers and use of automobiles forty years ago. It might conceivably have been possible, before our society had become so thoroughly motor-dependent, to prevent the future hypertrophy and constipation of our metropolitan areas, the poisoning of their air, the repeated decimation of our wildlife, and the killing and maiming of far more Americans than have yet felt the icy hand of cumulative poisons. Will we move fast enough, now, to escape possible immolation in the metabolic by-products of a technology gone wild?

Here, Vogt summarized the key dilemma of environmental technocrats in a nutshell: Was it their primary duty to protect the environment, or to promote economic development for human benefit? Scientific understanding by itself, no matter how rigorous, simply could not change the political and economic imperatives imposed by society. Moreover, these imperatives were getting so far out of control that they seemed to require "man's mismanagement of his environment" just to survive in the short term.[14]

Who would decide? Even some critics of modern, technological society thought an authoritarian response was necessary. In direct response to Vogt and Josué de Castro's earlier polemic, Jacques Ellul concluded:

> All experts on agricultural questions are in fact in fundamental agreement . . . . Only strict planning on a world scale can solve the problems of agriculture [and population;] . . . only human relocation and collective distribution of wealth can solve the problem of famine. This can only mean

14. Vogt, "Reviews on Man the Destroyer," *Natural History* Jan. 1963, 3-5; cf. Murray Bookchin [Lewis Herber, pseud.], *Our Synthetic Environment* (New York: Alfred A. Knopf, 1962).

> that man . . . will be obliged to apply extremely rigorous administrative and police techniques.[15]

As China's "Three Bad Years" of 1959-1961 make clear, collective redistribution of wealth and "rigorous administrative and police techniques" had a checkered record when it came to solving the problem of famine.[16]

Rachel Carson, in contrast, believed that people would rise up and democratically demand a solution that favored the environment once they understood the threats ecological degradation posed to their well-being. To a certain extent, that is exactly what happened among the world's relatively privileged youth. A "counterculture" sprang up that rejected "The Quest for Truth, The Conquest of Nature, The Abundant Society," and other values of the "technocratic society" that had given it birth.[17] These challenges were met by a dual response, symbolized by the career of Robert S. McNamara, "the can-do man in the can-do society, in the can-do era." First, as U.S. Secretary of Defense, he used overwhelming military force in a (failed) attempt to stop the triumph of revolutionary forces in Vietnam. Later, as head of the World Bank, he orchestrated a liaison between environmental and development interests that used technocratic

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15. Jacques Ellul, *The Technological Society*, trans. John Wilkinson (1954; New York: Alfred A. Knopf, 1964), 104-111, quote p. 108, originally published as *La technique ou l'enjeu du siècle* (Paris: Armand Colin, 1954).

16. Smil, *China's Environmental Crisis*, ch. 6.

17. Theodore Roszak, *The Making of a Counter Culture: Reflections on the Technocratic Society and Its Youthful Opposition* (Garden City, NY: Doubleday, 1969), xiv. See also Eric Zolov, *Refried Elvis: The Rise of the Mexican Counterculture* (Berkeley and Los Angeles: University of California Press, 1999); José Agustín, *La contracultura en México: La historia y el significado de los rebeldes sin causa, los jibitecas, los punks y las bandas* (Mexico City: Grijalbo, 1996); Robert V. Daniels, *Year of the Heroic Guerrilla: World Revolution and Counterrevolution in 1968* (New York: Basic Books, 1989); Ronald Fraser, ed., *1968: A Student Generation in Revolt: An International Oral History* (New York: Pantheon, 1988); George Katsiaficas, *The Imagination of the New Left: A Global Analysis of 1968* (Boston: South End Books, 1987).

projects to counter radicalism.[18] In the United States, popular pressure led to the passage of a series of environmental protection laws in the wake of *Silent Spring*. These laws gave birth to an elaborate bureaucracy dedicated to the "management of environmental restraint."[19] In short, as was so often the case in Peru, rumblings for popular democracy tended to reinforce the power and autonomy of technocrats.

The upshot of all this forced one of the main former beneficiaries of Peru's guano birds to suffer the consequences of its environmental sins. In 2001, 134 years after Bryce, Grace, & Co. was founded to supply guano ships stopping at the Islas Chincha, 92 years after James W. Grace sat on CAG's first board of directors, and almost 30 years after the Revolutionary Government of the Armed Forces divested its share in Peru's sugar and fishmeal industries (with full compensation), W. R. Grace & Co. filed for chapter 11 bankruptcy to protect itself from enormous liability due to massive asbestos contamination in Libby, Montana, and other sites. Over 100 people have died and hundreds more suffer from chronic respiratory illness as a direct result of exposure to the by-products of Grace's former vermiculite mine, and there is good evidence that experts informed its managers of the problem years before. Grace had already been subject to a lawsuit involving cancer-causing chemical pollution around Woburn, Massachusetts, as portrayed in the book and Hollywood feature film "A Civil Action," starring John Travolta. Grace might have faced regulatory discipline much sooner if the Environmental

18. See David Halberstam, *The Best and the Brightest* (New York: Random House, 1972), 215; Sachs, "Environment and Development," 253-254; cf. Deborah Shapley, *Promise and Power: The Life and Times of Robert McNamara* (Boston: Little, Brown, 1993).

19. Hays, *Beauty, Health, and Permanence* esp. ch. 12 "The Middle Ground: Management of Environmental Restraint"; cf. Jasanoff, *The Fifth Branch*.

Protection Agency had not ignored a 1982 report that clearly linked high cancer risks to Grace's vermiculite processing facility, a decision that suspiciously coincided with the final report of the Private Sector Survey on Cost Control chaired by J. Peter Grace, a centerpiece of the Ronald Reagan administration's campaign to dismantle the U.S. federal government's regulatory apparatus. The Grace Commission, as it was known, issued over 2,000 recommendations, many targeting the EPA for cuts. Thus, the "democratic" route to environmental protection had its shortcomings, particularly its torpid rate of action.[20]

In Peru, the heirs to the Lords of Guano have not given up on the idea of environmental management by technocrats. In 2003, the Peruvian guano industry was again plugging along under the independent management of PROABONOS (est. 1997), a quasi-state company modeled after CAG and run by conservation-minded agronomists. During its first three years of existence, PROABONOS produced 52,483 metric tons of guano *rico*, 8,000 of which were exported to organic farmers in the Northern Hemisphere. The green in that expensive organic asparagus flown in from Peru on your dinner table just might contain some nitrogen that passed through the gut of a guano bird. The Peruvian guano industry is back almost exactly where it started in 1909.[21]

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20. Bishel, "Business Ideology and U.S. Foreign Policy," esp. 19; "Información comercial: Banco Alemán Transatlántico," *La Prensa* 11 Apr. 1909 (morning ed.), p. 2, col. 1 [see correction "Información comercial: Compañía Administradora del Guano," *La Prensa* 12 Apr. 1909 (morning ed.), p. 1, col. 6]; Living on Earth, "Libby's Asbestos Legacy," radio broadcast week of 29 June 2001, [cited 5 July 2001]; idem, "EPA Investigates Itself," radio broadcast week of 28 July 2000, [cited 25 Oct. 2002], both available from http://www.loe.org/archives/archives.htm.

21. Peru, Ministerio de Agricultura, PROABONOS, *Memoria anual 1999* (Callao, May 2000), 10-12; PROABONOS, *Memoria annual 1998*, 14-16, 19; PROABONOS, *Memoria annual 1997*, 5, 7; Armando Rivera Calle, personal communication, June 2001.

Peruvians have found new uses for relics of the old guano and fishmeal industries. The concrete tower that once housed the Ministry of Fisheries is now home to Peru's Museo de la Nación and some of the ancient indigenous artifacts originally purchased by conservationist Albert Giesecke. It is a popular destination for foreign tourists. The hollowed-out shell of the palace built for CAG's managers in the 1920s is also still in use, as a sweatshop producing clothing for the cut-rate stores that serve Lima's seven million-plus working class. From its roof, one can get a good look at decaying symbols of Lima's former splendor: the seventeenth-century baroque Convento de San Francisco, Juan Rehr's post-1746 cathedral towers, the ornate courtyards and skylights of downtown Lima's departed elite, and the abandoned Art Deco headquarters of Gildemeister & Co. Peru's present and future are also visible: Dozens of small retail shops and street merchants hawk their wares, most imported from the other side of the Pacific. An unending stream of exhaust-spewing buses travels up and down Avenida Abancay, for which many blocks of old colonial Lima were razed by Augusto Leguía to make way for the automobile age. Private cars and taxis dart in and out of adjacent streets, trying to avoid this permanently clogged artery. All of this is overlooked by the meticulously clean, carefully guarded Congreso, Peru's living palace to democracy.

On Isla Don Martín, the old marine biology station that Enrique Ávila built still stands. Inside, its museum, archive, and living quarters are still intact, almost how he left them more than four decades ago. But outside things could not be more different. From the top of the island, one sees nothing but bare soil and rock, a handful of guano birds, CAG's old wooden buildings, and a few vultures perched on an old crane ready to take advantage of another animal's demise. In its glory days under CAG, this island was a continuous squawking colony, one of the great spectacles of nature. Isla Don Martín was once home to more guanayes at one time than the 1.4 million birds populating the entire Peruvian littoral during the 1998 El Niño.[22] Looking east toward the coast, one sees giant *bolicheras* chugging in and out of port and the unmistakable smoke plumes of several fishmeal plants. Looking west, one sees nothing but the vast Pacific Ocean, Peru's "fourth natural region."

We did not eat any meat out on the guano island, though we did eat a fresh cheese. Meat is too expensive, too perishable for the lone island guardians, and we did not think to bring any with us. We mainly ate lentils and rice, the staples of the guano worker. When we got back to Huacho, the nearest port, we were in too big a hurry to search out a decent *cevichería* (fish stand), so we stopped at fast and efficient Norky's, a Peruvian-owned chain, and pigged out on *pollo a la brasa* and *papas fritas*. A couple hundred thousand tons of fishmeal per year now makes it to the stomachs of Peruvians, via the concrete chicken ranches that line the Pan-American highway and ubiquitous roast-chicken joints that serve Peru's major towns and cities. For those who can afford it, "chicken from the sea" is among Peruvians' favorite foods. Nevertheless, Peruvians per capita still consume half the meat as the earth's average human.[23] Perhaps they are healthier for it.

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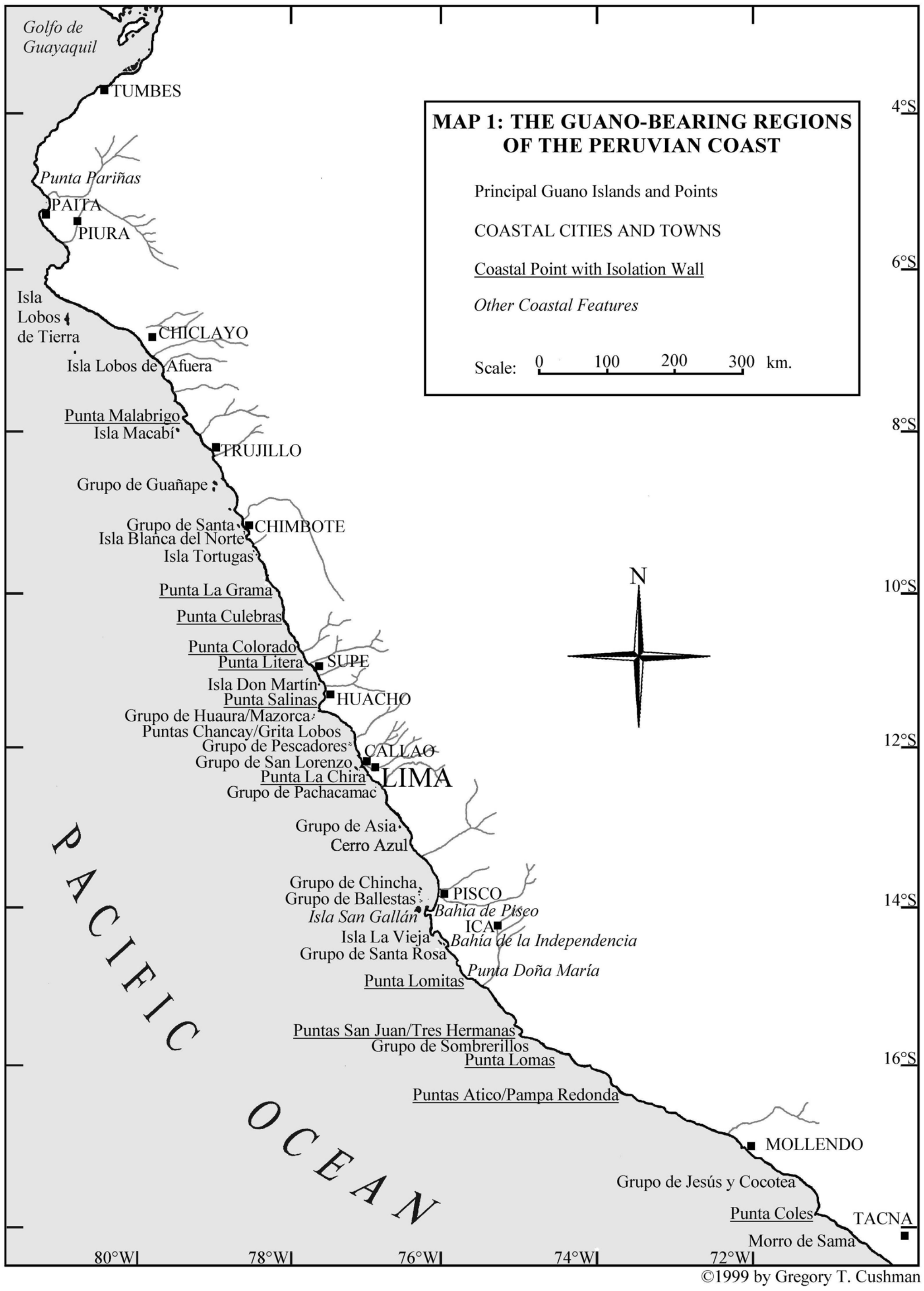
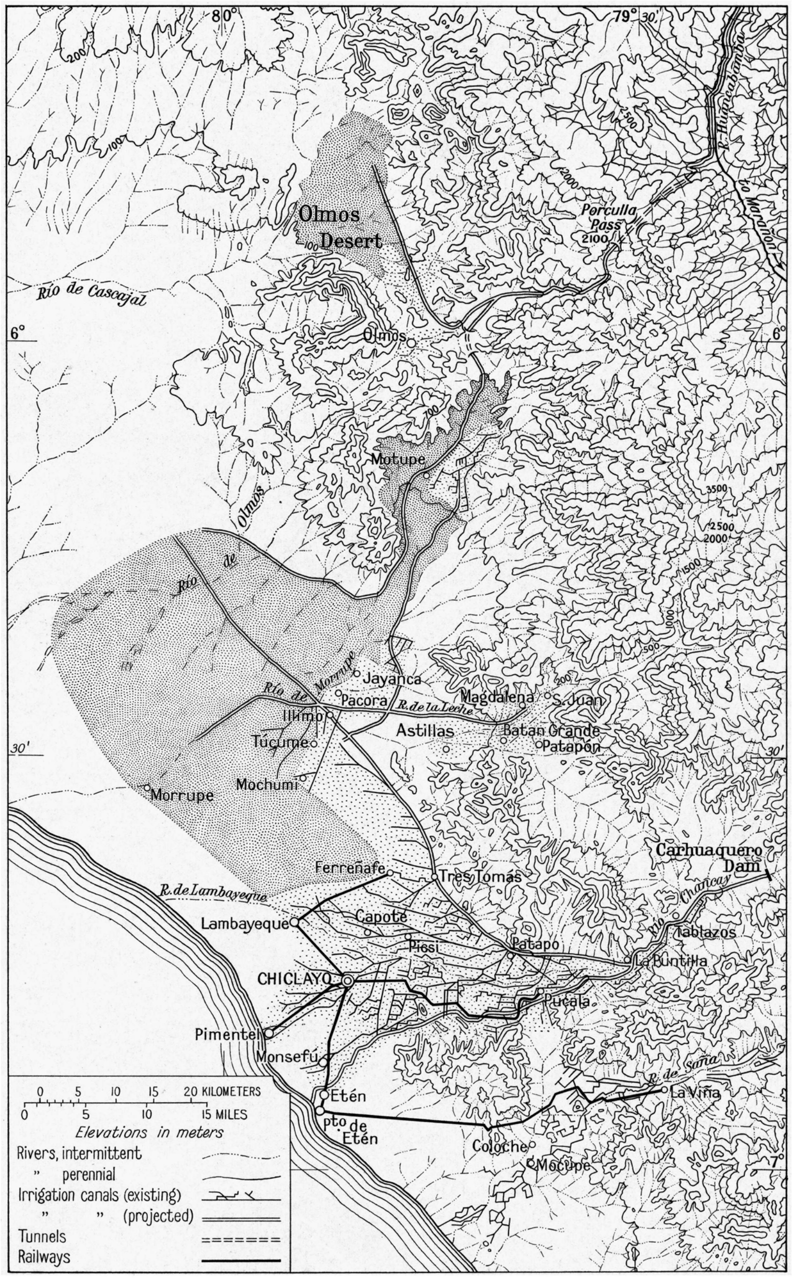
22. PROABONOS*, Memoria annual 1999*, 21-23; PROABONOS*, Memoria annual 1998*, 26.

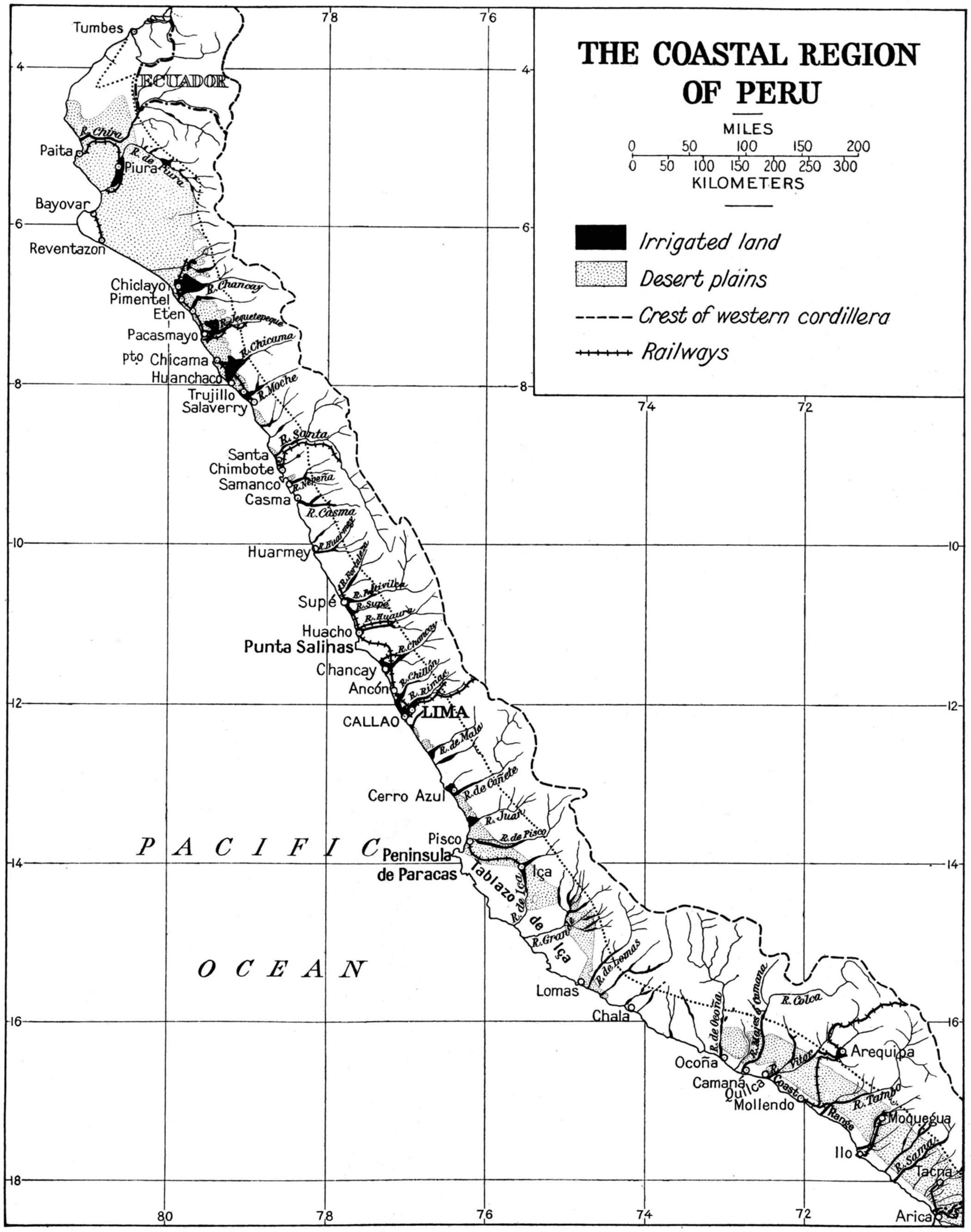
23. See table 8.

Breathe in. That pungent "smell of money" on Isla Don Martín comes from fishmeal, not from guano as it used to. Listen. The island is silent, except for the sea. Every spring will be silent on the guano islands as long as the new generation of technocrats who manage Peru have their way and keep extracting the maximum sustainable yield from the anchoveta fishery, and as long as affluent Peruvians and North Americans keep eating chicken at places like Norky's.


MAP 1: THE GUANO-BEARING REGIONS OF THE PERUVIAN COAST
Principal Guano Islands and Points
COASTAL CITIES AND TOWNS
Coastal Point with Isolation Wall
Other Coastal Features
Scale: 0 100 200 300 km.
N
Golfo de Guayaquil
TUMBES
Punta Pariñas
PAITA
PIURA
Isla Lobos de Tierra
CHICLAYO
Isla Lobos de Afuera
Punta Malabrigo
Isla Macabí
TRUJILLO
Grupo de Guañape
Grupo de Santa
CHIMBOTE
Isla Blanca del Norte
Isla Tortugas
Punta La Grama
Punta Culebras
Punta Colorado
Punta Litera
SUPE
Isla Don Martín
Punta Salinas
HUACHO
Grupo de Huaura/Mazorca
Puntas Chancay/Grita Lobos
Grupo de Pescadores
CALLAO
Grupo de San Lorenzo
Punta La Chira
LIMA
Grupo de Pachacamac
Grupo de Asia
Cerro Azul
Grupo de Chincha
PISCO
Grupo de Ballestas
Isla San Gallán
Bahía de Pisco
ICA
Isla La Vieja
Bahía de la Independencia
Grupo de Santa Rosa
Punta Doña María
Punta Lomitas
Puntas San Juan/Tres Hermanas
Grupo de Sombrerillos
Punta Lomas
Puntas Atico/Pampa Redonda
MOLLENDO
Grupo de Jesús y Cocotea
Punta Coles
TACNA
Morro de Sama
PACIFIC OCEAN
4°S
6°S
8°S
10°S
12°S
14°S
16°S
80°W
78°W
76°W
74°W
72°W
©1999 by Gregory T. Cushman

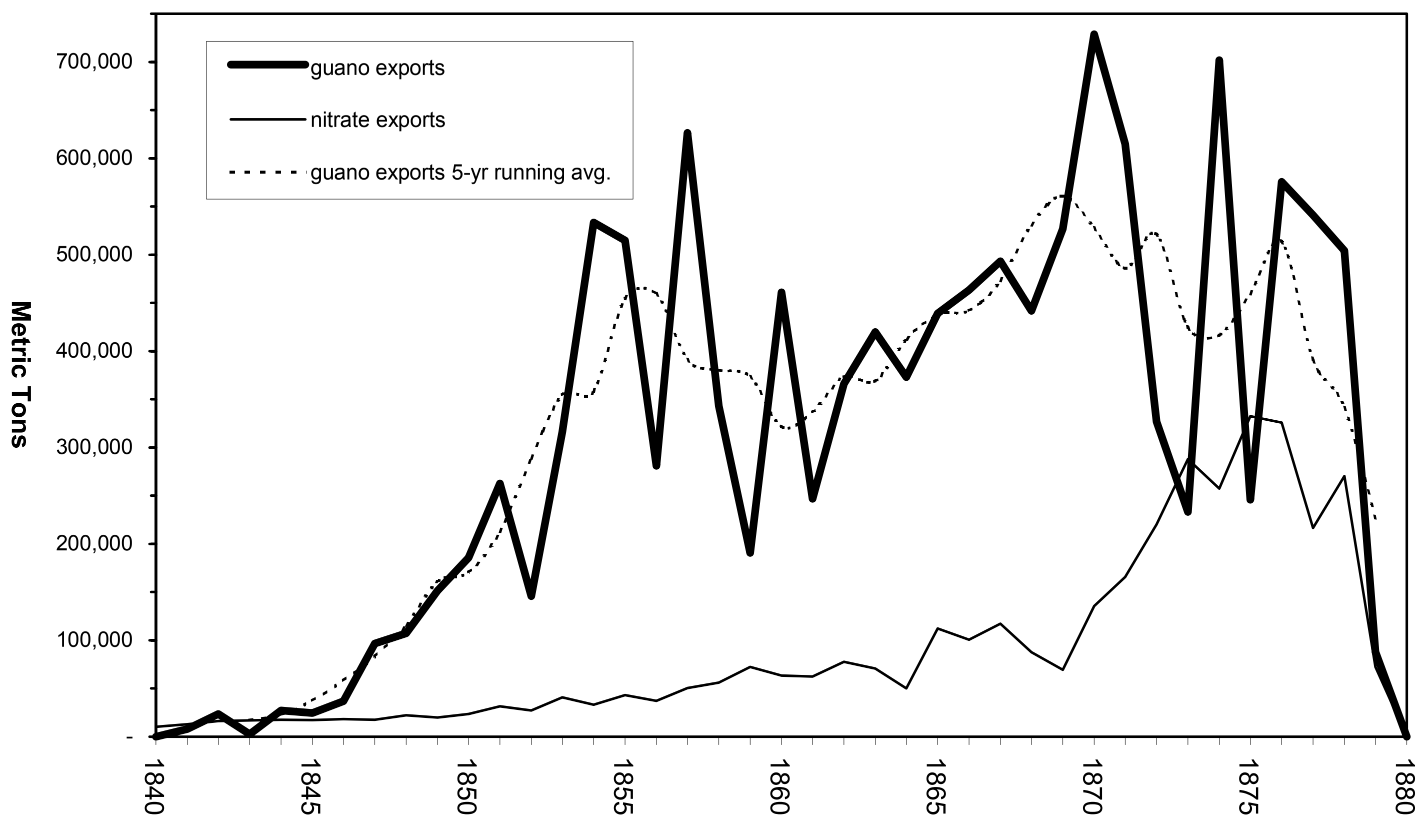


Map 2: The Lambayeque Irrigation Project:
Irrigated areas in 1924 (open stipple),
projected irrigated areas after 1924 (closed stipple)
(map: Johnson, Peru from the Air).



Map 3: The agricultural valleys, railroads, and towns of coastal Peru, circa 1930 (map: Johnson, Peru from the Air).

Fig. 1: Guano and Nitrate Exports from Peru, 1840-1880



Source: Shane J. Hunt, "Price and Quantum Estimates of Peruvian Exports, 1830-1962," (1973), table 21.

Fig. 2: Guano *Rico* Production in Peru, 1910-1985

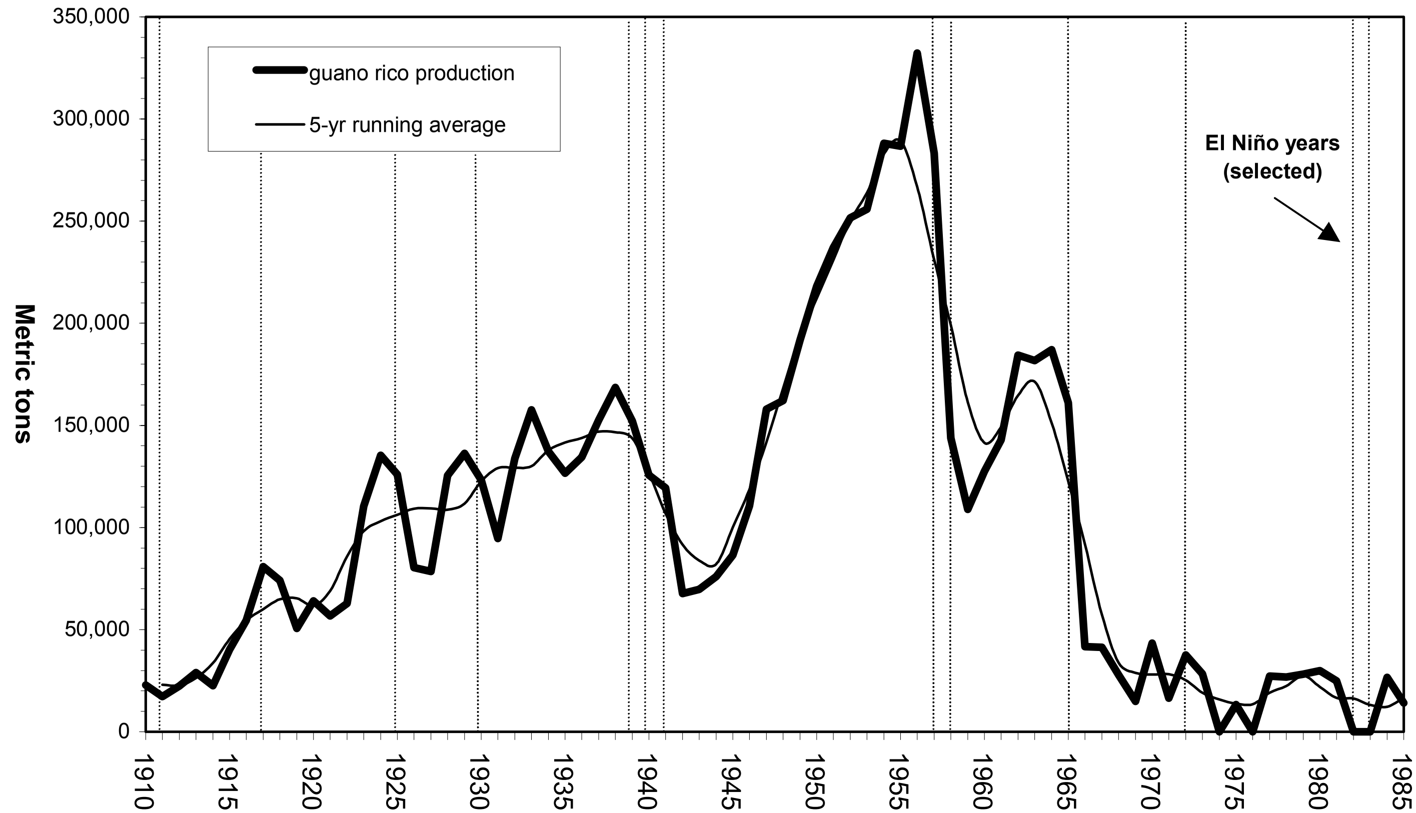


Fig. 3: Cotton Production in Peru, 1916-1976

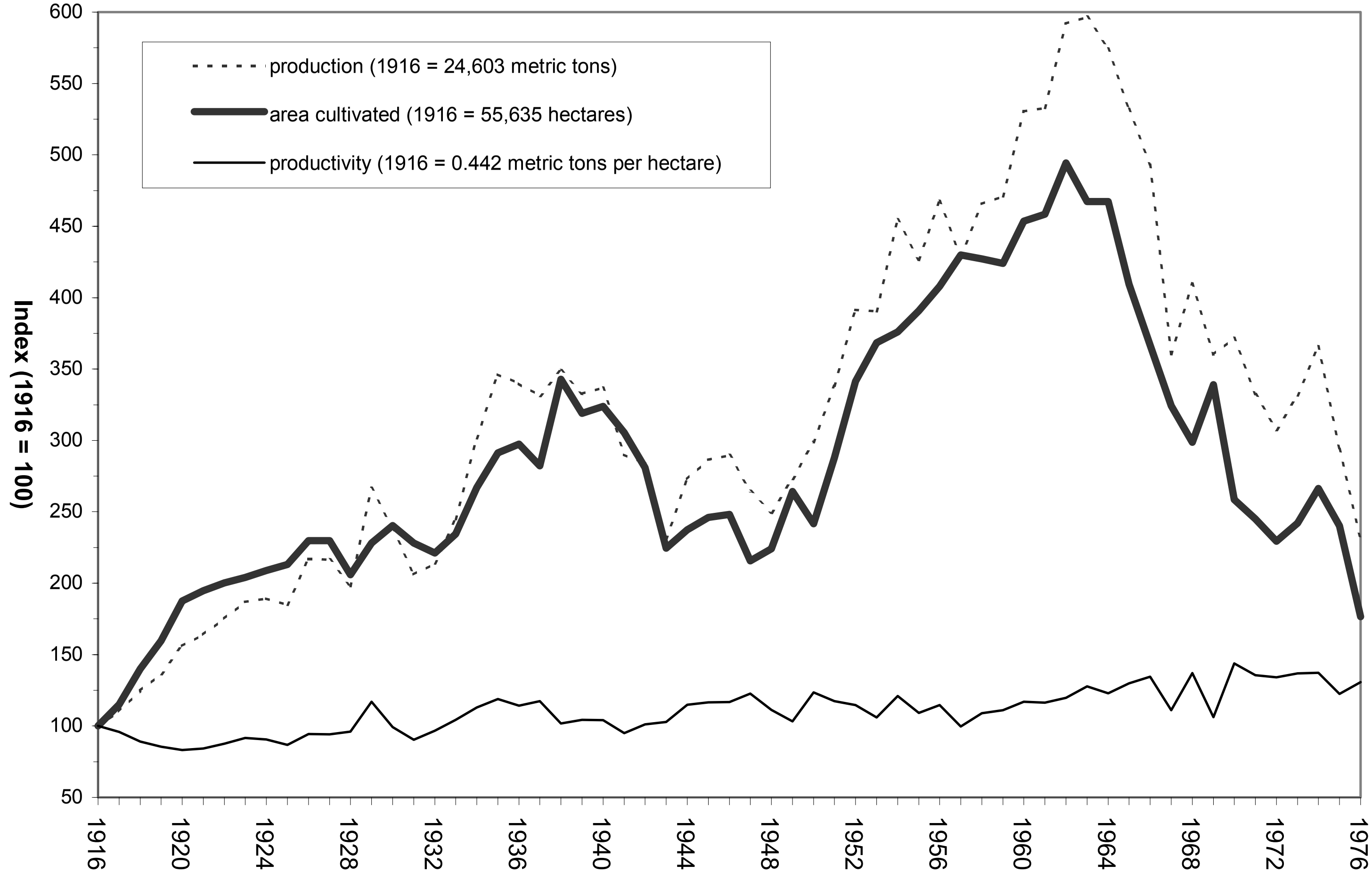


Fig. 4: Sugar Cane Production in Peru, 1916-1976

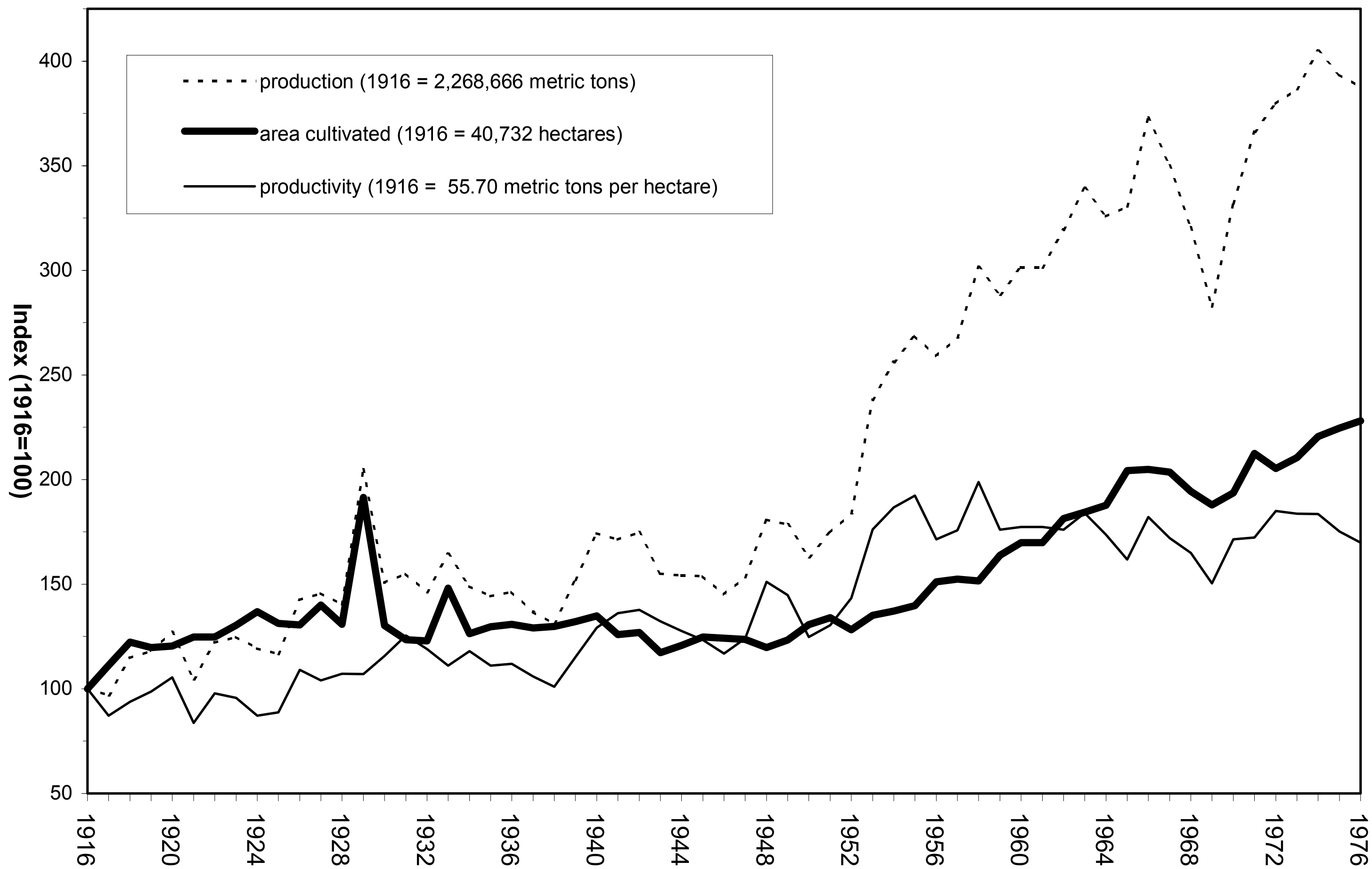


Fig. 5: Peruvian Cotton Exports, 1913-1973

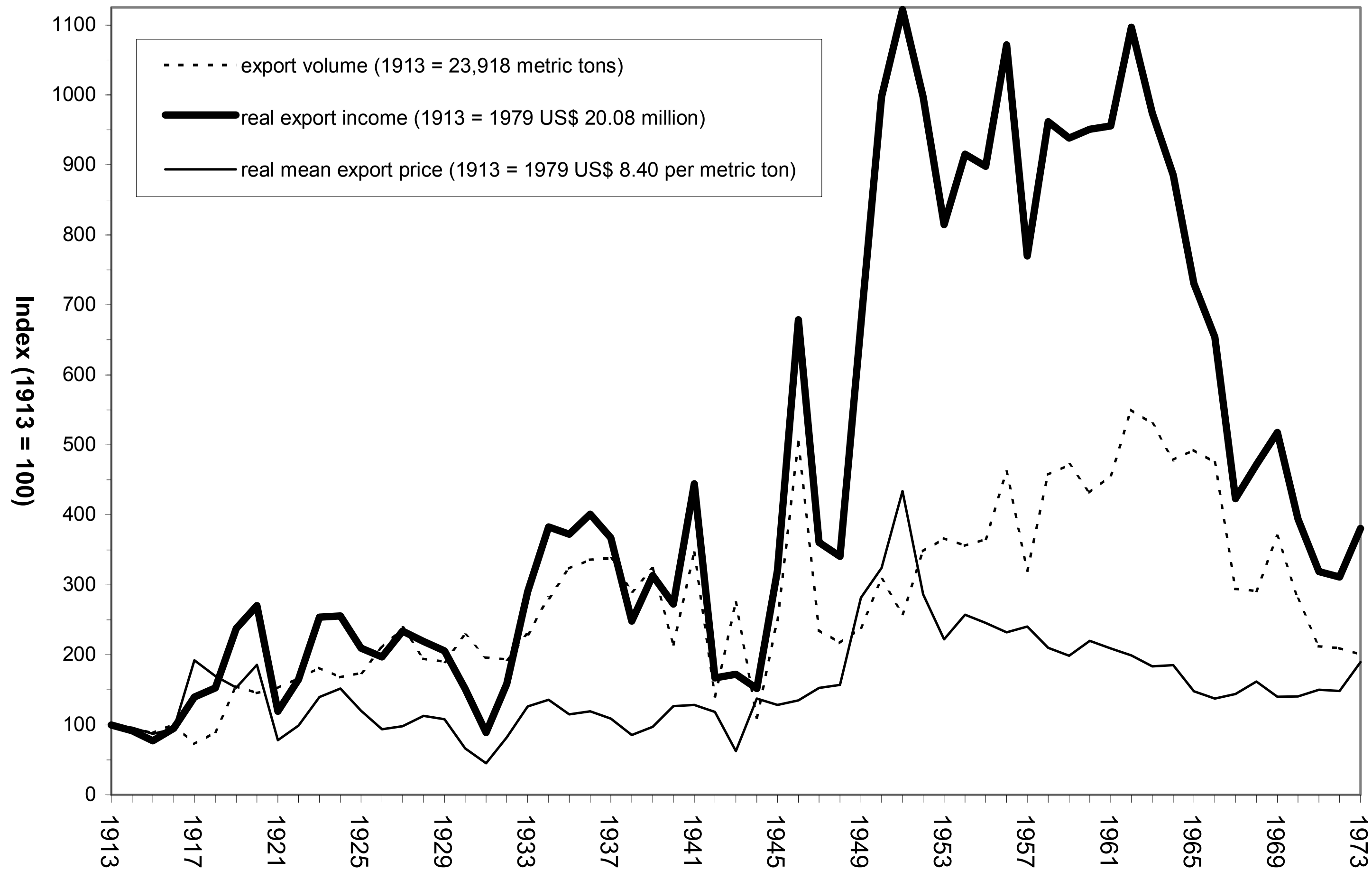


Fig. 6: Peruvian Cane Sugar Exports, 1913-1973

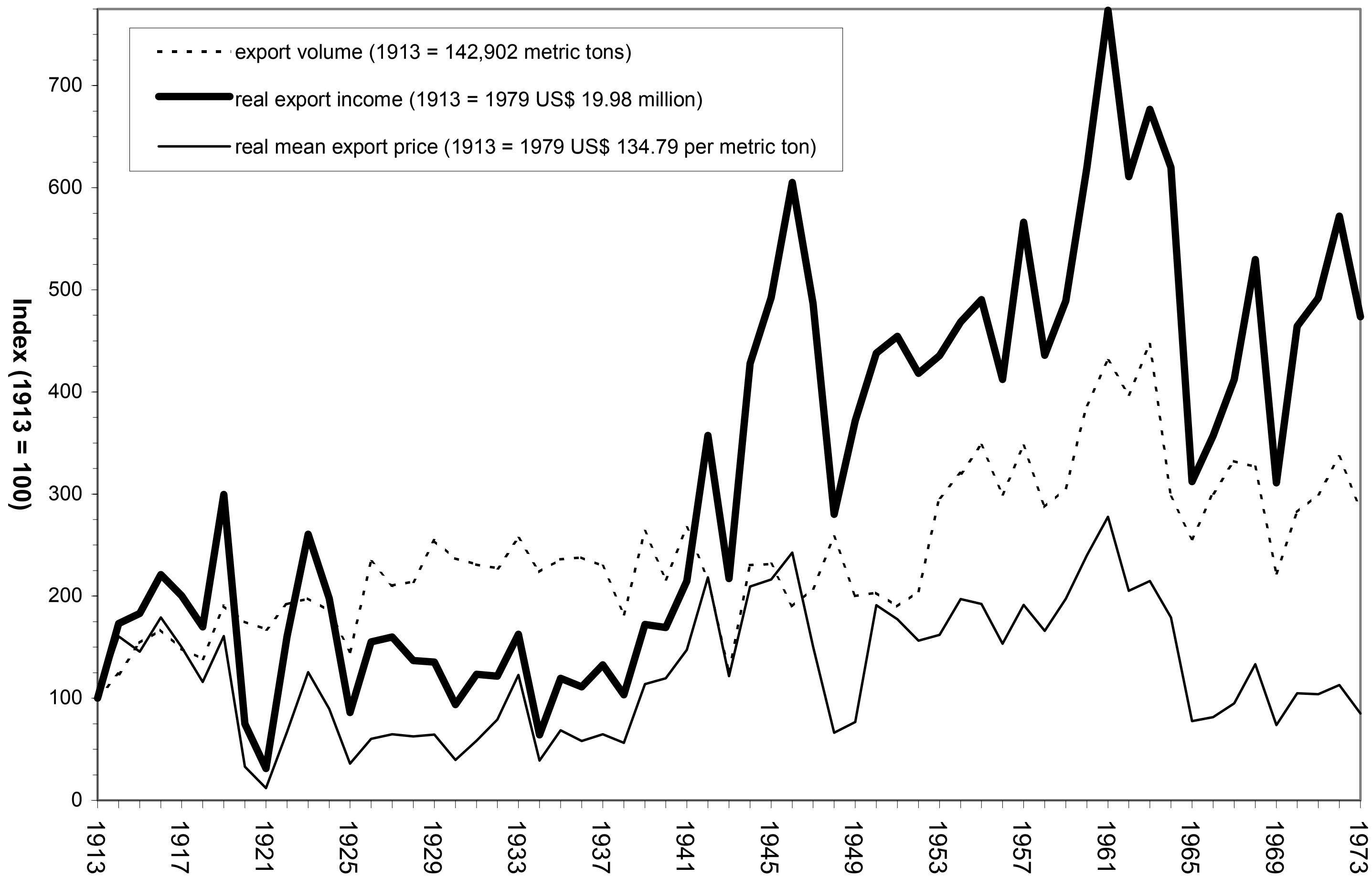
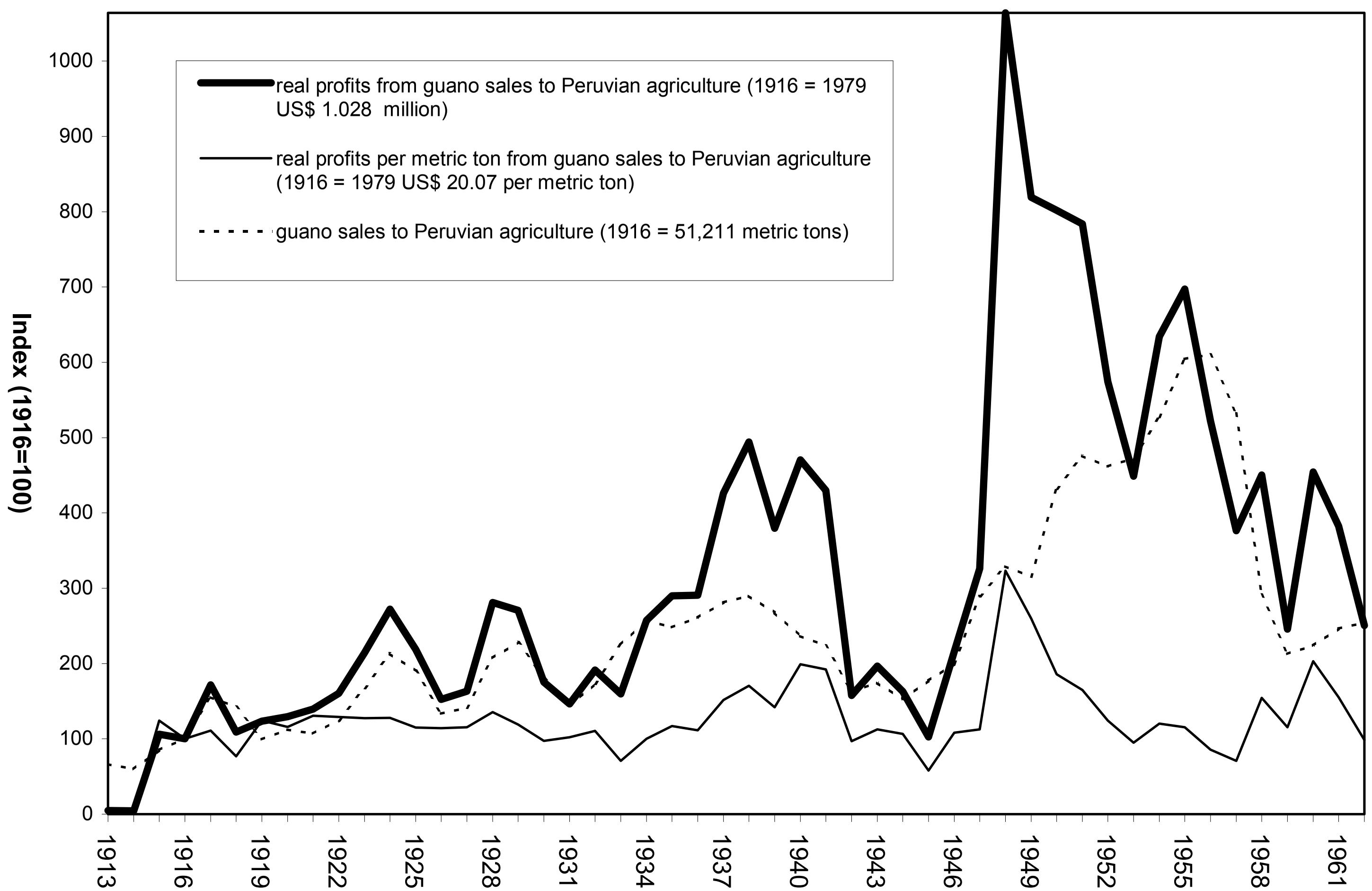


Fig. 7: Guano Sales in Peru, 1913-1962



Running six-monthly average anomalies of Djakarta air pressure and Puerto Chicama sea-surface temperature 1925-1964.

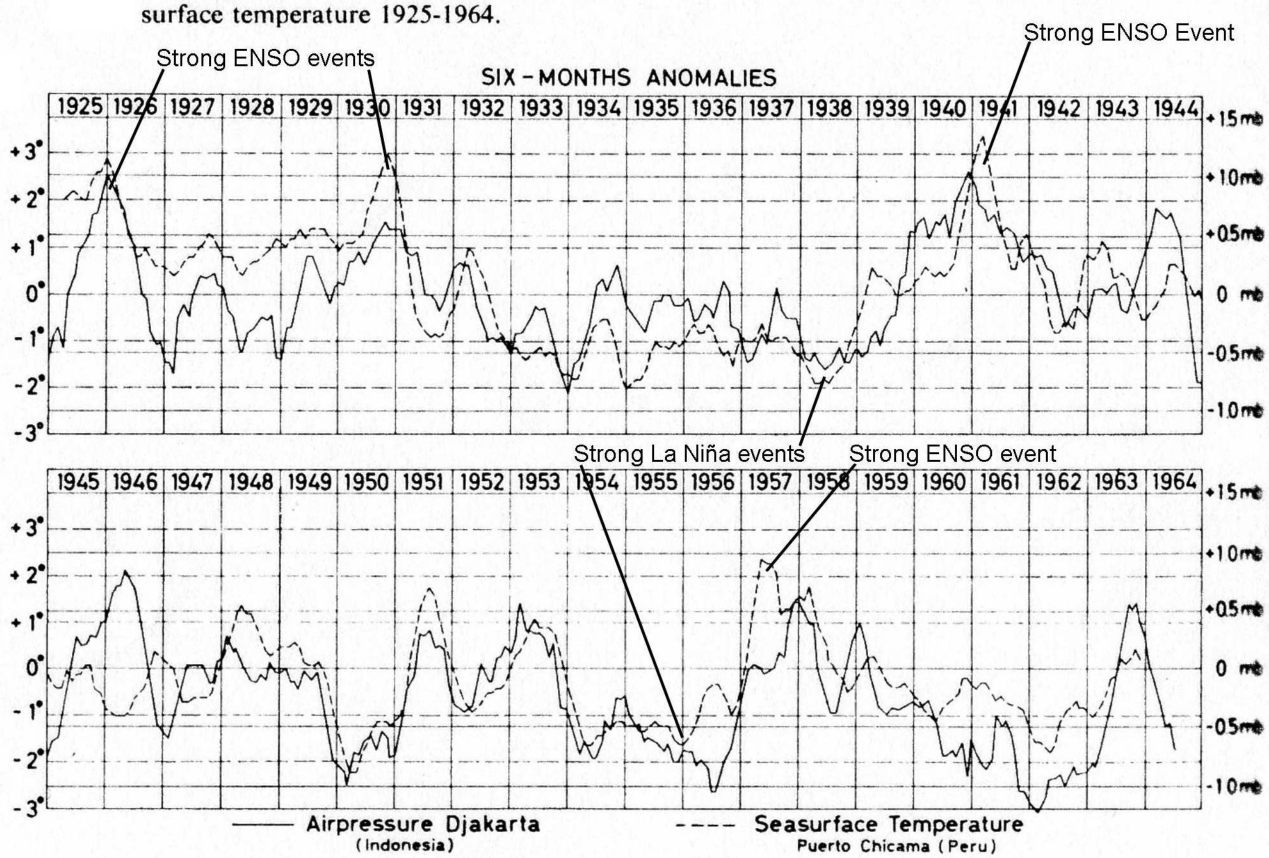
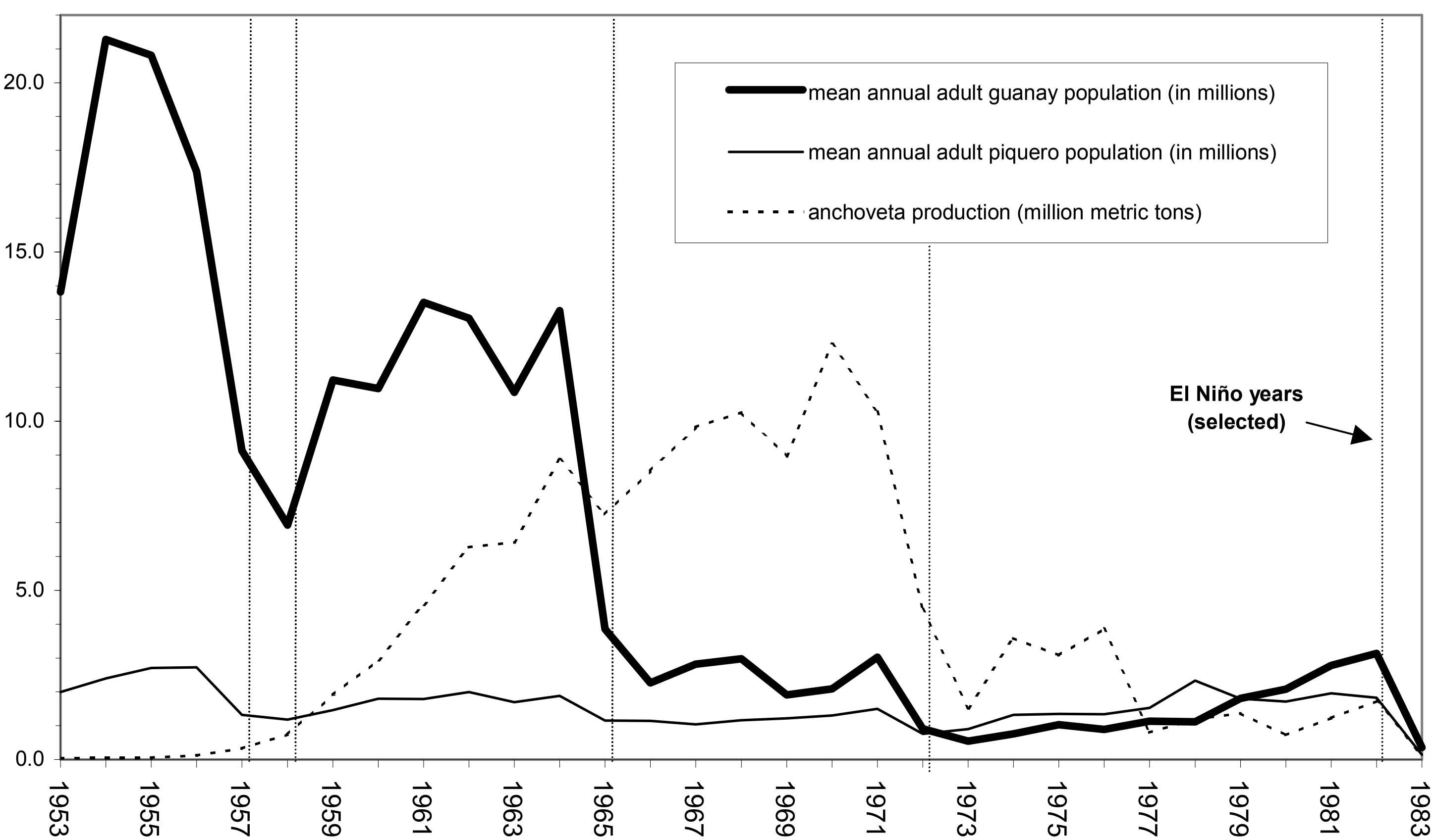


Fig. 8: The Discovery of ENSO: Measurements of the Southern Oscillation and Peruvian El Niño superimposed (Berlage, "The Southern Oscillation and World Weather" [1966]).

Fig. 9: Guano Bird Population and Anchoveta Production in Peru, 1953-1983



Source: Humberto Tovar, Victor Guillén, and María E. Nakama, "Monthly Population Size of Three Guano Bird Species off Peru, 1953 to 1982," in *The Peruvian Anchoveta and Its Upwelling Ecosystem: Three Decades of Change*, ed. D. Pauly and I. Tsukayama (Callao: IMARPE, 1987).

Fig. 10: Nitrogen Fertilizer Consumption in Peru, 1945-1995

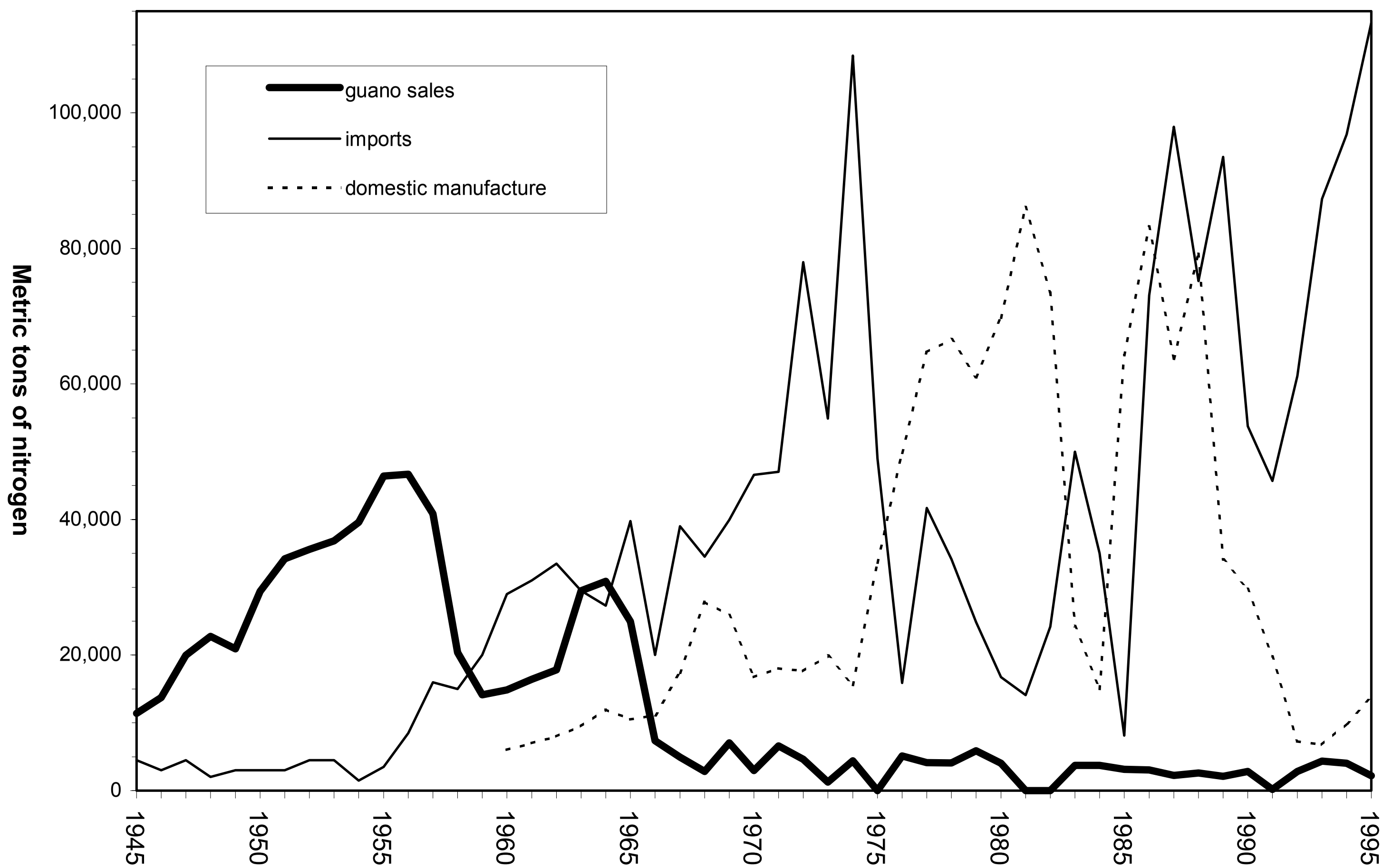
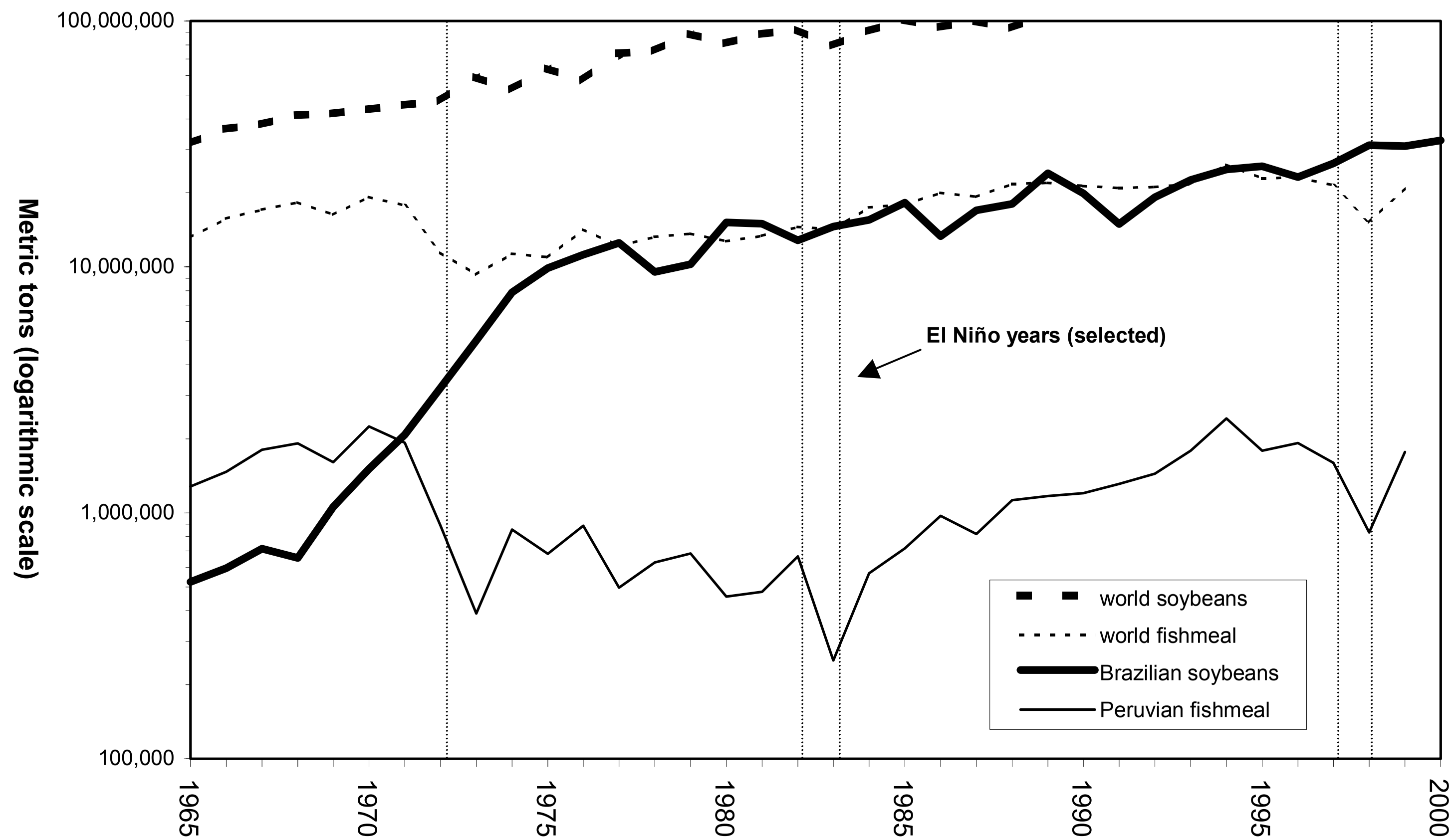
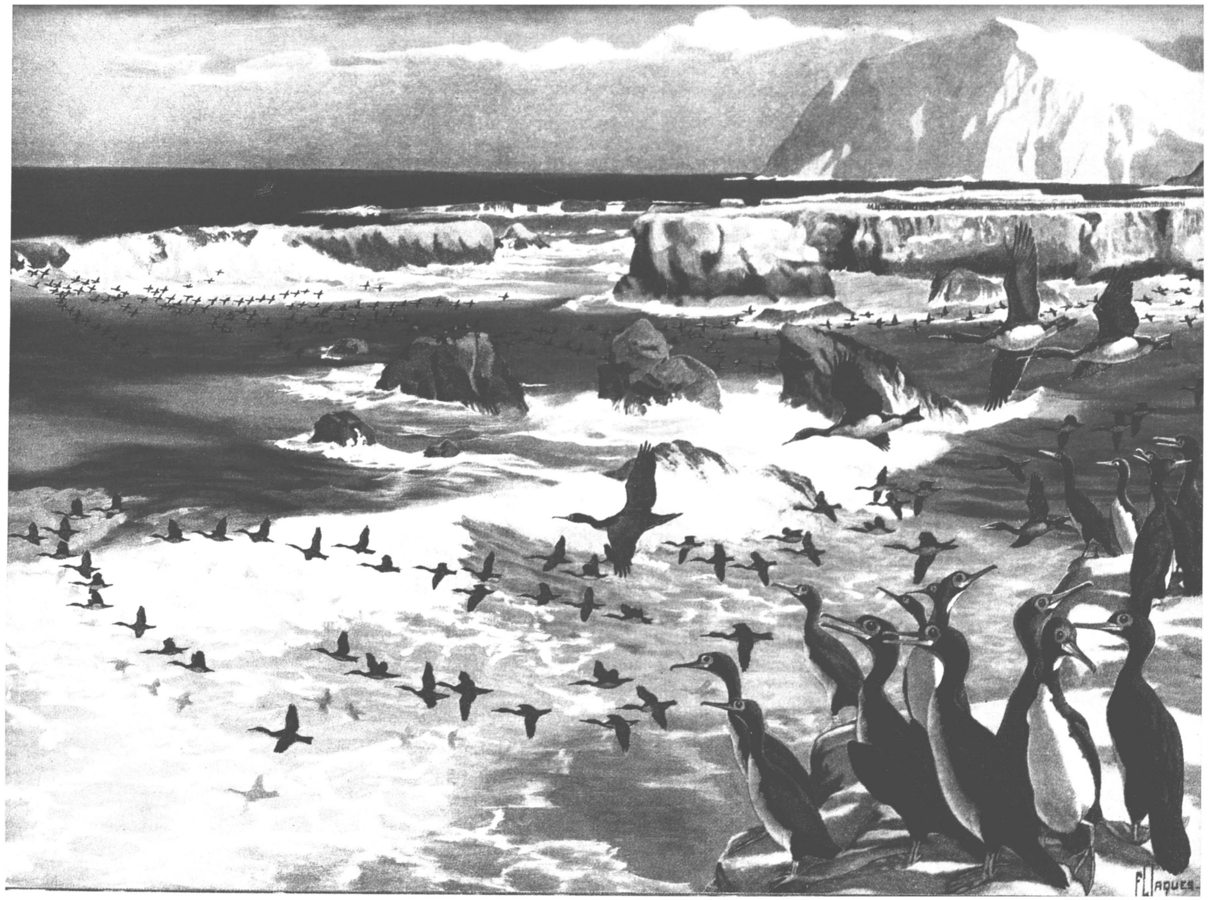


Fig. 11: World Soybean and Fishmeal Production, 1965-2000

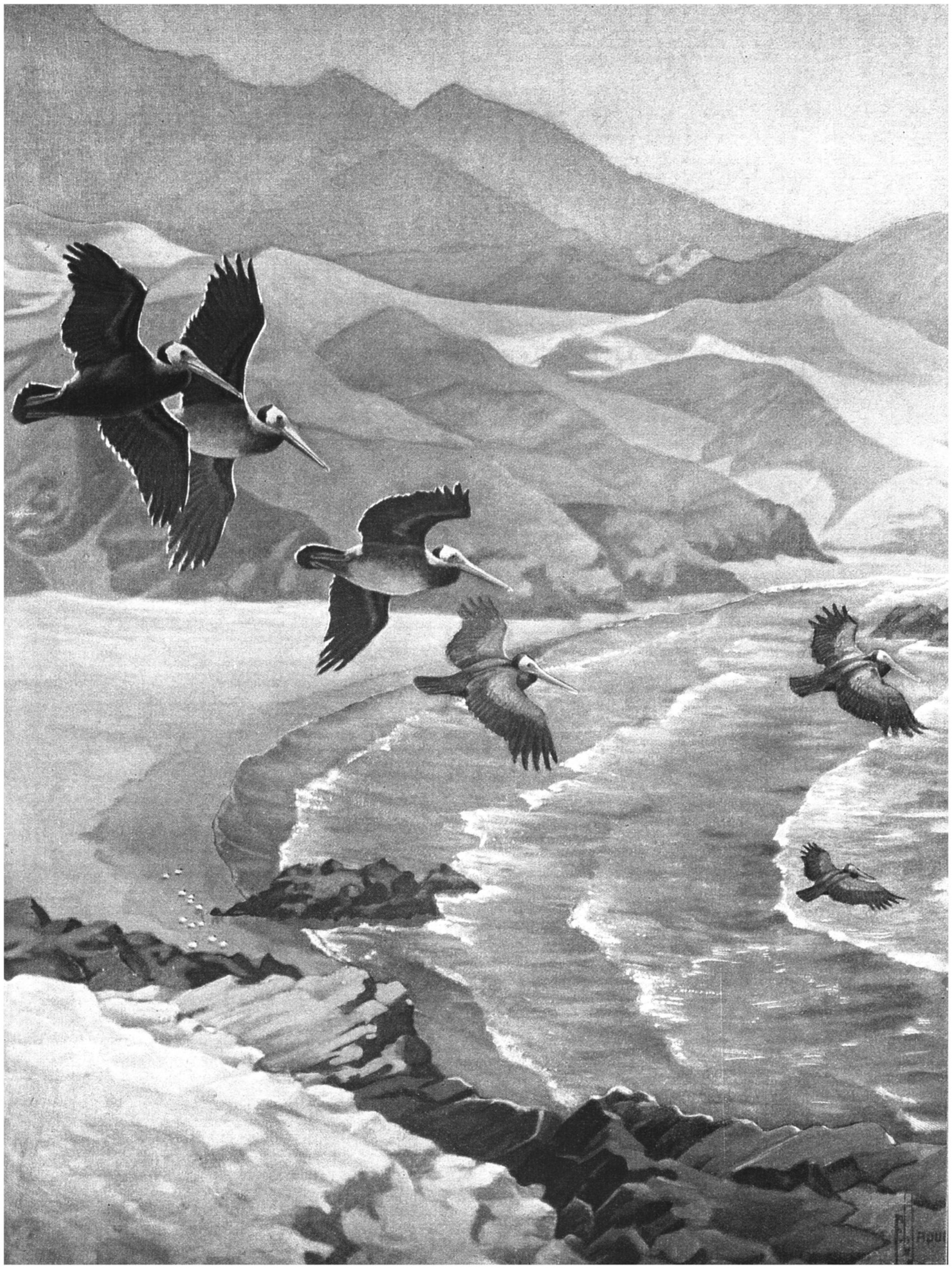


Illus. 1: Peru's first native-born professional ornithologist,
Enrique Ávila,with his young family, Jan. 1950
(photo: courtesy of Basilia Díaz viuda de Ávila).

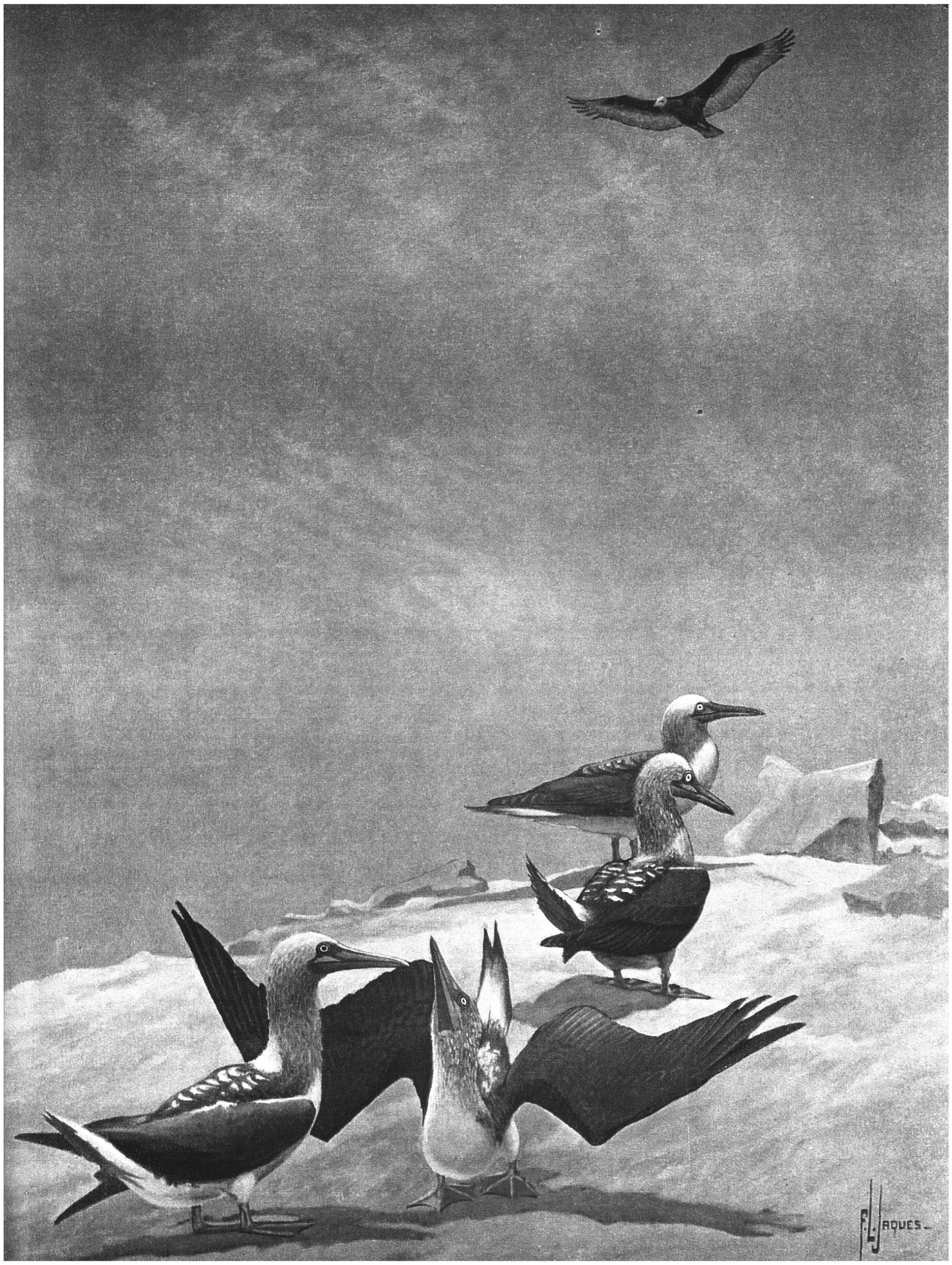


Illus. 2: The guanay or Peruvian cormorant (Phalacrocorax bougainvillii), Isla Santa Rosa, Peru, with Isla La Vieja in the background, by Francis L. Jaques (color plate: Murphy, Oceanic Birds).

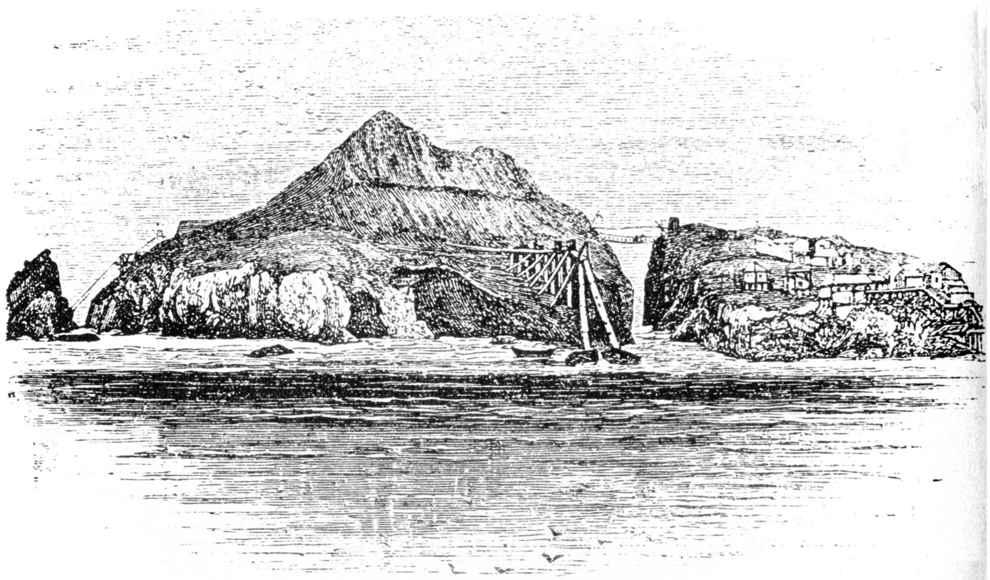
Illus. 3: The piquero or Peruvian booby (Sula variegata), Isla Pescadores, Peru, by Francis L. Jaques (color plate: Murphy, Oceanic Birds).



Illus. 4: The alcatraz or Peruvian pelican (Pelecanus thagus), Ancón, Peru, by Francis L. Jaques (color plate: Murphy, Oceanic Birds).-

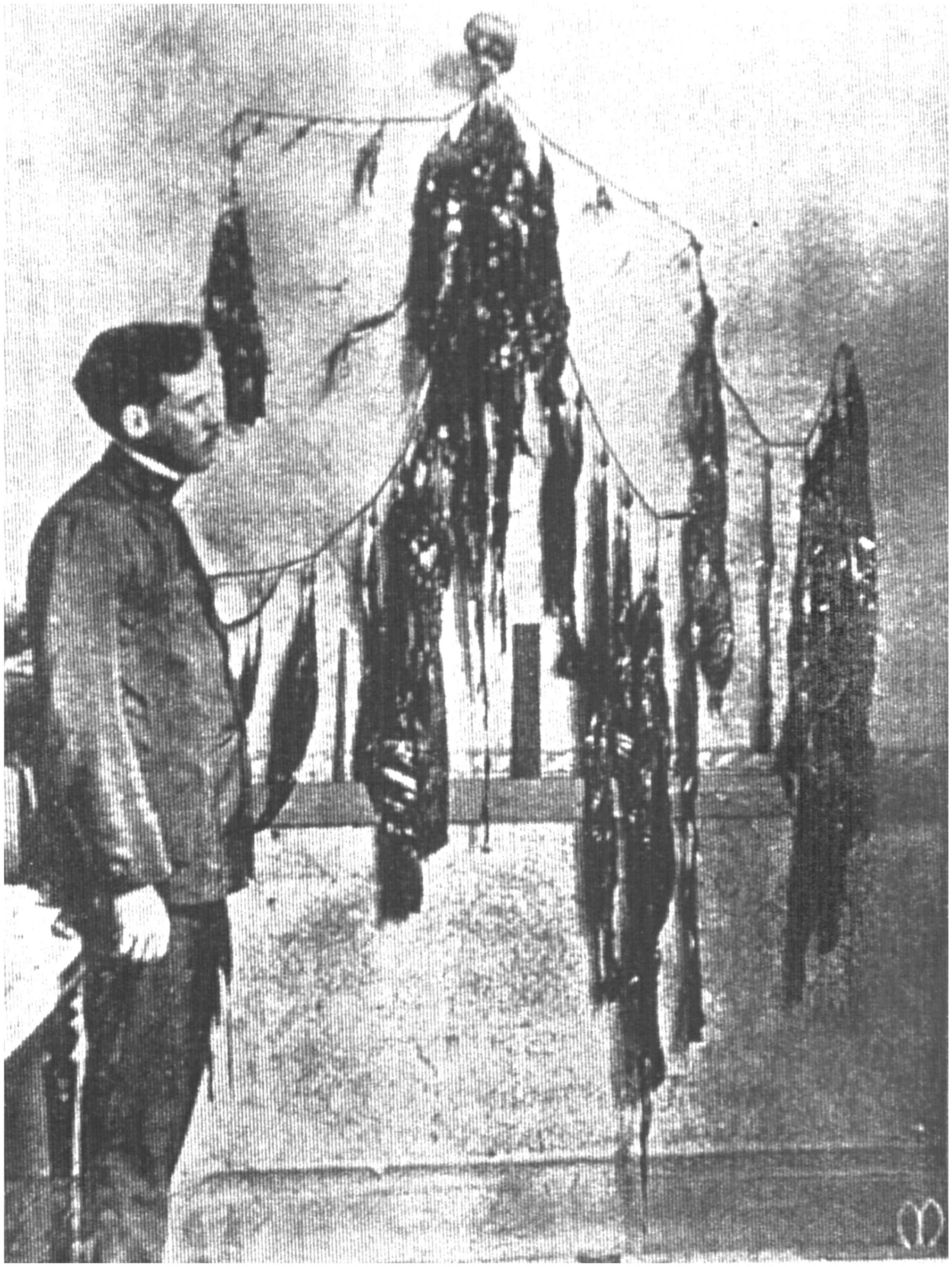


Illus. 5: The camanay or blue-footed booby (Sula nebouxii) in courtship performance with a turkey vulture (Cathartes aura) in flight, Isla Lobos de Tierra, Peru, by Francis L. Jaques (color plate: Murphy, Oceanic Birds).



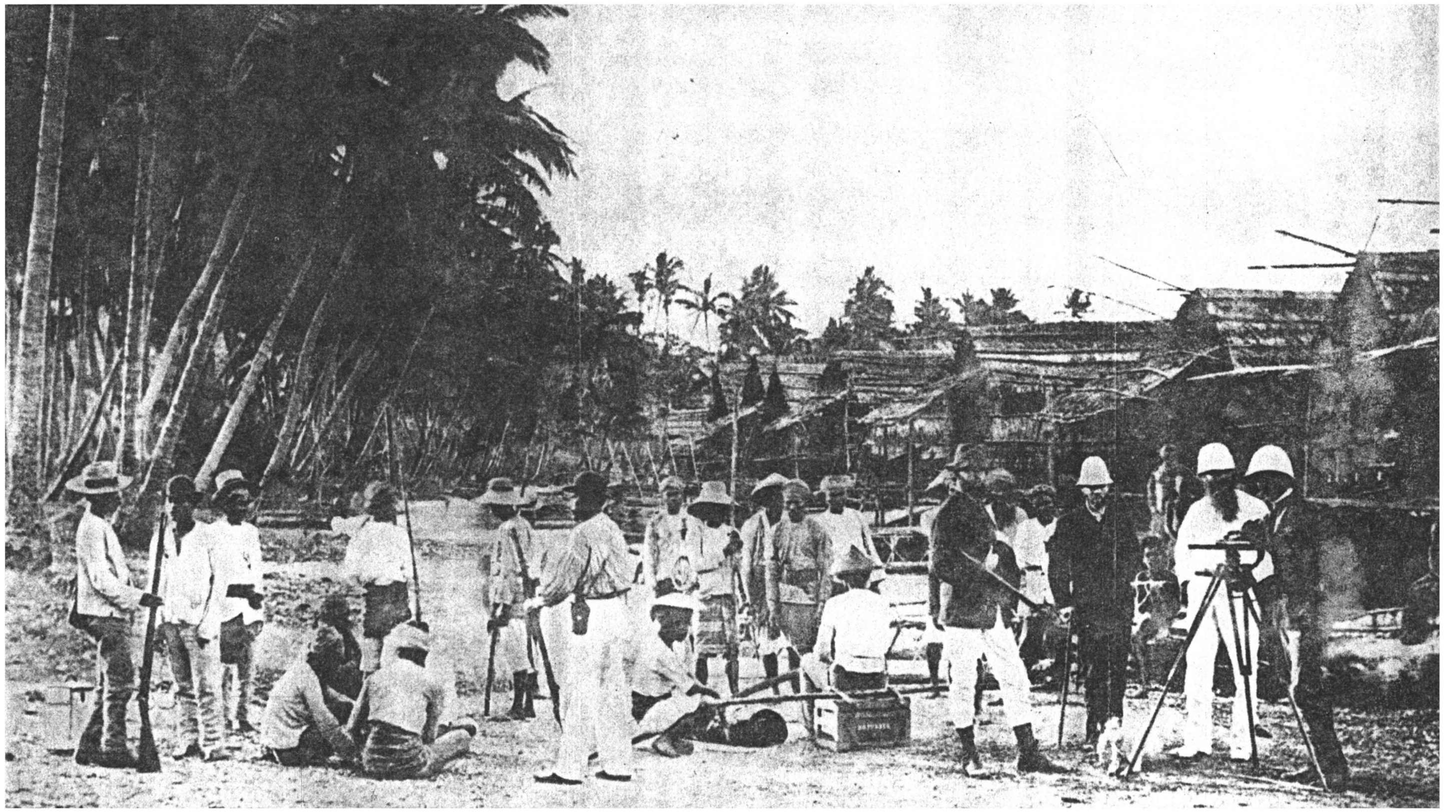
Illus. 6: Landscape changes due to guano extraction on Isla Macabí, mid-19th (above) to mid-20th centuries (below) (drawing: T. J. Hutchinson, Two Years in Peru [1873]; photo: courtesy of PROABONOS).

Illus. 7: Mariano Eduardo de Rivero y Ustáriz, a follower of Humboldt and one of the Peruvian Republic's first technocrats (painting).



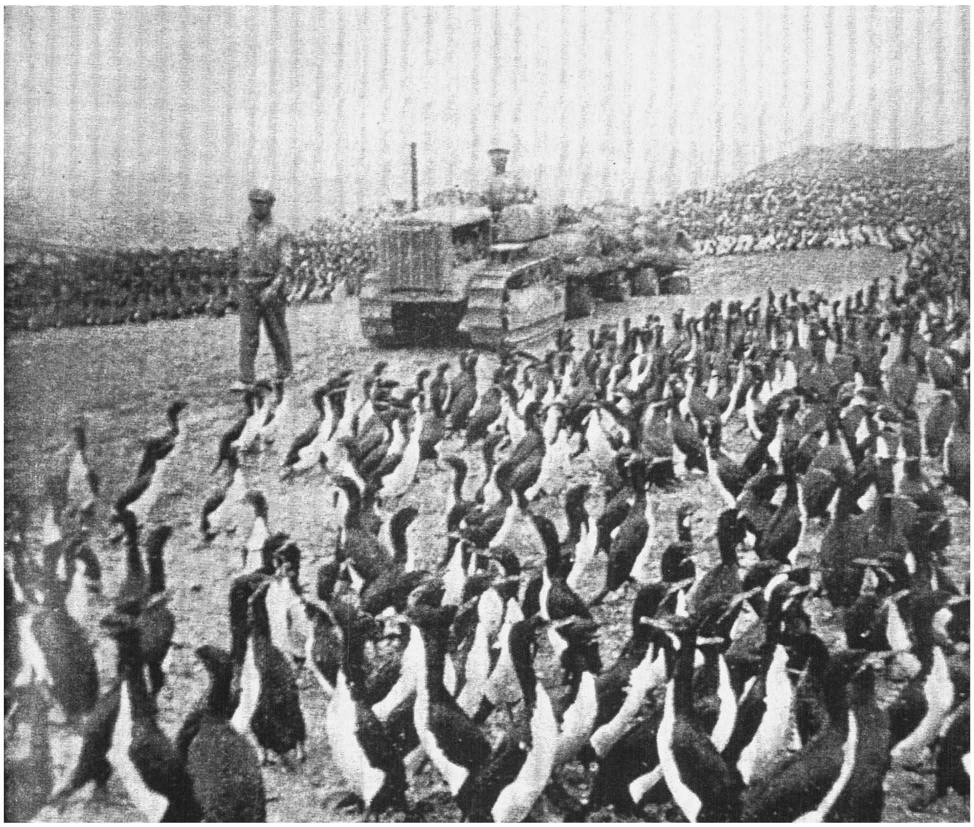
Illus. 8: Robert E. Coker with a specimen of marine algae from the Bahía de Callao, an icon of successful scientific exploration, 1907 (plate: MFOM 12 [1908]).

Illus. 9: Francisco Ballén Valle Riestra, general manager
of the Compañía Administradora del Guano,
1909-1930, 1934-1945 (illustration: BCAG 35:4 [1959]).

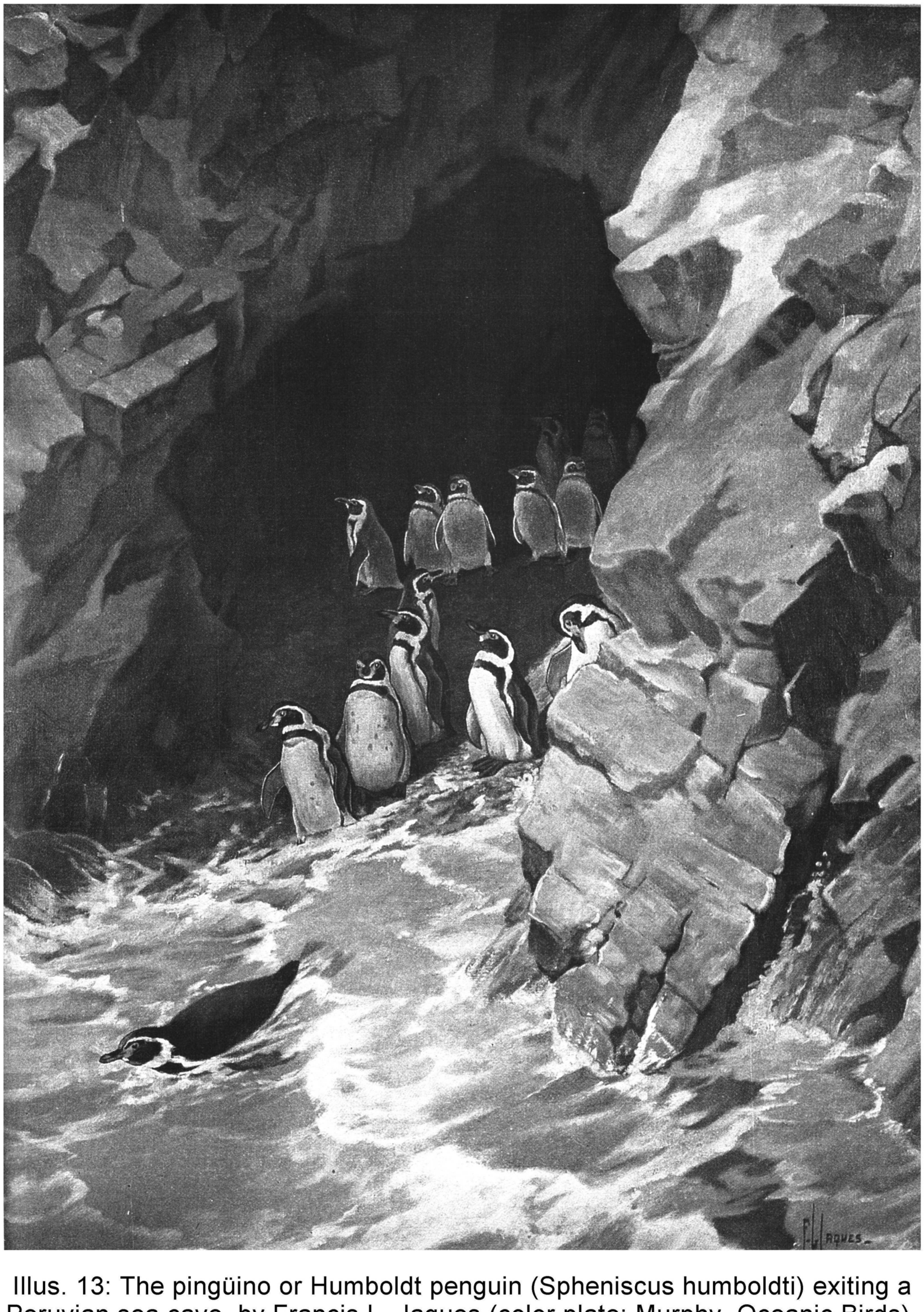


Illus. 10: One of the Tools of Empire: The H.O. Forbes expedition at Port Moresby, New Guinea, Sept. 1885. From right to left: Forbes, missionary G. W. Lawes, Capt. Musgrave (Asst. Deputy Commisioner of the British Protectorate), photographer J. W. Lindt, and Forbes's party of Malay and Ambonese assistants (plate: Lindt, Picturesque New Guinea).

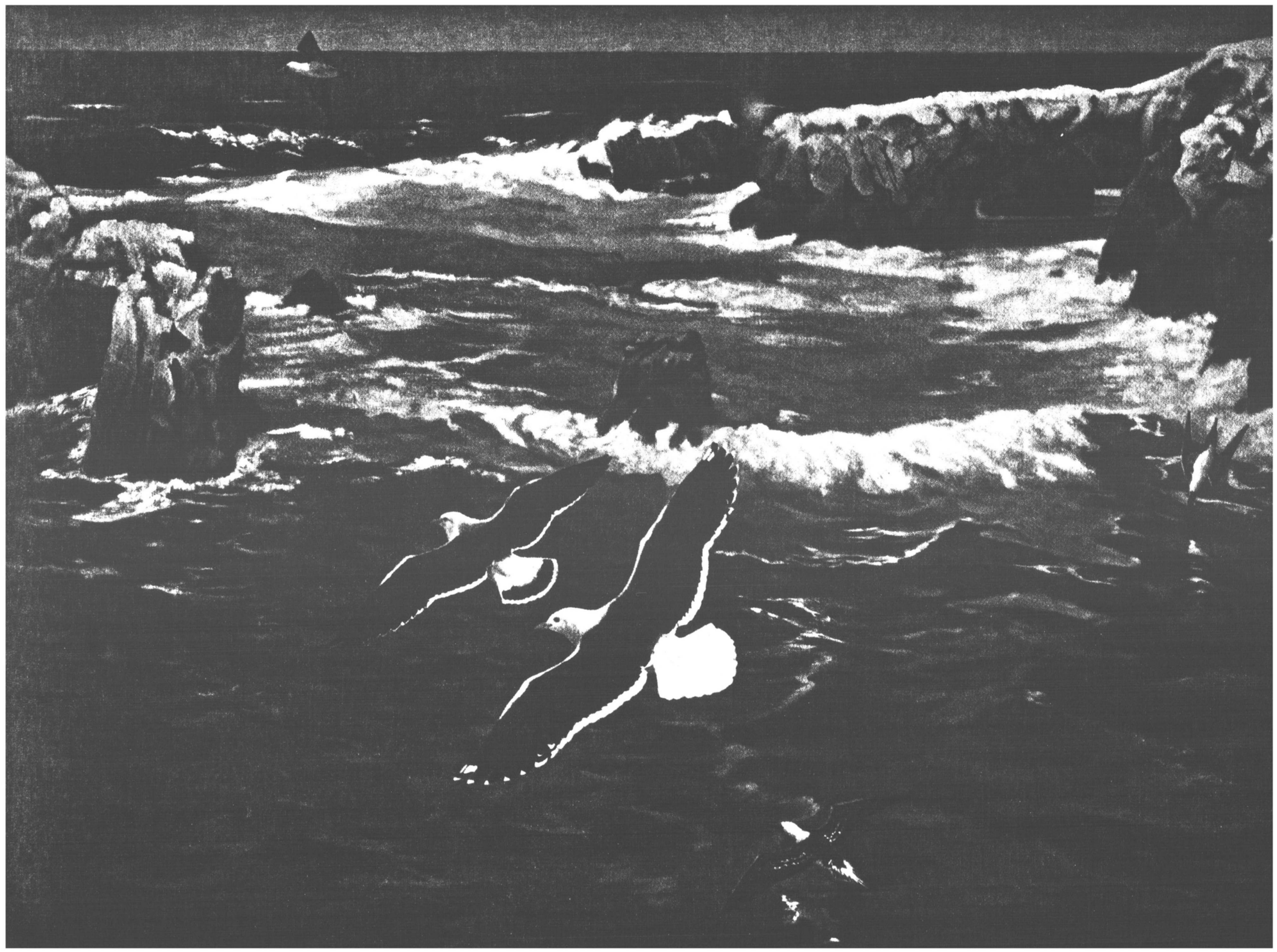
Illus. 11: The prodigy of Peru's new scientific elite:
Ingeniero Agrónomo José Antonio de Lavalle y García,
circa 1919 (illustration: Parker, Peruvians of To-Day).



Illus. 12: Guano production in the Machine Age: "Work of a caterpillar
on an island without causing the birds any discomfort,"
Isla Santa Rosa, May 1939 (photo: Vogt papers, box 4:1).

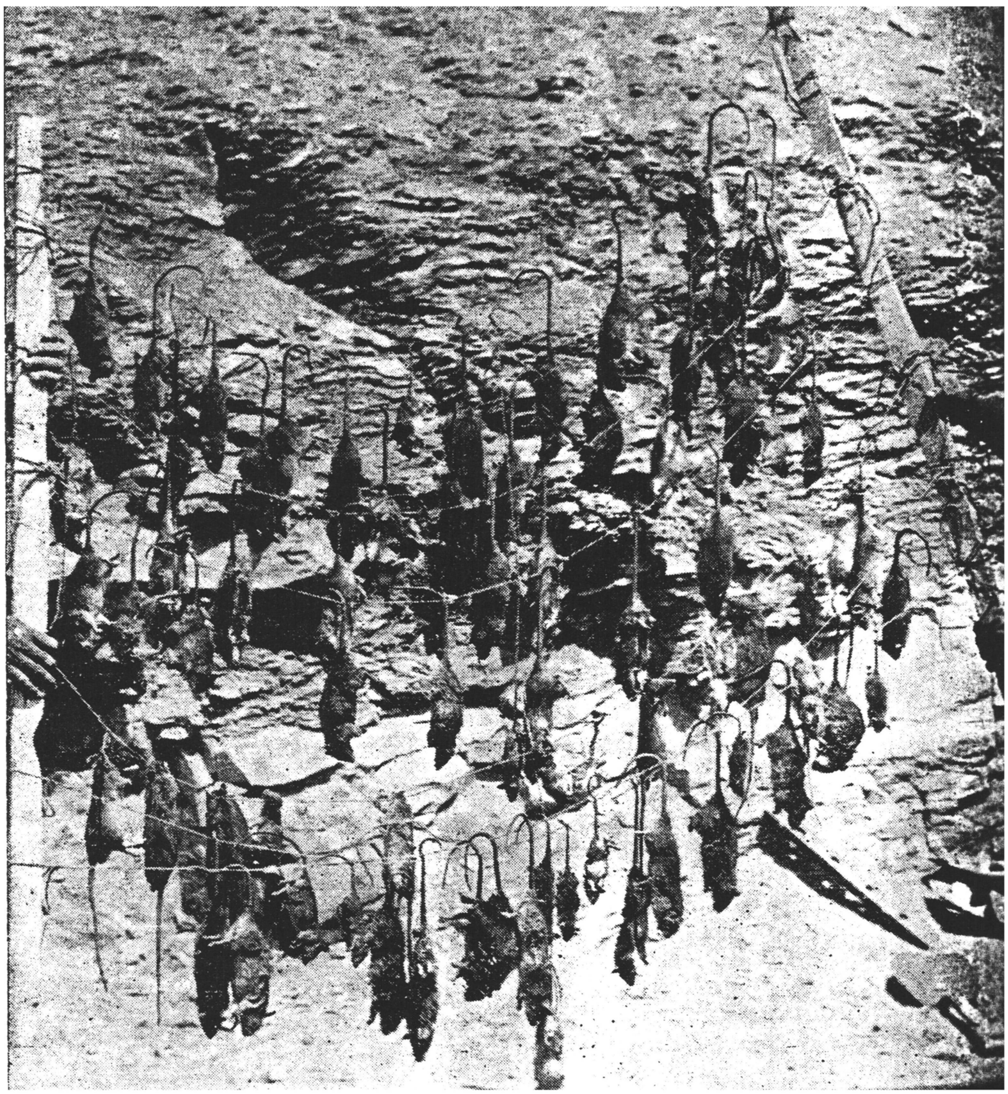


Illus. 13: The pingüino or Humboldt penguin (Spheniscus humboldti) exiting a Peruvian sea cave, by Francis L. Jaques (color plate: Murphy, Oceanic Birds).

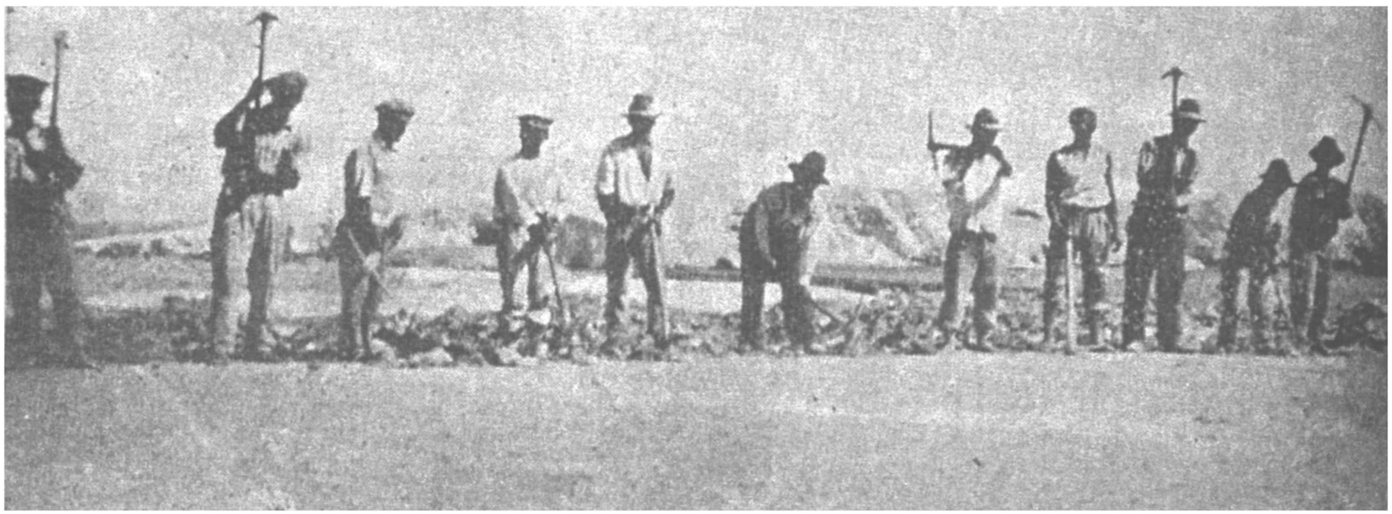


Illus. 14: The simeón or band-tailed gull (Larus belcheri, top) and cleo or kelp gull (L. dominicanus), Isla Santa Rosa, Peru, by Francis L. Jaques (color plate: Murphy, Oceanic Birds).

Illus. 15: Andean condors killed by CAG sharpshooter Melitón Lurquín on Isla San Gallán, circa 1919 (plate: Murphy, Bird Islands).



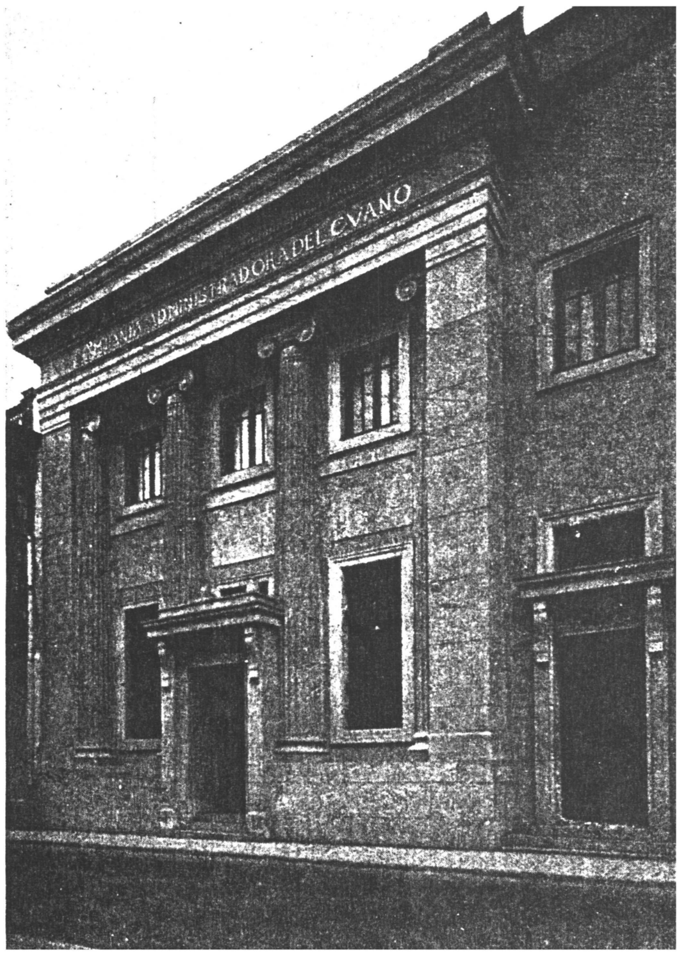
Illus. 16: "Rats killed in an afternoon of work using sulfur anhydride" on one of the guano islands (illustration: BCAG 16:12 [Dec. 1940]).



Illus. 17: Workers using an age-old technology of guano extraction: the pick (illustration: BCAG 18:11 [1942]).

Illus. 18: Workers using a new technology for guano conservation: the broom; note guanayes in the background, Isla Santa Rosa, May 1939, photo by William Vogt (cover: BCAG 15:7 [1939]).

Illus. 19: An industrial island in a monocultural sea: W. R. Grace & Co.'s Paramonga sugar central and estate near Supe, ca. 1929 (photo: Johnson, Peru from the Air).



Illus. 20: A neoclassical palace for the Lords of Guano,
Compañía Administradora del Guano headquarters
in Lima (illustration: BCAG 2:6 [1926]).

¿Está Ud. **SEGURO** de que aplica a sus tierras la **CANTIDAD** y **CLASE DE ABONOS** que necesitan?

¿No está Ud. aplicando elementos **QUE SOBRAN** o dejando de aplicar aquellos **QUE FALTAN**?

Esto se lo permitirá apreciar **EL ANALISIS DE SUS TIERRAS** hecho en el

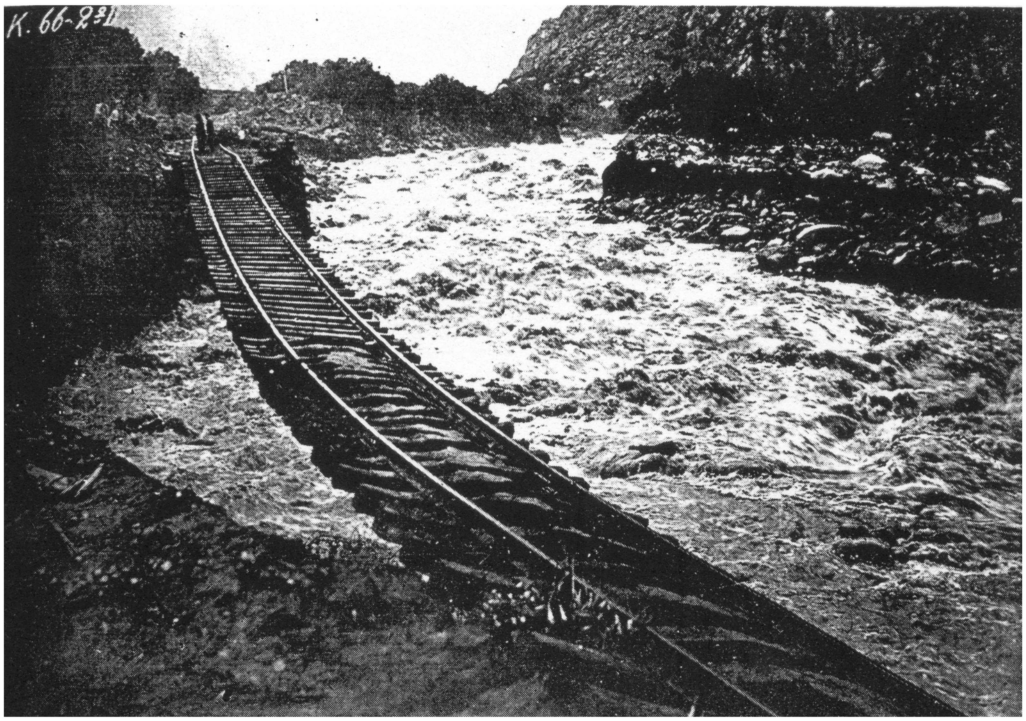
Laboratorio de Análisis Agrícolas

DE LA

Compañía Administradora del Guano

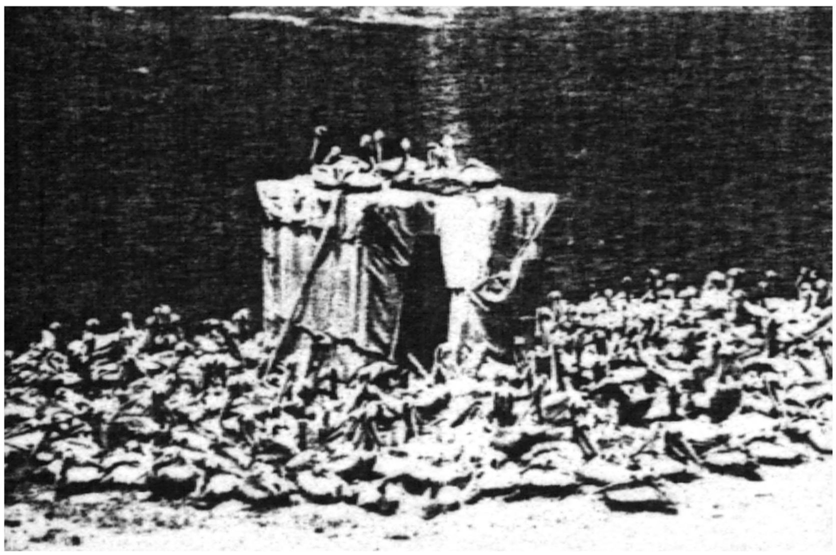
CALLE DE ZARATE. **CASILLA 809.**

Illus. 21: Advertisement for CAG's new agricultural laboratory (BCAG 2:3 [1926]).



Illus. 22: Flood damage to the Central Andean Railway during the torrents of 1925 along the Río Rímac (illustration: BCAG 2:3 [1926]).

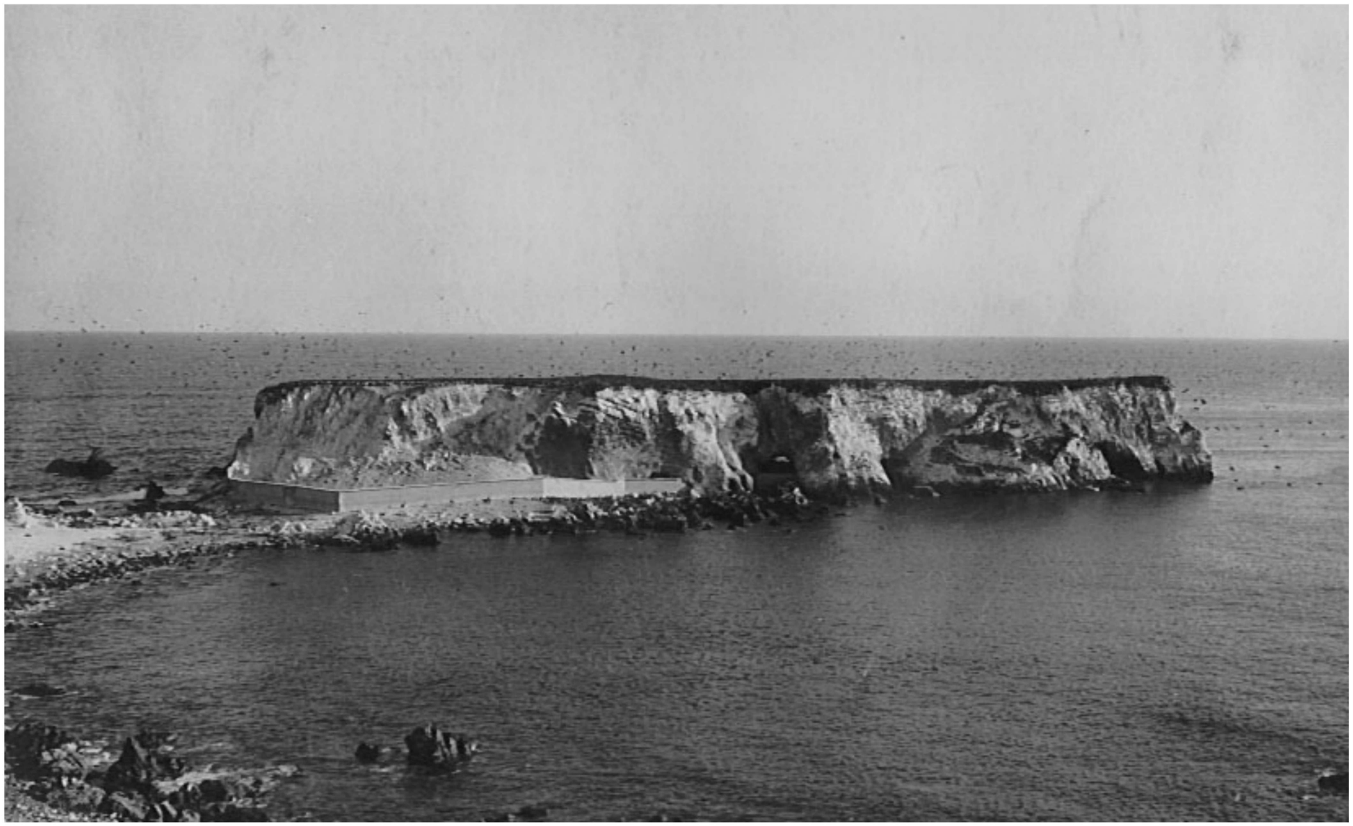
Illus. 23: The ornithologist William Vogt equipped
for work on Isla Lobos de Tierra, Aug. 1939
(photo: Vogt papers, box 4:1).



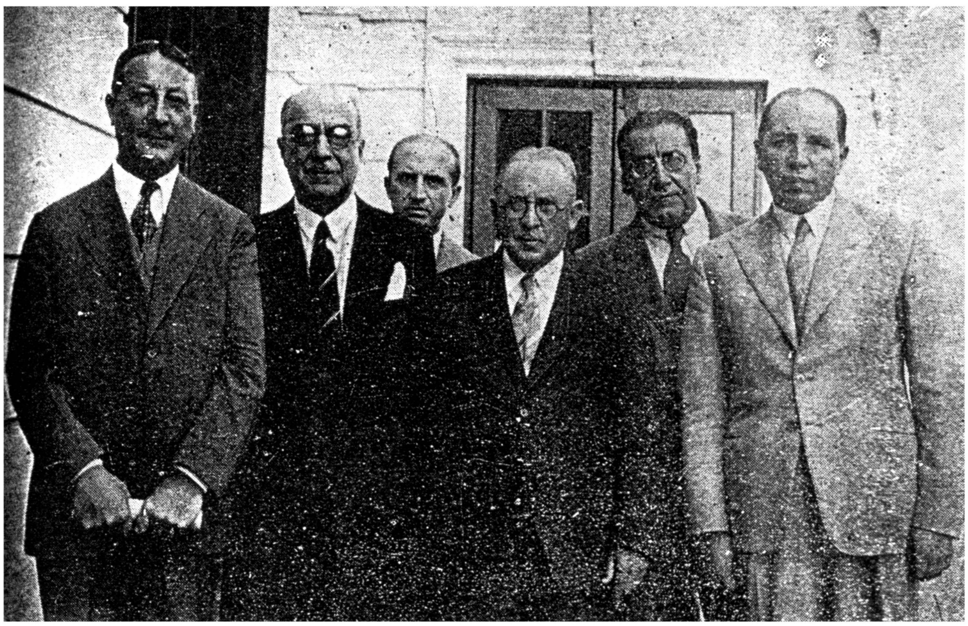
Illus. 24: A Space for Science in the Making:
Blind used by William Vogt to observe nesting pelicans
on Isla Chincha Norte, 1941 (photo: Vogt papers, box 4:1).

Illus. 25: "Birds calmly nesting even in the places most traveled by man"
Juana Allraum Vogt at the Isla Macabí guard station, 1940
(photo: Vogt papers, box 4:1).

Illus. 26: Ingeniero Agrónomo Carlos Llosa Belaúnde,
the architect of CAG's redirection after World War II
(illustration: BCONAFER 4:9-10 [1966]).

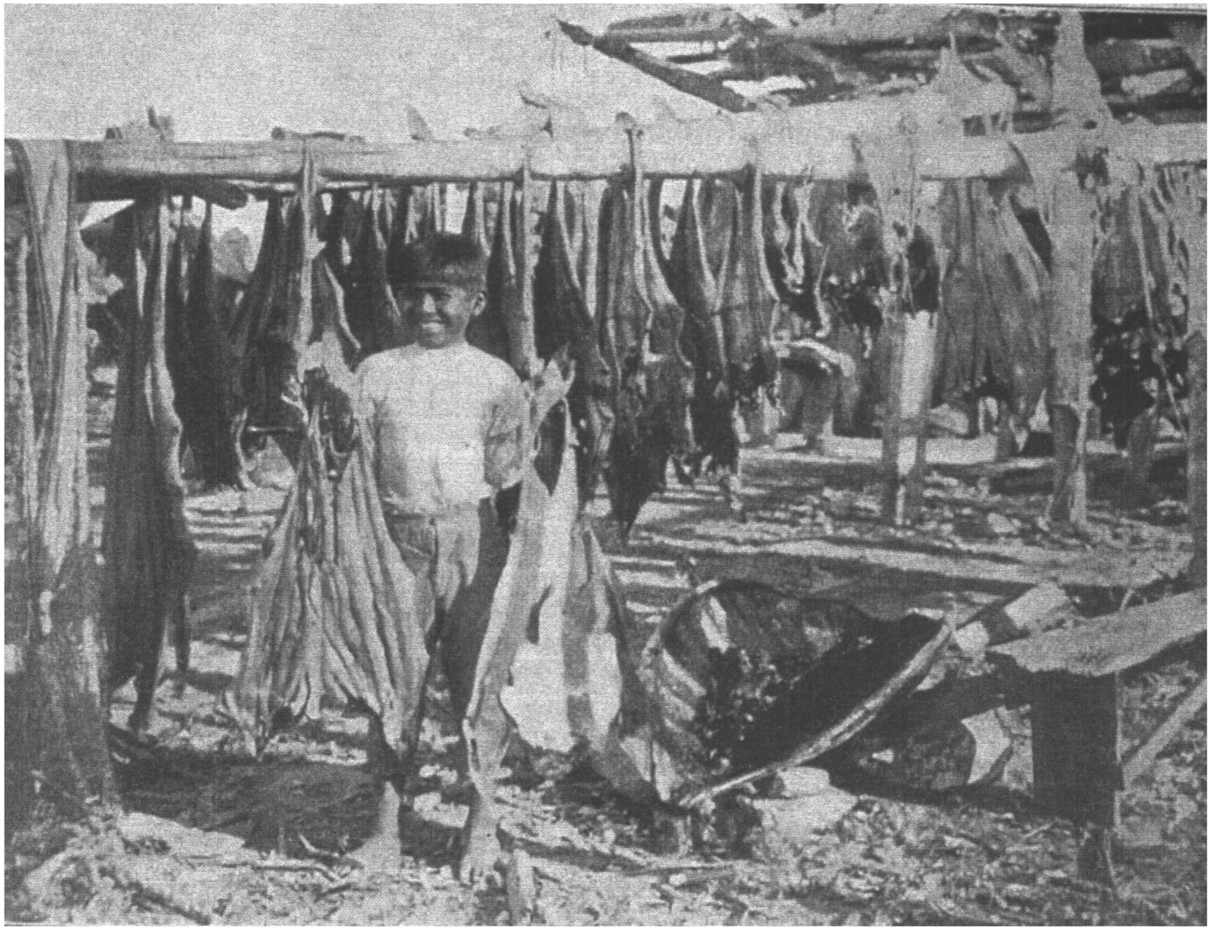


Illus. 27: An artificial guano island: Bird colony on Punta Tres Hermanas protected by an isolation wall (photo: courtesy of PROABONOS).

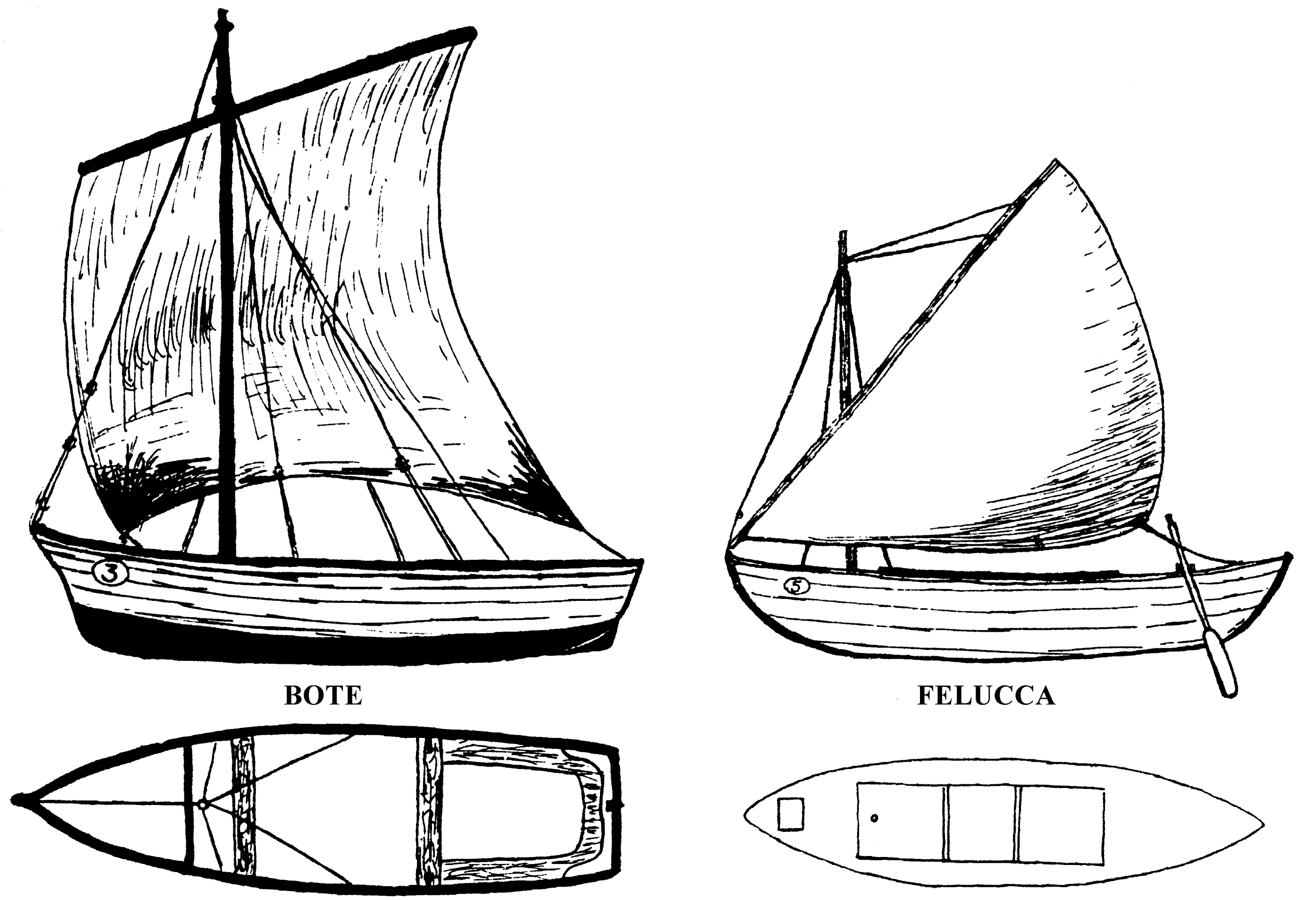


Illus. 28: Founding officers of the Comité Nacional de Protección a la Naturaleza.
Left to right: political scientist Albert Giesecke, CAG general manager
Francisco Ballén, agribusiness representative Luis Alayza Paz Soldán,
former Audubon president Gilbert Pearson, biologist and natural history
museum director Carlos Morales Macedo, and agronomist Carlos Barreda,
Lima, 26 Apr. 1940 (illustration: BCNPN 7 [1950]).

Illus. 29: Workers loading barrels of oil rendered from lobos del mar, ca. 1920 (plate: Murphy, Bird Islands of Peru).

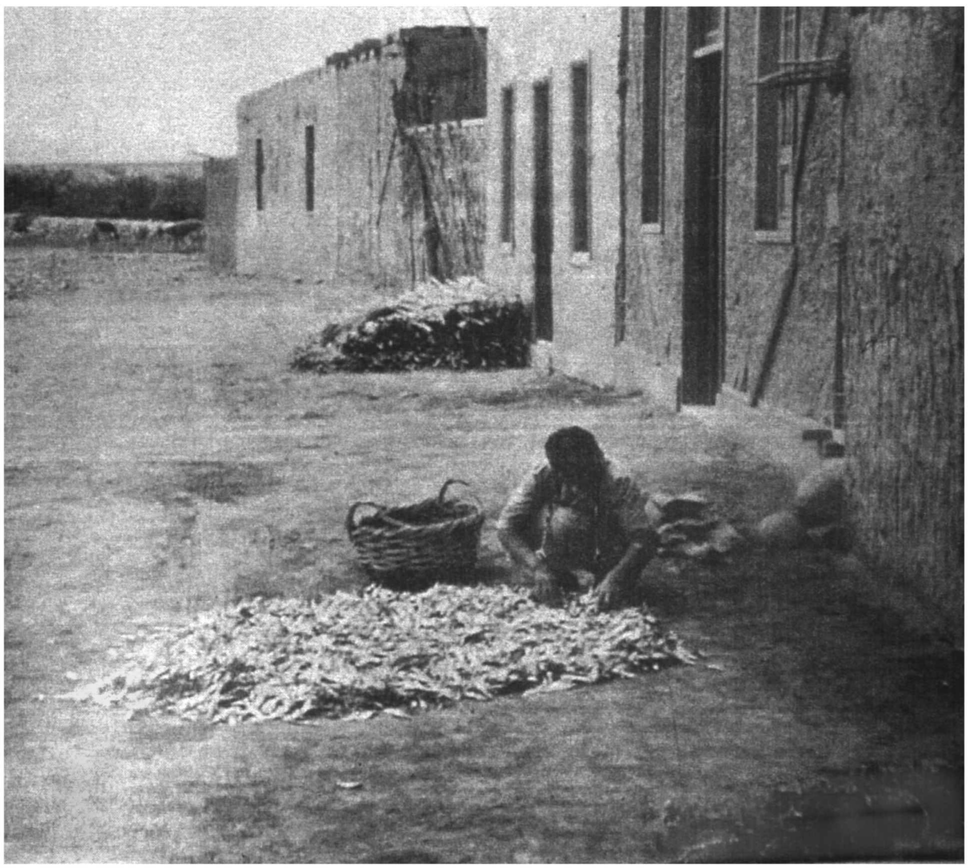


Illus. 30: "Drying sharks, guitar-fishes, etc., without the use of salt" at a seasonal fishing camp on Isla Lobos de Tierra, 1907 (plate: Coker, "The Fisheries and Guano Industry of Peru").

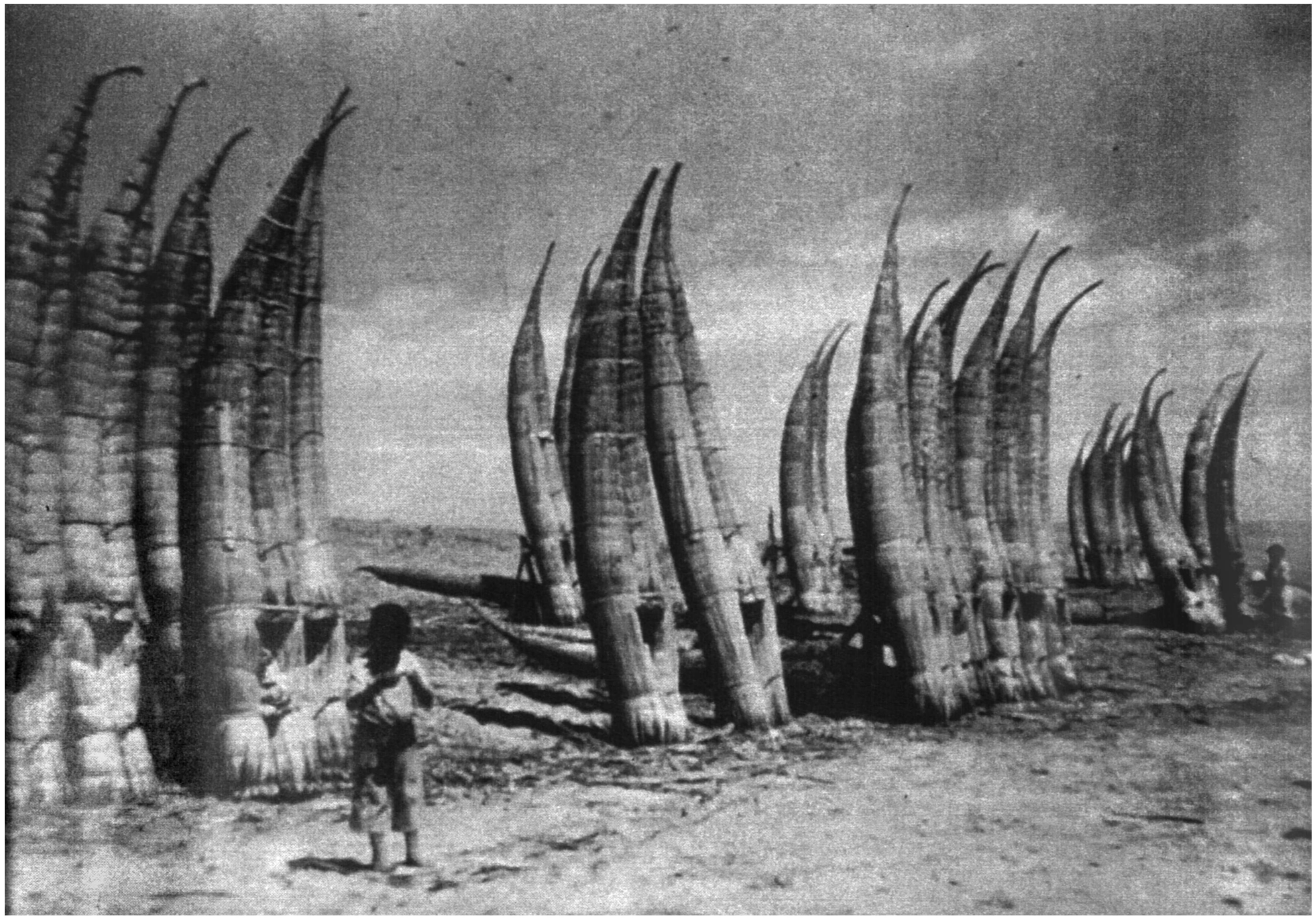


Illus. 31: The dominant types of fishing craft used in Peru in 1941, both originally introduced by immigrants from the Mediterranean basin (adapted from plate: Fiedler, Jarvis, and Lobell, The Fisheries and Fishery Industries of Peru).

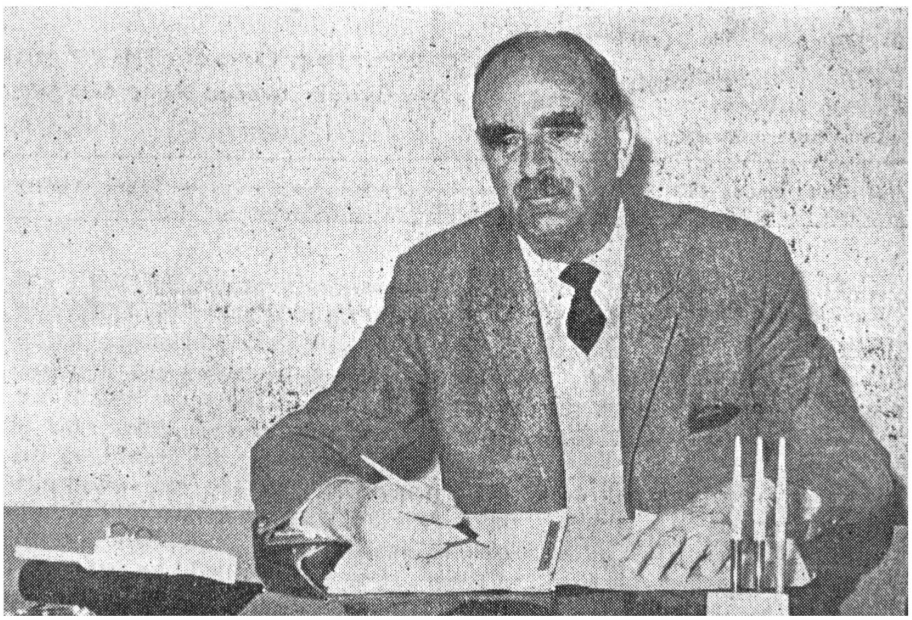
Illus. 32: The type of gasoline-powered patrol launch purchased for CAG's Policía Pesquera, maximum speed 19 km/hr (plate: BCAG 6:1 [1930]).



Illus. 33: A woman sorting anchoveta for local consumption, 1941
(plate: Fiedler, Jarvis, and Lobell,
The Fisheries and Fishery Industries of Peru).



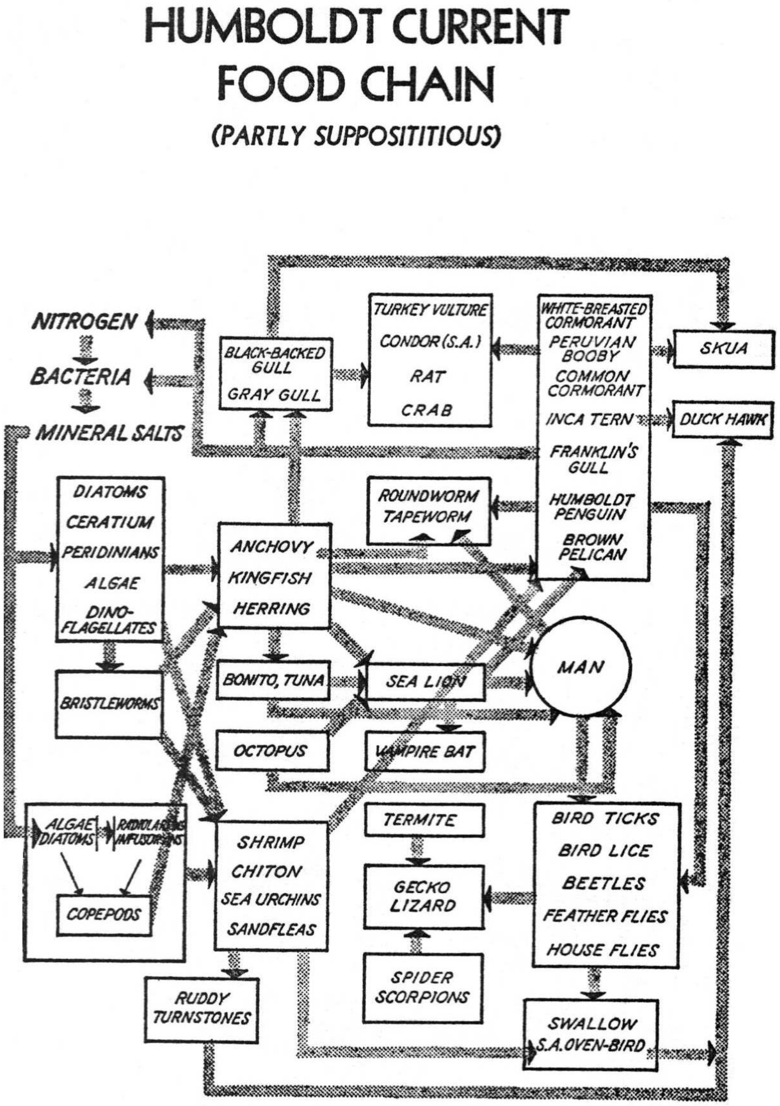
Illus. 34: Caballitos de totora (reed boats), an ancient indigenous fishing technology still in extensive use in 1941 (plate: Fiedler, Jarvis, and Lobell, The Fisheries and Fishery Industries of Peru).



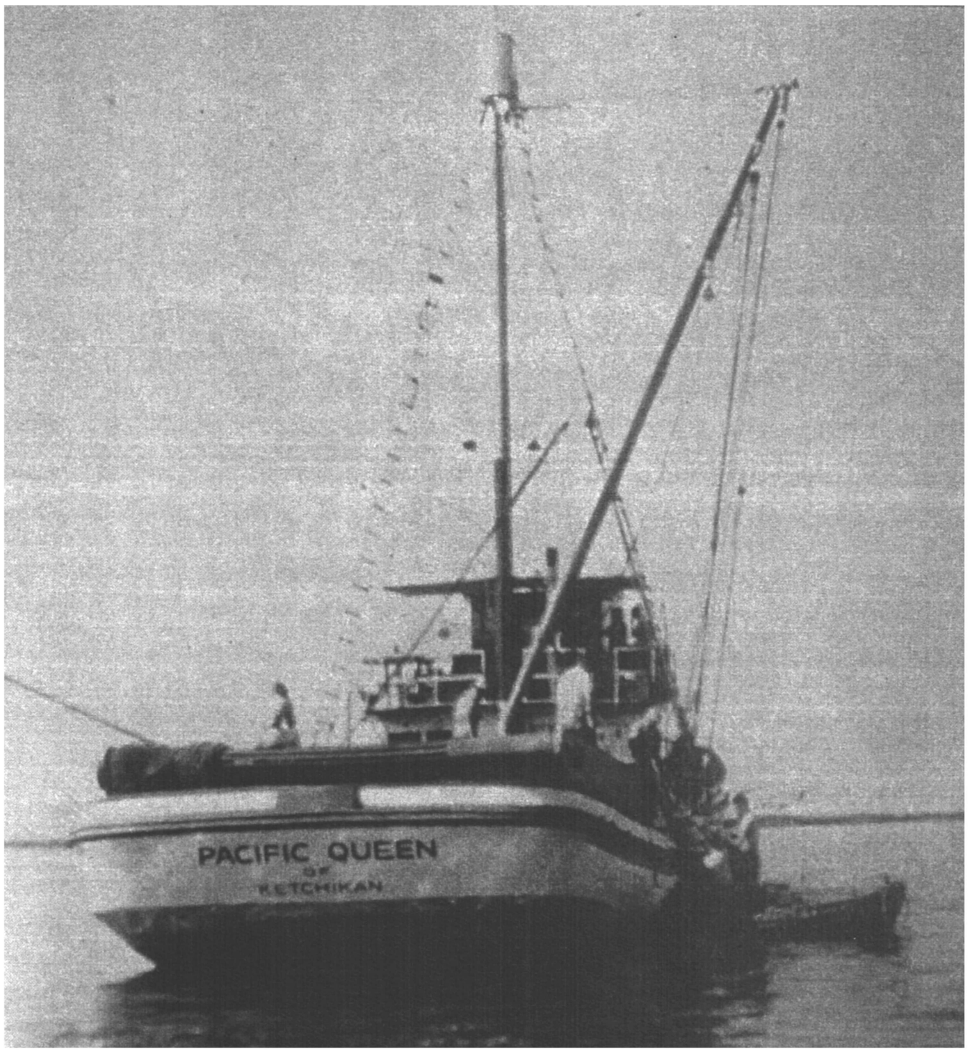
Illus. 35: The father of Peruvian oceanography:
German fishery biologist Erwin H. Schweigger
(illustration: BCONAFER 3:8 [Aug. 1965]).

Illus. 36: Peruvian Marine Science in Action:
agronomist Luis Gamarra Dulanto
measuring ocean salinity off Isla Guañape Bajo,
Feb. 1939 (photo: Vogt papers, box 4:1).

Illus. 37: Banding a guanay on the Islas Ballestas, Feb. 1940
(photo: Vogt papers, box 4:1).



Illus. 38: Note Vogt's placement of nitrogen derived from guano at the base and humans at the top of this marine food chain (illustration: Vogt, Road to Survival).



Illus. 39: The purse-seine trawler Pacific Queen, Peru's first full-time oceanographic vessel, 1941 (plate: Fiedler, Jarvis, and Lobell, The Fisheries and Fishery Industries of Peru).

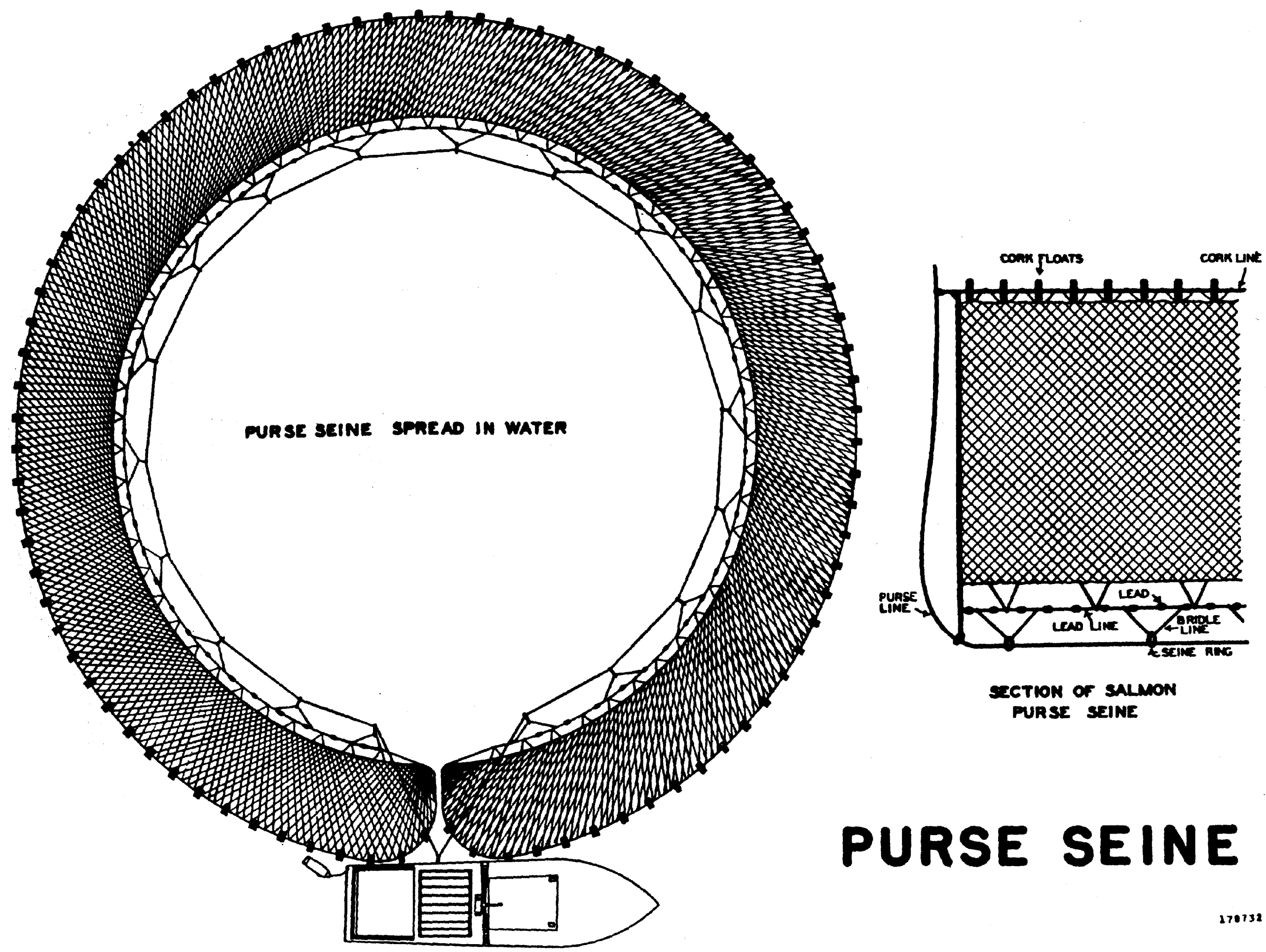
Illus. 40: Enrique M. del Solar Cáceda,
an agro-exporting aristocrat turned
fishery scientist and entrepreneur
(illustration: Pesca Mar. Apr. 1962).

Illus. 41: Frances N. Clark when she graduated with a Ph.D.
in ichthyology from the University of Michigan in 1925
(photo: courtesy of Scripps Institution of Oceanography Archives).

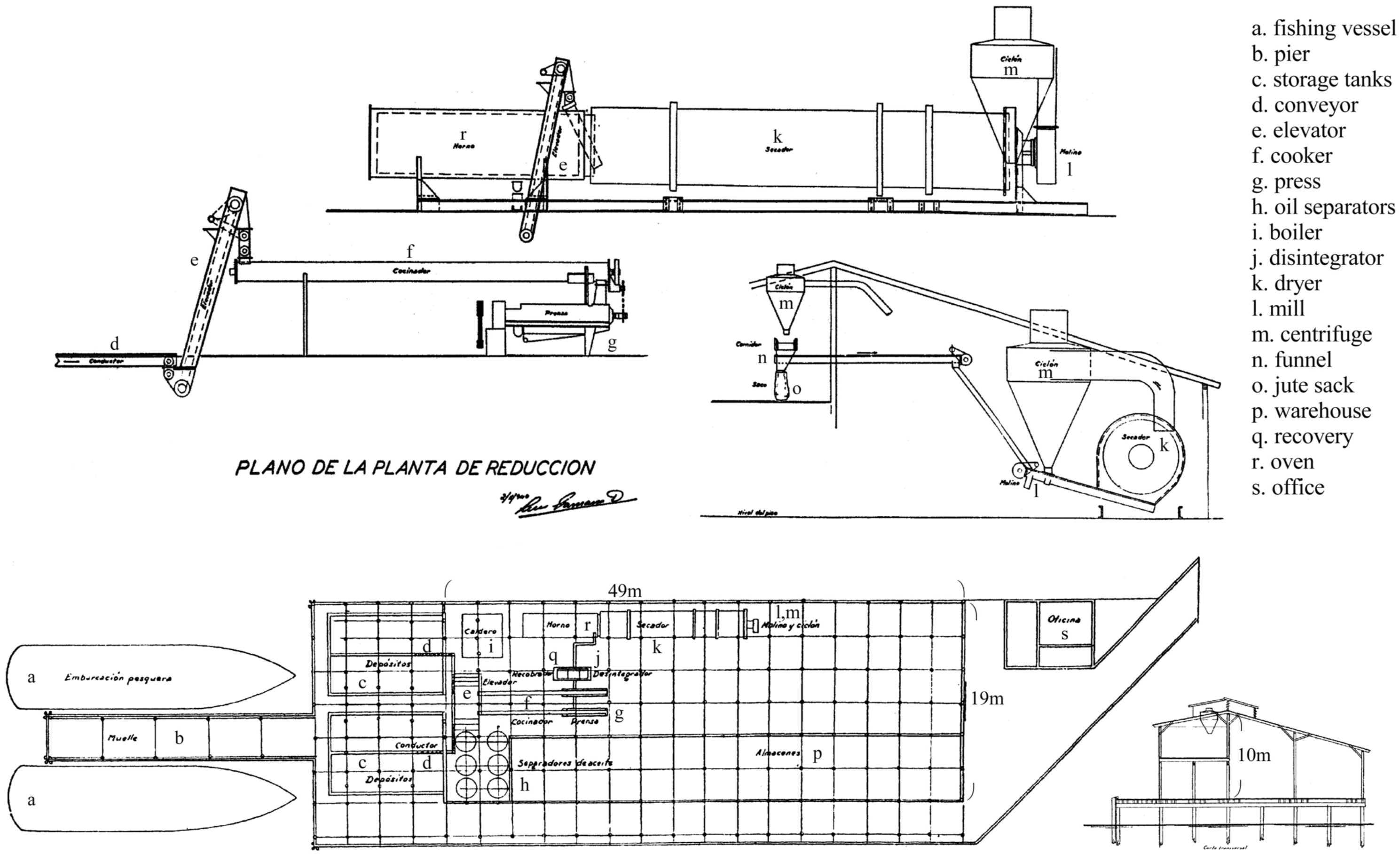
Illus. 42: Ornithologist Robert Cushman Murphy "interviewing a Blue-footed Booby at El Muerto Island" in the Golfo de Guayaquil, 1925 (plate: Murphy, Oceanic Birds).

Illus. 43: Fishery population biologist Milner "Benny" Schaefer, circa 1965 (photo: courtesy of Scripps Institution of Oceanography Library).

Illus. 44: The headquarters for Big Oceanographic Science along the Pacific Coast of South America: the Instituto del Mar del Perú (IMARPE) at La Punta, Callao, 1997 (photo: by author).

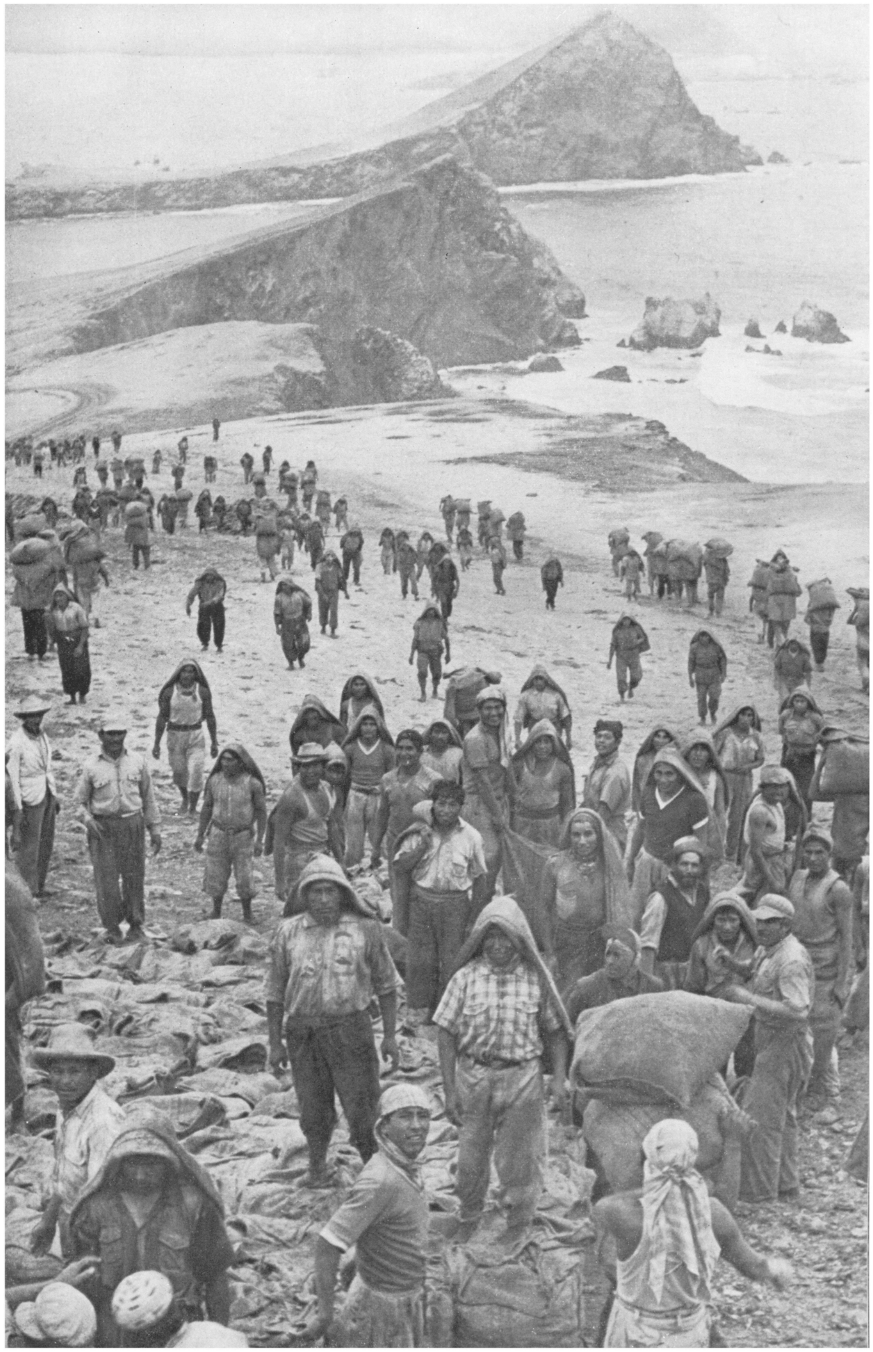


Illus. 45: "General view and detail of a purse seine," the basic technology of industrialized anchoveta fishing (plate: Fiedler, Jarvis, and Lobell, The Fisheries and Fishery Industries of Peru).

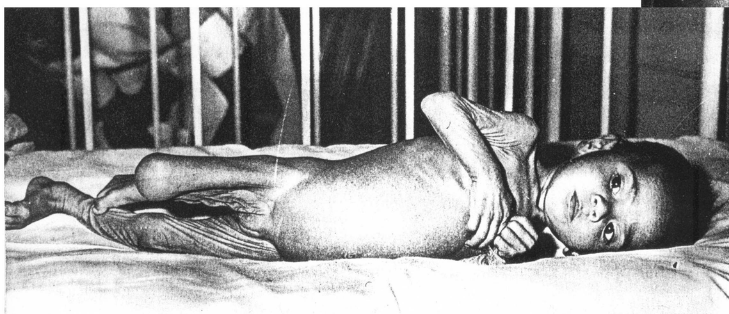


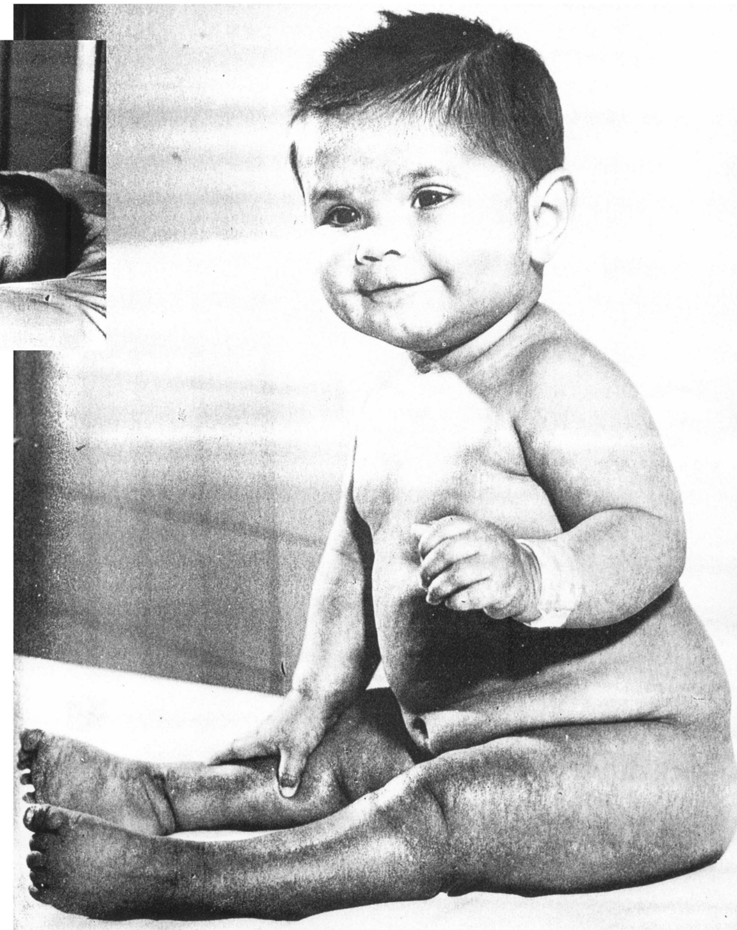
Illus. 46: Design for the first fishmeal reduction plant in Peru by Luis Gamarra Dulanto.
Upper and lower portions of diagram are shown to 3:1 (adapted from: BCAG 16:11 [1940]).

Illus. 47: Peru's first neoliberal technocrat,
Finance Minister Pedro Beltrán Espantoso, ca. 1959
(illus.: Diccionario histórico y biográfico del Perú).



Illus. 48: "There never were 40 million birds": Photo of guano workers used to create distrust in CONAFER and IMARPE's bird population figures (Pesca Mar. 1964).





Illus. 49: "Isabelita," Peru's poster child for the end of world hunger. With a diet of pasta fortified with fishmeal, physicians at the Clínica Anglo Norte-Americana raised the weight of this malnourished infant from 3.5 kg (7 lb. 12 oz.) at 8 months (above) to 9 kg (19 lb 13 oz) at 12 months (right). These images were reproduced in a number of Peruvian periodicals, including the front page of the arch-conservative daily La Prensa (illustrations: Pesca Aug. 1961).

Table 1: Fertilizer Use by Peruvian Coastal Agriculture, circa 1914-1915

Fertilizers used (in rough order of importance)	Crop/Land Use	Percent of Total Cultivated Area	Percent Share of Fertilizer Purchases
guano *rico*	sugar cane	36.5	62.7
salitre ($NaNO_3$)	cotton	25.8	31.5
guano *pobre*	pasture/feed lots (incl. alfalfa)	13.4	--
potassium sulfate	fields in preparation	6.6	--
	sharecropped (*yanaconizada*)	5.8	--
animal dung	fallow	4.9	--
cane juice froth	maize	2.6	3.8
ammonium sulfate	rice	0.9	1.3
nitrolim ($CaCN_2$)	legumes	0.9	--
	root crops (*camote*, *yuca*, potato)	0.5	--
kainite (KCl)[a]	other crops	2.4	--

Source: CAG, Sección Técnica, *Las necesidades de guano de la agricultura nacional*, 117-205, 209-240, graph following p. 294.

[a] Used by cotton growers only.

Table 2: Global Nitrogen Fertilizer Production, 1900-2000 (metric kilotons of nitrogen)

	Peruvian guano	Chilean nitrates $NaNO_3$	Coke-oven gas recovery $(NH_4)_2SO_4$	Cyanamide synthesis $CaCN_2$	Haber-Bosch process NH_3	Total nitrogen production[a]
1900	<1.0	220	120	0	0	340
1910	7.1	360	230	10	0	610
1920	9.0	410	290	70	150	950[b]
1929	16.4	510	425	255	930	2,160[b]
1950	29.2	270	500	310	3,700	4,810
1970	6.1	120	950	300	30,230	31,620
2000	4.0[c]	120	370	80	85,130	85,700

Source: Smil, *Enriching the Earth*, app. F, L; "Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962," *MCAG* 54 (1963); Humberto Tovar S., "Las poblaciónes de aves guaneras en los ciclos reproductivos de 1969/70 a 1973/74," *Inf.Inst.Mar Perú* 45 (1978), 12; Peru, Ministerio de Agricultura, PROABONOS, *Memoria anual 1999* (Callao, May 2000).

[a] Rounded to ten kilotons.

[b] Includes 20 kilotons of nitrogen produced by the electric-arc process.

[c] 1999 production figures.

Table 3: Pay Received by Guano Island Workers, North Zone, 1919-1969

	daily wage				basic daily ration			
	laborer		overseer		laborer		overseer	
	S/.	1979US$	S/.	1979US$	S/.	1979US$	S/.	1979US$
1919[a]	1.20	0.91	--	--	--	--	--	--
1945	2.44	1.11	3.60	1.64	2.01	0.92	2.52	1.15
1949	5.47	2.48	7.73	3.50	3.92	1.78	5.23	2.37
1956	13.07	1.71	17.94	2.34	[b]	[b]	[b]	[b]
1960	17.77	1.70	27.67	2.65	10.22	0.98	11.20	1.07
1965	33.97	2.12	54.72	3.42	16.33	1.02	17.25	1.08
1969	39.47	1.63	58.09	2.40	25.40	1.05	26.44	1.09

Source: "Resumen de los gastos y promedios de las islas de la zona norte--Campaña 37a.--año 1945," Dec. 1945; Manuel E. Razetto, "Resumen de los gastos y promedios de las islas de la campaña 41a.--año 1949," Feb. 1950; J. Pablo Miñan, "Resumen de los costos y promedios de las islas de la zona norte--campaña 48a.--año 1956," Dec. 1956; Fernando Angobaldo C., "Resumen de los costos y promedios de la zona norte campaña 52a.--año 1960," 31 Dec. 1960; Guido A. Razetto T., "Diversos promedios de islas zona norte 1965," Dec. 1965; idem, "Trabajos de explotación de guano rico, baja ley, pobre y mezclas. Rendimiento y costos de las tareas--Zona Norte, año 1969," 22 Sept. 1969; all from ACAG-Zona Norte. Portocarrero, Beltrán, and Romero, *Compendio estadístico del Perú*, 88-89.

[a] Average pay for entire coast.

[b] Together, laborers and overseers received an average daily ration of S/.8.25 = 1979US$1.08.

Table 4: Guano *Rico* Distribution in Peru, 1909-1935

Year	Total Large Purchases[a] (metric tons)	Total Small Purchases[b] (metric tons)	Ratio	Number of Large Purchasers
1911-12	12,843	2,323	5.5 : 1	130
1915-16	39,482	3,585	11.0 : 1	93
1920-21	51,208	6,190	8.3 : 1	231
1925-26	87,172	10,239	8.5 : 1	302
1930-31	82,853	8,891	9.3 : 1	228
1934-35	113,918	17,483	6.5 : 1	384
Total (1909-35):	1,562,841	170,884	9.1 : 1	567[c]

Source: "Anexos: Detalle de la distribución y venta del guano en los puertos," *MCAG* 3-26 (1912-1935).

[a] Large purchases (*ventas mayores*) refer to orders by single plantations/latifundia amounting to greater than one metric ton during CAG's fiscal year.

[b] Small purchases (*ventas menores*) refer to purchases amounting to less than one metric ton by undifferentiated minifundia and gardeners.

[c] In 1935, CAG listed a total of 567 different farming entities that had purchased at least one metric ton of guano during some fiscal year of its first 26 years of operation.

Table 5: Principal Guano Consumers in Peru, 1909-1935

Plantation (Owner circa 1914, Region[a])	Consumption 1909-1925 (rank/metric tons/ percentage)			Consumption 1909-1935 (rank/metric tons/ percentage)		
Casa Grande (Gildemeister & Co., Chicama)	1.	51,571	6.1	1.	130,124	7.7
Cartavio (W. R. Grace & Co., Chicama)	2.	34,660	4.1	2.	72,490	4.3
Paramonga (Sociedad Agrícola Paramonga, Supe)[b]	9.	18,558	2.2	3.	48,413	2.9
Pomalca y Collud (Gutiérrez brothers, Lambayeque)	11.	17,266	2.0	4.	44,466	2.6
Tumán y Calupe (Pardo family, Lambayeque)	6.	19,823	2.3	5.	43,148	2.6
Chiclín (Larco Herrera brothers, Chicama)	3.	23,803	2.8	6.	41,687	2.5
Cayaltí (Aspíllaga brothers, Lambayeque)	7.	19,746	2.3	7.	39,546	2.4
Laredo (José Ignacio Chopitea, Moche)[c]	8.	18,947	2.2	8.	38,067	2.3
San Nicolás (Barreda y Laos family, Supe)	5.	21,652	2.5	9.	37,525	2.2
Infantas (Sociedad Agrícola Infantas, Lima)	13.	14,397	1.7	10.	28,186	1.7
Humaya (Sociedad Agrícola Humaya, Huaura)	16.	10,771	1.3	11.	26,920	1.6
San Benito (Nosiglia brothers, Cañete)	22.	7,952	0.9	12.	26,387	1.6
Santa Bárbara (British Sugar Co., Cañete)	4.	23,636	2.8	13.	25,968	1.5
San Jacinto (British Sugar Co., Chimbote)	12.	15,833	1.9	14.	25,923	1.5
Tambo Real (Peruvian Sugar Est., Chimbote)	14.	13,547	1.6	15.	24,086	1.4
Chiquitoy (Larco Herrera brothers, Chicama)	24.	7,233	0.8	16.	23,938	1.4
Esquivel y Retes (del Solar brothers, Chancay)	18.	9,836	1.2	17.	22,504	1.3
Hualcará (Felipe Espantoso, Cañete)	17.	10,402	1.2	18.	20,508	1.2
Unánue (Luis Larraburre, Cañete)	21.	8,440	1.0	19.	20,090	1.2
Roma (Víctor Larco Herrera, Chicama)[c]	10.	18,233	2.1	20.	19,058	1.1
Palpa (Empresa Agrícola Palpa, Chancay)	20.	8,575	1.0	21.	16,820	1.0
Pátapo y Tulipe (Cía. Agr. Chiclayo, Lambayeque)	19.	9,805	1.2	22.	16,312	1.0
Herbay Alto (Sociedad Agrícola Herbay Alto, Cañete)	26.	6,027	0.7	23.	14,801	0.9
Huando (Antonio Graña, Chancay)	25.	6,124	0.7	24.	12,763	0.8
Montalván (Reynaldo Luza, Cañete)	--	1,612	0.2	25.	12,654	0.8
El Naranjal (Testamentaria F. Tallieri, Lima)	23.	7,524	0.8	29.	11,451	0.7
Sausal (Gildemeister & Co., Chicama)[c]	15.	11,228	1.3	30.	11,228	0.7
La Huaca (de las Casas family, Chancay)	--	2,216	0.3	--	4,595	0.3
Urrutia (Luis Albizuri, Pisco)	--	600	0.1	--	1,446	0.1
Total guano *rico* consumption:		852,418	49.3		1,686,009	51.3

Source: "Anexos: Detalle de la distribución y venta del guano en los puertos," *MCAG* 5, 17, 26 (1914, 1926, 1935); Gonzales, *Plantation Agriculture and Social Control in Northern Peru*, 26-33, 45-51; Thorp and Bertram, *Peru*, 1899-1977, 360 n. 10

[a] See app. 7. [b] Established by the Canaval family, later purchased by W. R. Grace & Co.

[c] Incorporated into Casa Grande or purchased by Gildemeister & Co.

Table 6: Guano *Rico* Distribution in Peru, 1934-1960

Year	Total Large Purchases[a] (metric tons)	Total Small Purchases[b] (metric tons)	Ratio	Destination Crop	Amount Purchased (metric tons/	percent share)
1934-35	113,918	17,483	6.5 : 1	cotton:	78,937	60.1
				sugar cane:	37,417	28.5
				grain/rice:	15,048	11.5
1941	90,648	23,499	3.9 : 1	cotton:	54,896	48.1
				sugar cane:	25,847	22.6
				other food crops:	16,458	14.4
				grain/rice:	16,345	14.3
				flax:	601	0.5
1945	51,808	32,124	1.6 : 1	grain/rice:	46,042	54.9
				cotton/cane/flax:	20,151	24.0
				other food crops:	12,758	15.2
				forage:	4,605	5.5
				coffee/fruit:	376	0.4
1950	184,398	35,630	5.2 : 1	grain:	82,485	37.5
				cotton:	56,853	25.8
				sugar cane:	26,246	11.9
				rice:	23,542	10.7
				other food crops:	19,272	8.8
				forage:	11,566	5.3
				flax:	65	<0.1
1956	243,402	59,727	4.1 : 1	cotton:	63,853	24.9
				unclassified[c]:	59,727	19.7
				grain:	57,486	22.4
				other crops:	50,911	16.8
				rice:	35,014	13.6
				sugar cane:	22,603	8.8
				forage:	11,722	3.9
				potatoes:	1,814	0.6

Continued on next page

Table 6--*Continued*

Year	Total Large Purchases[a] (metric tons)	Total Small Purchases[b] (metric tons)	Ratio	Destination Crop	Amount Purchased (metric tons/	percent share)
1960	66,351	29,636	2.2 : 1	unclassified[c]:	29,636	30.9
				grain:	17,720	18.5
				cotton:	14,848	14.8
				rice:	14,763	15.4
				sugar cane:	6,957	7.2
				potatoes:	5,974	6.2
				other crops:	3,643	3.8
				forage:	2,523	2.6
Total (1935-62):	3,679,156	992,050	3.7 : 1			
Total (1909-62):	5,241,997	1,162,934	4.5 : 1			

Source: "Anexos: Clasificación de las ventas de guano a la agricultura nacional y su contenido en unidades de nitrógeno," *MCAG* 26, 33 (1935, 1942); "Anexos: Guano rico--ventas mayores: Clasificación por cultivos de las ventas a la agricultura nacional con su contenido de unidades de nitrógeno y valores correspondentes," *MCAG* 37, 42, 48, 52 (1946, 1951, 1957, 1961); "Anexos: Guano rico--ventas menores: Clasificación por cultivos de las ventas a la agricultura nacional con su contenido de unidades de nitrógeno y valores correspondentes," *MCAG* 37, 42, 48, 52 (1946, 1951, 1957, 1961); "Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962," *MCAG* 54 (1963).

[a] Large purchases (*ventas mayores*) refer to purchases by a single plantation/latifundia amounting to greater than one metric ton during CAG's fiscal year.

[b] Small purchases (*ventas menores*) refer to purchases less than one metric ton by minifundia or gardeners.

[c] The destination crop for small purchases was left unclassified by CAG; most small purchases went to grain and other food crops.

Table 7: Fish Production and Exports in Peru, 1941-1953 (in metric tons)

Year	Industrial Fishing Companies	Total Anchoveta Production	Total Fish Production	Total Fish Products Exports	Fish Liver Exports	Salted Fish Exports	Canned Fish Exports	Frozen Fish & Shrimp Exports	Fishmeal Exports
1939	1	11	4,849	--	--	--	--	--	--
1940	2	34	6,404	--	--	--	--	--	--
1941	2	23	11,889	208	0	100[a]	0	0	0
1942	4	81	21,063	510	320	13	40	0	0
1943	6	21	26,725	1,766	534	233	755	0	0
1944	9	28	30,268	3,647	738	1,824	915	0	0
1945	12	40	33,124	6,587	695	4,108	1,754	0	0
1946	22	17	41,722	10,560	554	7,085	2,653	0	0
1947	30	1	36,650	6,230	476	240	4,618	0	474
1948	44	2	47,652	6,440	78	7	4,872	712	675
1949	56	6	60,801	11,549	8	<1	6,199	2,611	2,708
1950	58	440	83,641	21,570	4	0	8,721	9,106	3,742
1951	56	12,000	105,551	23,534	0	0	8,995	8,364	6,051
1952	55	15,950	113,000	29,221	0	0	12,500	7,800	8,915
1953	56	37,112	117,777	31,629	0	0	10,710	6,317	10,609

Source: Antonio Tarnawiecki, “A Survey of the Development of Oceanic Fisheries in Peru,” *Peruvian Yearbook & Northern Peru Supplement of the Peruvian Times* Jan. 1955, 135; Javier Iparraguirre Cortez, *Estadística económica de la industria pesquera* (Lima: Ministerio de Agricultura, Dirección de Pesquería y Caza, 1959); Edmonds, “Reasons Underlying Development of the Peruvian Fishing Industry,” 8.

[a] Regional exports to other South American countries.

Table 8: Global Meat Production, Consumption, and Trade, 1961-2000

	1961	1971	1981	1991	2000
Meat production (1000s of metric tons)					
World	71,177	104,575	139,055	183,836	232,965
U.S.A.	16,513	22,071	24,833	29,553	37,661
European Union	15,993	22,761	29,517	33,284	35,966
China	2,550	8,712	15,443	33,362	63,227
Japan	687	1,816	3,014	3,422	3,005
Latin America & Caribbean	8,111	10,433	16,644	21,120	31,169
Brazil	2,120	3,086	5,586	8,465	14,683
Peru	217	277	397	535	910
Sub-Saharan Africa	2,663	3,445	4,444	5,474	6,580
Net trade, all meat and meat products (1000s of metric tons)					
World (total imports)	3,391	5,962	9,831	14,204	22,836
U.S.A.	-207	-562	7	420	3,399
European Union	-1,085	-967	527	1,297	2,153
China	27	208	246	632	-593
Japan	-35	-277	-659	-1,402	-2,399
Latin America & Caribbean	471	669	690	177	311
Brazil	33	151	419	397	1,375
Peru	-8	-16	-18	-22	-26
Sub-Saharan Africa	17	75	-96	-239	-198
Per-capita meat consumption (calories/day)					
World	110	136	155	181	210
U.S.A.	335	378	389	411	445
European Union	265	345	397	417	428
China	29	87	132	240	402
Japan	26	75	116	149	165
Latin America & Caribbean	178	168	213	214	268
Brazil	112	126	168	234	330
Peru	78	78	71	75	99
Sub-Saharan Africa	61	60	61	57	56

Source: FAO Statistical Databases, [cited 8-13 Oct. 2002], available from <http://apps.fao.org/>.

Table 9: Global Live Animal Production, Slaughter, and Trade, 1961-2000

	1961	1971	1981	1991	2000
World live animal stocks (millions of head)					
Beef cattle	942	1,097	1,228	1,297	1,346
Chickens	3,899	5,389	7,526	11,113	14,461
Pigs	406	618	780	866	908
Sheep	994	1,064	1,110	1,184	1,058
Andean camelids	5	6	6	5	6
Total (all types[a])	7,282	9,396	12,221	16,713	20,656
World live animal imports (millions of head)					
Beef cattle	4.9	6.9	7.0	8.2	8.2
Chickens	47.2	122.6	287.3	449.4	732.0
Pigs	2.6	5.4	9.7	13.4	16.6
Sheep	6.8	8.6	17.4	21.4	14.4
Total (all types[a])	63.6	149.3	342.3	540.1	825.7
World slaughtered animals (millions of head)					
Beef cattle	173	204	237	258	278
Chickens	6,585	11,405	19,334	28,080	41,377
Pigs	376	595	749	936	1,151
Sheep	331	372	401	473	487
Andean camelids	0.8	0.5	0.4	0.4	0.5
Total (all types[b])	8,365	13,808	22,426	32,350	47,691
World slaughtered animal production (1000s of metric tons)					
Beef cattle	27,685	38,074	45,940	53,896	56,517
Chickens	7,553	13,643	24,321	37,269	58,187
Pigs	24,743	39,414	52,986	70,908	89,584
Sheep	4,930	5,626	5,860	7,121	7,624
Andean camelids	27	18	15	14	14
Total (all types[b])	71,177	104,575	139,055	183,836	232,965

Source: FAO Statistical Databases, [cited 8-13 Oct. 2002], available from <http://apps.fao.org/>.

[a] Does not include beehives.

[b] Includes asses, beef cattle, buffalo, camels, other camelids (alpaca, llama, guanaco, vicuña), chickens, ducks, goats, geese, horses, mules, pigeons and other birds, pigs, rabbits and other rodents, sheep, turkeys. Production by weight also includes game meat, snails, and other misc.

Appendix 1: Guano and Nitrate Exports from Peru, 1840-1995

Year	Nitrate Exports (metric tons)	Index (73,444 metric tons = 100)[a]	Total Guano Exports (metric tons)	Index (134,185 metric tons = 100)[b]
1840	10,459	14	0	0
1841	12,810	17	8,085	6
1842	16,418	22	23,441	17
1843	16,989	23	2,617	2
1844	17,489	24	27,189	20
1845	17,307	24	24,701	18
1846	18,361	25	36,914	28
1847	17,622	24	96,724	72
1848	22,314	30	107,356	80
1849	19,785	27	151,621	113
1850	23,545	32	185,724	138
1851	31,713	43	262,739	196
1852	27,277	37	145,968	109
1853	40,767	56	316,116	236
1854	33,141	45	533,280	397
1855	43,097	59	514,957	384
1856	37,334	51	280,928	209
1857	50,408	69	626,584	467
1858	56,131	76	343,055	256
1859	72,413	99	190,586	142
1860	63,518	86	460,862	343
1861	62,331	85	246,893	184
1862	77,833	106	365,973	273
1863	70,870	96	419,789	313
1864	50,167	68	373,157	278
1865	112,353	153	439,049	327
1866	100,634	137	463,383	345
1867	117,315	160	493,335	368
1868	87,699	119	441,754	329
1869	69,324	94	526,726	393
1870	135,397	184	728,703	543
1871	165,872	226	614,668	458
1872	220,198	300	326,960	244
1873	288,133	392	233,021	174
1874	257,384	350	701,820	523
1875	332,557	453	245,693	183

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Appendix 1--*Continued*

Year	Nitrate Exports (metric tons)	Index (73,444 metric tons = 100)[a]	Total Guano Exports (metric tons)	Index (134,185 metric tons = 100)[b]
1876	326,000	444	575,476	429
1877	216,507	295	541,222	403
1878	270,249	368	504,134	376
1879	72,558	99	87,987[c]	66
1880-1882	0	0	0[c]	0
1883	--	--	167,534[c]	114
1884	--	--	47,864[c]	36
1885	--	--	38,150[c]	28
1886	--	--	139,716[c]	104
1887	--	--	24,316[c]	18
1888	--	--	83,942[c]	62
1889	--	--	78,200[c]	58
1890	--	--	0	0
1891	--	--	12,650	9
1892	--	--	30,780	23
1893	--	--	68,681	51
1894	--	--	39,788	30
1895	--	--	17,649	13
1896	--	--	16,723	12
1897	--	--	20,626	15
1898	--	--	31,772	24
1899	--	--	44,212	33
1900	--	--	11,460	9
1901	--	--	49,888	37
1902	--	--	69,578	52
1903			89,211	66
	Guano *Rico* Exports[d] (metric tons)	Guano *Pobre* Exports[e] (metric tons)		
1904			83,877	63
1905			69,315	52
1906			96,463	72
1907			98,583	73
1908			77,326	58
1909[f]			24,902	19
1909/10	25,469	20,701	46,170	34
1910/11	43,660	14,820	58,480	44
1911/12	34,582	30,684	65,266	49
1912/13	16,205	20,220	36,425	27
1913/14	19,865	14,612	34,477	26

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Appendix 1--*Continued*

Year	Guano *Rico* Exports[c] (metric tons)	Guano *Pobre* Exports[d] (metric tons)	Total Guano Exports (metric tons)	Index (134,185 metric tons = 100)[b]
1914/15	28,498	15,419	43,917	33
1915/16	18,706	0	18,706	14
1916/17-1919/20	0	0	0	0
1920/21	4,064	0	4,064	3
1921/22	6,045	0	6,045	5
1922/23	24,028	0	24,028	18
1923/24	23,142	0	23,142	17
1924/25	22,332	0	22,332	17
1925/26	21,128	0	21,128	16
1926/27	10,983	0	10,983	8
1927/28	12,657	0	12,657	9
1928/29	16,208	0	16,208	12
1929/30	23,814	5,950	29,764	22
1930/31	25,375	7,112	32,487	24
1931/32	16,500	0	16,500	12
1932/33	47,657	0	47,657	36
1933/34	44,042	4,761	48,803	36
1934/35	3,983	10,480	14,463	11
1935/36	0	254	254	<1
1936/37	0	375	375	<1
1937/38	0	5,420	5,420	4
1938[g]	16,911	510	17,421	13
1939	14,927	0	14,927	11
1940	0	0	0	0
1941	0	8,474	8,474	6
1942-1944	0	0	0	0
1945	81	0	81	0
1946-1948	0	0	0	0
1949	33	0	33	<1
1950	2,350	0	2,350	2
1951	39	0	39	<1
1952	95	0	95	<1
1953	1,072	0	1,072	1
1954	905	0	905	1
1955	12,397	0	12,397	9
1956	10,224	445	10,669	8
1957	27,645	0	27,645	21

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Appendix 1--*Continued*

Year	Guano *Rico* Exports[c] (metric tons)	Guano *Pobre* Exports[d] (metric tons)	Total Guano Exports (metric tons)	Index (134,185 metric tons = 100)[b]
1958	13,789	0	13,789	10
1959	12,376	0	12,376	9
1960	12,974	0	12,974	10
1961	16,866	0	16,866	13
1962	13,335	0	13,335	10
1963	13,806	0	13,806	10
1964	6,550	0	6,550	5
1965	--	--	0	0
1966	--	--	0	0
1967-1975	--	--	n.d.	n.d.
1976-1977	--	--	0	0
1978	--	--	2,000	1
1979	--	--	500	<1
1980	--	--	3,500	3
1981	--	--	3,600	3
1982	--	--	800	1
1983	--	--	2,300	2
1984	--	--	4,600	3
1985-1993	--	--	0	0
1994	--	--	300	<1
1995	--	--	400	<1
1840-1890[h]	--	--	12,959,051	
1891-1909[h]	--	--	953,484	
1909/10-1928/29[h]	327,572	116,456	444,028	
1929/30-1963[h]	331,196	43,781	374,977	
1891-1995[h,i]	--	--	1,772,137	

Sources: Shane J. Hunt, "Price and Quantum Estimates of Peruvian Exports, 1830-1862" (Discussion paper no. 33, Research Program in Economic Development, Woodrow Wilson School of Public and International Affairs, Princeton University, 1973), table 21; Robert G. Greenhill and Rory M. Miller, "The Peruvian Government and the Nitrate Trade, 1873-1879," *JLAS* 5:1 (May 1973), 108, table 1; José Antonio de Lavalle y García, *El guano y la agricultura nacional* (Lima: La Opinión Nacional, 1914), 41; "Anexos: Extracción de guanos verificada por The Peruvian Corporation Ltd.," *MCAG* 12 (1921); "Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962," *MCAG* 54 (1963); *MCONAFER* 1 (1967), 49; S. Zuta and L. A. Flores, "Oceanography Development in Peru," in *Oceanography: The Past*, ed. M. Sears and D. Merriman (New York: Springer-Verlag, 1980), 645; PESCA-PERU, *Qué ha hecho y adonde va PESCA-PERU* (Lima, 1982), 12; Richard Webb and Graciela Fernández Baca, eds., *Almanaque estadístico: Perú en números 1990* (Lima: Cuánto, 1990), 388; idem, *Anuario estadístico: Perú en números 1999* (Lima: Cuánto, 1999), 767-768; Peru, Instituto Nacional de Estadística e Informática, *Perú: Series estadísticas, 1970-94* (Lima: Dirección Técnica de Indicadores Económicas, 1995), 144.

[a] From 1830-1879, average annual nitrate exports amounted to 73,444 metric tons.

[b] From 1909-1963, average annual guano *rico* production amounted to 134,185 metric tons, i.e. the average amount of annual replacement under managed conditions.

[c] Chile occupied Peru's guano islands from late 1879 until 1883 during the War of the Pacific. By agreement, Chile received one-half of Peru's guano exports from 1883-1889; totals for these years include Chile's share.

[d] Guano *rico* or guano *azoado* contains greater than four percent nitrogen by weight.

[e] Guano *pobre* or guano *fosfatado* contains less than four percent nitrogen by weight.

[f] A two-month period before the establishment of the Compañía Administradora del Guano.

[g] A nine-month period that included the entire guano harvest during 1938.

[h] Exports by Quirós/Allier/Myers & Co./other private contractors (1840-1849), Antony Gibbs & Sons/other private contractors (1849-1861), various private contractors (1861-1869), Dreyfus Bros. & Co./Peruvian Guano Co./other private contractors (1870-1878), private contractors (1879-1890), Peruvian Corporation of London (1891-1928/29), Compañía Administradora del Guano (1929/30-1963), CONAFER (1964-1972), PESCA-PERU (1975-1995).

[i] Excludes 1965-1975; no data available.

Appendix 2: Guano Production in Peru, 1891-1995

Year (El Niño Event Strength)[a]	Guano *Rico* Production[b] (metric tons)	Index (1916/17 = 100)	Total Guano Production[c] (metric tons)	Index (1916/17 = 100)
1891 (VS)	--	--	12,650	23
1892	--	--	30,780	57
1893	--	--	68,681	126
1894	--	--	39,788	73
1895	--	--	17,649	32
1896	--	--	17,962	33
1897 (M+)	--	--	25,314	46
1898	--	--	34,267	63
1899 (S)	--	--	47,441	87
1900 (S)	--	--	17,757	33
1901	--	--	62,844	115
1902 (M+)	--	--	81,378	149
1903	--	--	104,522	192
1904	--	--	113,115	208
1905	--	--	108,949	200
1906	--	--	142,091	261
1907 (M)	--	--	141,729	260
1908	--	--	106,325	195
1909[d]	--	--	26,306	--
1909/10	48,809	90	70,292	129
1910/11 (M+)	66,587	122	90,417	166
1911/12 (S)	51,746	95	101,566	186
1912/13	38,607	71	70,172	129
1913/14	48,832	90	70,169	129
1914/15 (M+)	50,988	94	76,200	140
1915/16	58,929	108	58,929	108
1916/17	54,472	100	54,472	100
1917/18 (S)	80,866	148	80,866	148
1918/19	74,076	136	74,076	136
1919/20	50,628	93	50,628	93
1920/21	68,174	125	68,174	125
1921/22	62,757	115	62,757	115
1922/23 (M)	84,332	155	84,332	155
1923/24	110,508	203	110,508	203
1924/25	148,046	272	148,046	272
1925/26 (VS)	136,333	250	136,333	250
1926/27	80,404	148	80,404	148

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Appendix 2--*Continued*

Year (El Niño Event Strength)[a]	Guano *Rico* Production[b] (metric tons)	Index (1916/17 = 100)	Total Guano Production[c] (metric tons)	Index (1916/17 = 100)
1927/28	78,493	144	78,493	144
1928/29	125,471	230	125,471	230
1929/30	136,263	250	151,461	278
1930/31 (M)	123,317	226	132,974	244
1931/32	94,700	174	94,700	174
1932/33 (S)	133,741	246	133,741	246
1933/34	157,634	289	162,358	298
1934/35	137,203	252	148,256	272
1935/36	126,635	232	127,722	234
1936/37	134,442	247	136,056	250
1937/38	152,532	280	159,138	292
1938[e]	168,619	310	169,786	312
1939 (M+)	152,198	279	152,778	280
1940 (S)	125,637	231	126,545	232
1941 (S)	119,399	219	119,642	220
1942	67,643	124	79,201	145
1943 (M+)	69,697	128	91,820	169
1944	75,939	139	78,842	145
1945	86,418	159	93,359	171
1946	110,608	203	113,536	208
1947	157,970	290	160,433	295
1948	162,230	298	163,262	300
1949	191,773	352	193,874	356
1950	218,146	400	218,456	401
1951	237,071	435	237,077	435
1952	251,687	462	253,425	465
1953 (M+)	255,772	470	260,797	479
1954	288,173	529	293,977	540
1955	286,773	526	289,876	532
1956	332,223	610	336,438	618
1957 (S)	283,284	520	285,407	524
1958 (S)	143,857	264	167,009	307
1959	108,919	200	127,307	234
1960	127,540	234	157,915	290
1961	142,937	262	159,198	292
1962	184,332	338	206,097	378
1963	181,672	334	203,437	373
1964	187,087	343	205,092	377

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Appendix 2--*Continued*

Year (El Niño Event Strength)[a]	Guano *Rico* Production[b] (metric tons)	Index (1916/17 = 100)	Total Guano Production[c] (metric tons)	Index (1916/17 = 100)
1965 (M+)	161,020	296	169,790	312
1966	41,693	77	55,505	102
1967	41,322	76	64,891	119
1968	27,810	51	35,111	64
1969	14,901	27	20,112	37
1970	43,397	80	50,225	92
1971	16,416	30	22,328	41
1972 (S)	37,676	69	47,112	86
1973 (S)	28,406	52	33,088	61
1974	0	0	0	0
1975	13,333	24	31,516	58
1976 (M)	0	0	0	0
1977	27,295	50	36,645	67
1978	26,826	49	29,576	54
1979	28,194	52	29,299	54
1980	29,983	55	42,014	77
1981	24,900	46	28,900	53
1982 (VS)	0	0	0	0
1983 (VS)	0	0	0	0
1984	26,700	49	26,700	49
1985	14,100	26	26,600	49
1986	20,434	38	22,575	41
1987 (M)	21,820	40	21,820	40
1988	12,720	23	15,887	29
1989	11,707	21	18,694	34
1990	14,997	28	14,997	28
1991	18,236	33	20,070	37
1992 (M)	1,346	2	1,346	2
1993	14,350	26	20,078	37
1994	21,643	40	31,106	57
1995	25,795	47	29,017	53

	Guano *Rico* Production		Total Guano Production	
	(metric tons)	(metric tons/yr)	(metric tons)	(metric tons/yr)
1891-1908[f]	--	--	1,173,242	69,014
1909-1963[f]	7,246,042	134,185	7,678,205	142,189
1891-1995[f]	--	--	10,001,541	96,169

Sources: José Antonio de Lavalle y García, *El guano y la agricultura nacional* (Lima: La Opinión Nacional, 1914), 41; "Anexos: Extracción de guanos verificada por The Peruvian Corporation Ltd.," *MCAG* 12 (1921); "Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962," *MCAG* 54 (1963); *MCONAFER* 1 (1965), 3, 6; Humberto Tovar S., "Las poblaciónes de aves guaneras en los ciclos reproductivos de 1969/70 a 1973/74," *Inf.Inst.Mar Perú* 45 (1978), 12; S. Zuta and L. A. Flores, "Oceanography Development in Peru," in *Oceanography: The Past*, ed. M. Sears and D. Merriman (New York: Springer-Verlag, 1980), 645; PESCA-PERU, *Qué ha hecho y adonde va PESCA-PERU* (Lima, 1982), 12; Richard Webb and Graciela Fernández Baca, eds., *Almanaque estadístico: Perú en números 1990* (Lima: Cuánto, 1990), 388; idem, *Anuario estadístico: Perú en números 1999* (Lima: Cuánto, 1999), 767-768; Peru, Instituto Nacional de Estadística e Informática, *Perú: Series estadísticas, 1970-94* (Lima: Dirección Técnica de Indicadores Económicas, 1995), 144.

[a] El Niño event strength as determined by W. H. Quinn and V. T. Neal, "The Historical Record of El Niño Events," in *Climate Since A.D. 1500*, rev. ed., ed. Raymond S. Bradley and Philip D. Jones (London: Routledge, 1995), 623-648; M = moderate, M+ = moderately strong, S = strong, VS = very strong.

[b] Guano *rico* or guano *azoado* contains greater than four percent nitrogen by weight.

[c] Includes both guano *rico* and guano *pobre* or guano *fosfatado* production containing less than four percent nitrogen by weight.

[d] A two-month period before the establishment of the Compañía Administradora del Guano.

[e] A nine-month period that included the entire guano harvest during 1938.

[f] Sales by private contractors (1896-1909), Compañía Administradora del Guano (1909/10-1963), CONAFER (1964-1972), FERTIPERU (1973-1974), PESCA-PERU (1975-1995).

Appendix 3: Guano Sales in Peru, 1896-1995

Year (El Niño Event Strength)[a]	Demand for Guano *Rico*[b] (metric tons)	Guano *Rico* Sales (metric tons)	Nitrogen Content of Guano *Rico* Sales (metric tons)	Nitrogen Content Index (1916/17 = 100)	Total Guano Sales[c] (metric tons)	Total Guano Sales Index (1916/17 = 100)
1896	--	--	--	--	1,239	2
1897 (M+)	--	--	--	--	4,688	9
1898	--	--	--	--	2,495	5
1899 (S)	--	--	--	--	3,229	6
1900 (S)	--	--	--	--	6,297	12
1901	--	--	--	--	12,956	25
1902 (M+)	--	--	--	--	11,800	23
1903	--	--	--	--	15,311	30
1904	--	--	--	--	29,238	57
1905	--	--	--	--	39,634	77
1906	--	--	--	--	45,628	89
1907 (M)	--	--	--	--	43,146	84
1908	--	--	--	--	28,999	57
1909[d]	--	--	--	--	1,404	--
1909/10	35,491	23,008	2,393	40	23,790	46
1910/11 (M+)	54,189	22,598	2,418	40	31,938	62
1911/12 (S)	67,522	14,753	1,496	25	33,889	66
1912/13	97,309	22,492	2,065	34	33,837	66
1913/14	114,397	27,362	2,367	39	34,078	67
1914/15 (M+)	129,380	20,814	1,948	32	30,607	60
1915/16	36,931	43,678	4,438	73	43,678	85
1916/17	43,374	51,211	6,053	100	51,211	100

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Appendix 3--*Continued*

Year (El Niño Event Strength)[a]	Demand for Guano *Rico*[b] (metric tons)	Guano *Rico* Sales (metric tons)	Nitrogen Content of Guano *Rico* Sales (metric tons)	Nitrogen Content Index (1916/17 = 100)	Total Guano Sales[c] (metric tons)	Total Guano Sales Index (1916/17 = 100)
1917/18 (S)	65,006	79,408	10,164	168	79,408	155
1918/19	62,464	72,892	8,951	148	72,892	142
1919/20	34,326	50,926	6,376	105	50,926	99
1920/21	55,586	57,351	7,530	124	57,351	112
1921/22	43,035	54,683	7,743	128	54,683	107
1922/23 (M)	43,372	63,743	8,554	141	63,743	124
1923/24	71,874	85,935	10,733	177	85,935	168
1924/25	92,477	109,146	14,178	234	109,146	213
1925/26 (VS)	89,144	97,411	12,284	203	97,411	190
1926/27	64,347	68,301	8,743	144	68,301	133
1927/28	49,270	72,485	8,974	148	72,485	142
1928/29	97,487	106,271	14,134	234	106,271	208
1929/30	95,362	108,386	13,071	216	116,694	228
1930/31 (M)	83,806	90,674	11,751	194	92,453	181
1931/32	64,229	73,270	9,430	156	73,531	144
1932/33 (S)	79,497	88,616	11,680	193	88,686	173
1933/34	103,619	115,170	14,534	240	115,402	225
1934/35	136,310	131,400	16,806	278	131,840	257
1935/36	161,815	125,854	16,663	275	127,051	248
1936/37	205,243	132,342	17,509	289	133,595	261
1937/38	237,127	142,782	19,718	326	143,903	281
1938[e]	262,522	147,857	20,641	341	148,514	290
1939 (M+)	227,689	136,537	18,528	306	137,105	268

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Appendix 3--*Continued*

Year (El Niño Event Strength)[a]	Demand for Guano *Rico*[b] (metric tons)	Guano *Rico* Sales (metric tons)	Nitrogen Content of Guano *Rico* Sales (metric tons)	Nitrogen Content Index (1916/17 = 100)	Total Guano Sales[c] (metric tons)	Total Guano Sales Index (1916/17 = 100)
1940 (S)	229,453	120,302	16,108	266	121,152	237
1941 (S)	197,571	114,147	15,170	251	114,422	223
1942	204,663	71,613	9,431	156	83,220	163
1943 (M+)	248,890	67,537	9,347	154	89,445	175
1944	267,913	75,177	10,382	172	78,284	153
1945	293,684	83,932	11,390	188	90,853	177
1946	361,241	100,449	13,741	227	102,126	199
1947	369,736	146,931	19,968	330	148,301	290
1948	345,601	166,102	22,756	376	168,473	329
1949	354,878	160,338	20,908	345	161,550	315
1950	356,757	220,028	29,418	486	221,342	432
1951	366,047	243,394	34,221	565	243,708	476
1952	486,912	236,064	35,575	588	236,492	462
1953 (M+)	437,004	240,767	36,837	609	241,937	472
1954	529,757	267,260	39,608	654	270,056	527
1955	559,884	306,680	46,431	767	309,563	604
1956	547,138	306,961	46,689	771	312,620	610
1957 (S)	619,350	268,670	40,865	675	272,534	532
1958 (S)	678,858	137,190	20,386	337	149,379	292
1959	665,164	100,054	14,118	233	108,879	213
1960	695,097	101,830	14,837	245	114,620	224
1961	706,504	117,505	16,451	272	126,201	246
1962	724,626	121,875	17,818	294	130,429	255

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Appendix 3--*Continued*

Year (El Niño Event Strength)[a]	Demand for Guano *Rico*[b] (metric tons)	Guano *Rico* Sales (metric tons)	Nitrogen Content of Guano *Rico* Sales (metric tons)	Nitrogen Content Index (1916/17 = 100)	Total Guano Sales[c] (metric tons)	Total Guano Sales Index (1916/17 = 100)
1963	755,769	190,350	29,501	487	190,350	372
1964	674,061	182,769	30,870	510	182,769	357
1965 (M+)	663,559	156,289	24,959	412	156,289	305
1966	337,993	43,236	7,360	122	43,236	84
1967	--	--	--	--	--	--
1968	--	--	--	--	--	--
1969	--	--	--	--	--	--
1970	--	--	--	--	40,516	79
1971	--	--	--	--	41,277	81
1972 (S)	--	--	--	--	51,564	101
1973 (S)	--	--	--	--	57,687	113
1974	--	--	--	--	17,047	33
1975	--	--	--	--	3,310	6
1976 (M)	--	--	--	--	353	1
1977	--	--	--	--	32,286	63
1978	--	--	--	--	36,747	72
1979	--	--	--	--	33,344	65
1980	--	--	--	--	25,826	50
1981	--	--	--	--	18,900	37
1982 (VS)	--	--	--	--	18,100	35
1983 (VS)	--	--	--	--	13,200	26
1984	--	--	--	--	19,500	38
1985	--	--	--	--	36,600	71

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Appendix 3--*Continued*

Year (El Niño Event Strength)[a]	Demand for Guano *Rico*[b] (metric tons)	Guano *Rico* Sales (metric tons)	Nitrogen Content of Guano *Rico* Sales (metric tons)	Nitrogen Content Index (1916/17 = 100)	Total Guano Sales[c] (metric tons)	Total Guano Sales Index (1916/17 = 100)
1986	--	--	--	--	25,300	49
1987 (M)	--	--	--	--	11,200	22
1988	--	--	--	--	18,000	35
1989	--	--	--	--	14,800	29
1990	--	--	--	--	19,700	38
1991	--	--	--	--	7,200	14
1992 (M)	--	--	--	--	5,700	11
1993	--	--	--	--	11,900	23
1994	--	--	--	--	21,500	42
1995	--	--	--	--	34,800	68

Year	Demand for Guano *Rico*[b] (metric tons)	Guano *Rico* Sales (metric tons)	Nitrogen Content of Guano *Rico* Sales (metric tons)		Total Guano Sales[c] (metric tons)	(metric tons/yr)
1896-1908[f]	--	--	--		244,660	20,388
1909-1963[f]	13,250,928	6,212,162	854,328		6,597,694	122,180
1896-1995[f,g]	--	--	--		7,654,004	81,426

Sources: José Antonio de Lavalle y García, *El guano y la agricultura nacional* (Lima: La Opinión Nacional, 1914), 41; "Anexos: Extracción de guanos verificada por The Peruvian Corporation Ltd.," *MCAG* 12 (1921); "Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962," *MCAG* 54 (1963); *MCONAFER* 1 (1967), 49; S. Zuta and L. A. Flores, "Oceanography

Development in Peru," in *Oceanography: The Past*, ed. M. Sears and D. Merriman (New York: Springer-Verlag, 1980), 645; PESCA-PERU, *Qué ha hecho y adonde va PESCA-PERU* (Lima, 1982), 12; Richard Webb and Graciela Fernández Baca, eds., *Almanaque estadístico: Perú en números 1990* (Lima: Cuánto, 1990), 388; idem, *Anuario estadístico: Perú en números 1999* (Lima: Cuánto, 1999), 767-768; Peru, Instituto Nacional de Estadística e Informática, *Perú: Series estadísticas, 1970-94* (Lima: Dirección Técnica de Indicadores Económicas, 1995), 144.

[a] El Niño event strength as determined by W. H. Quinn and V. T. Neal, "The Historical Record of El Niño Events," in *Climate Since A.D. 1500*, rev. ed., ed. Raymond S. Bradley and Philip D. Jones (London: Routledge, 1995), 623-648; M = moderate, M+ = moderately strong, S = strong, VS = very strong.

[b] CAG required all large purchasers of fertilizer to report their estimated guano needs before the beginning of each new fiscal year. These amounts were reported in CAG statistics as "*pedidos de la agricultura nacional*." Guano *rico* or guano *azoado* contains greater than four percent nitrogen by weight.

[c] Includes guano *rico* as well as guano *pobre* or guano *fosfatado* containing less than four percent nitrogen by weight.

[d] A two-month period before the establishment of the Compañía Administradora del Guano.

[e] A nine-month period that included the entire guano harvest during 1938.

[f] Sales by private contractors (1896-1909), Compañía Administradora del Guano (1909/10-1963), CONAFER (1964-1972), FERTIPERU (1973-1974), PESCA-PERU (1975-1995).

[g] Excludes 1965-1969; no data available.

Appendix 4: Profits from Guano Sold by the Compañía Administradora del Guano, 1909-1962

Year (El Niño Event Strength)[a]	Net Earnings from Sales to Peruvian Agriculture (S/.)	Real Net Earnings from Sales (1979 US$)	Real Net Earnings from Sales (1979 US$ / metric ton)	Net Earnings from Guano Exports (S/.)	Real Net Earnings from Exports (1979 US$)	Real Net Earnings from Exports (1979 US$ / metric ton)	Real Net Earnings from All Guano Sales (1979 US$)	Index (1916/17 = 100)
1909/10	23,008	--	--	0	0	0	--	--
1910/11 (M+)	33,317	--	--	0	0	0	--	--
1911/12 (S)	32,138	--	--	0	0	0	--	--
1912/13	34,074	--	--	0	0	0	--	--
1913/14	33,868	47,896	1.41	0	0	0	47,896	5
1914/15 (M+)	32,038	43,643	1.43	0	0	0	43,643	4
1915/16	862,355	1,090,329	24.96	0	0	0	1,090,329	106
1916/17	1,050,326	1,028,014	20.07	0	0	0	1,028,014	100
1917/18 (S)	1,766,352	1,765,673	22.24	0	0	0	1,765,673	172
1918/19	1,299,024	1,122,180	15.40	0	0	0	1,122,180	109
1919/20	1,682,985	1,270,053	24.94	0	0	0	1,270,053	124
1920/21	1,976,608	1,331,918	23.22	0	0	0	1,331,918	130
1921/22	2,014,333	1,432,968	26.21	0	0	0	1,432,968	139
1922/23 (M)	2,214,276	1,649,286	25.87	0	0	0	1,649,286	160
1923/24	2,805,845	2,201,932	25.62	0	0	0	2,201,932	214
1924/25	3,700,845	2,800,493	25.66	0	0	0	2,800,493	272
1925/26 (VS)	3,782,034	2,670,864	27.42	0	0	0	2,670,864	260
1926/27	2,224,623	1,565,247	22.92	0	0	0	1,565,247	152
1927/28	2,296,523	1,677,745	23.15	0	0	0	1,677,745	163

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Appendix 4--*Continued*

Year (El Niño Event Strength)[a]	Net Earnings from Sales to Peruvian Agriculture (S/.)	Real Net Earnings from Sales (1979 US$)	Real Net Earnings from Sales (1979 US$ / metric ton)	Net Earnings from Guano Exports (S/.)	Real Net Earnings from Exports (1979 US$)	Real Net Earnings from Exports (1979 US$ / metric ton)	Real Net Earnings from All Guano Sales (1979 US$)	Index (1916/17 = 100)
1928/29	3,695,067	2,891,294	27.21	0	0	0	2,891,294	281
1929/30	5,075,197	4,066,346	34.85	1,600,449	1,282,311	43.08	5,348,656	520
1930/31 (M)	7,388,355	6,186,875	66.92	2,234,375	1,871,025	57.59	8,057,900	784
1931/32	3,021,115	2,682,790	36.49	1,326,091	1,177,586	71.37	3,860,376	376
1932/33 (S)	5,436,058	5,087,713	57.37	3,333,336	3,119,734	65.46	8,207,447	798
1933/34	5,052,328	4,847,133	42.00	3,340,128	3,204,472	65.66	8,051,605	783
1934/35	3,332,543	3,134,068	23.77	517,185	486,383	33.63	3,620,451	352
1935/36	3,218,645	2,982,858	23.48	1,323	1,226	4.83	2,984,084	290
1936/37	3,402,873	2,993,890	22.41	6,093	5,361	14.30	2,999,251	292
1937/38	5,413,102	4,493,424	31.23	135,884	112,798	20.81	4,606,221	448
1938[a]	9,152,877	7,531,887	50.71	2,979,595	2,451,904	140.74	9,983,790	971
1939 (M+)	7,642,948	6,400,191	46.68	2,983,303	2,498,212	167.36	8,898,403	866
1940 (S)	6,258,378	4,837,357	39.93	0	0	0	4,837,357	471
1941 (S)	7,282,650	5,188,218	45.34	1,080,968	770,090	90.88	5,958,308	580
1942	2,557,045	1,621,917	19.49	0	0	0	1,621,917	158
1943 (M+)	3,472,194	2,021,017	22.60	0	0	0	2,021,017	197
1944	3,294,857	1,673,053	21.37	0	0	0	1,673,053	163
1945	2,319,083	1,056,756	11.63	8,308	3,786	46.74	1,060,541	103
1946	5,332,505	2,218,166	21.72	0	0	0	2,218,166	216
1947	10,433,640	3,353,639	22.61	0	0	0	3,353,639	326

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Appendix 4--*Continued*

Year (El Niño Event Strength)[a]	Net Earnings from Sales to Peruvian Agriculture (S/.)	Real Net Earnings from Sales (1979 US$)	Real Net Earnings from Sales (1979 US$ / metric ton)	Net Earnings from Guano Exports (S/.)	Real Net Earnings from Exports (1979 US$)	Real Net Earnings from Exports (1979 US$ / metric ton)	Real Net Earnings from All Guano Sales (1979 US$)	Index (1916/17 = 100)
1948	11,509,026	2,827,854	16.79	0	0	0	2,827,854	275
1949	39,335,981	8,429,062	52.18	39,679	8,503	257.65	8,437,564	821
1950	46,492,341	8,876,295	40.10	3,308,400	631,638	268.78	9,507,934	925
1951	46,506,006	8,063,996	33.09	46,715	8,100	207.70	8,072,096	785
1952	36,535,596	5,931,395	25.08	173,290	28,133	296.14	5,959,528	580
1953 (M+)	32,687,385	4,841,168	20.01	1,550,839	229,687	214.26	5,070,855	493
1954	46,770,130	6,739,527	24.96	1,535,697	221,292	244.52	6,960,820	677
1955	69,659,871	9,616,329	31.06	17,740,194	2,448,979	197.55	12,065,307	1,174
1956	49,861,671	6,511,123	20.83	8,782,226	1,146,816	107.49	7,657,938	745
1957 (S)	63,512,182	7,597,019	27.88	31,153,445	3,726,424	134.80	11,323,443	1,101
1958 (S)	68,639,287	7,535,581	50.45	26,485,928	2,907,764	210.88	10,443,345	1,016
1959	51,443,935	5,067,980	46.55	25,804,900	2,542,160	205.41	7,610,140	740
1960	78,048,227	7,469,143	65.16	29,230,308	2,797,313	215.61	10,266,456	999
1961	84,802,962	7,654,409	60.65	41,227,588	3,721,248	220.64	11,375,657	1,107
1962	64,255,054	5,436,049	41.68	33,789,632	2,858,641	214.37	8,294,690	807
1913-1962	920,583,149	199,563,760	31.77/yr	240,415,879	40,261,585	111.48/yr	239,825,345	4,894,395/yr

Sources: "Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962," *MCAG* 54 (1963); Felipe Portocarrero S., Arlette Beltrán B., and María Elena Romero P., *Compendio estadístico del Perú, 1900-1990* (Lima: Universidad del Pacífico, Centro de Investigación, 1992), 88-89.

[a] A nine-month period that included the entire guano harvest during 1938.

Appendix 5: Income from Guano Sales, Cotton, Cane Sugar, and Fishmeal Exports in Peru, 1900-1980

Year	Net Earnings from All Guano Sales (million US$)	Real Net Earnings from All Guano Sales (million 1979 US$)	Cotton Export Income (million US$)	Cotton Real Export Income (million 1979 US$)	Cotton Share of Total Export Income (per-cent)	Cane Sugar Export Income (million US$)	Cane Sugar Real Export Income (million 1979 US$)	Cane Sugar Share of Total Export Income (per-cent)	Fish-meal Export Income (million US$)	Fish-meal Real Export Income (million 1979 US$)	Fish-meal Share of Total Export Income (per-cent)
1900	--	--	0.66	--	7.2	2.97	--	32.2	--	--	--
1901	--	--	0.75	--	8.5	2.10	--	23.9	--	--	--
1902	--	--	0.60	--	8.0	2.53	--	33.7	--	--	--
1903	--	--	0.61	--	7.7	2.11	--	26.7	--	--	--
1904	--	--	0.59	--	7.1	2.06	--	24.8	--	--	--
1905	--	--	0.81	--	6.8	3.76	--	31.8	--	--	--
1906	--	--	0.89	--	7.7	2.85	--	24.8	--	--	--
1907	--	--	0.99	--	8.5	1.69	--	14.4	--	--	--
1908	--	--	1.64	--	14.5	2.15	--	19.0	--	--	--
1909	0.005	--	2.49	--	18.6	2.39	--	17.9	--	--	--
1910	0.007	--	3.08	--	21.3	2.85	--	19.7	--	--	--
1911	0.007	--	2.11	--	13.9	2.01	--	13.2	--	--	--
1912	0.007	--	2.08	--	10.7	2.89	--	14.9	--	--	--
1913	0.007	0.048	2.98	20.08	15.5	2.96	19.98	15.4	--	--	--
1914	0.007	0.044	2.95	18.42	16.0	5.54	34.62	30.1	--	--	--
1915	0.203	1.090	2.89	15.50	11.0	6.83	36.60	25.9	--	--	--

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Appendix 5--*Continued*

Year	Guano Earnings (million US$)	Guano Real Earnings (million 1979 US$)	Cotton Export Income (million US$)	Cotton Real Export Income (million 1979 US$)	Cotton Share of Total Export Income (per-cent)	Cane Sugar Export Income (million US$)	Cane Sugar Real Export Income (million 1979 US$)	Cane Sugar Share of Total Export Income (per-cent)	Fish-meal Export Income (million US$)	Fish-meal Real Export Income (million 1979 US$)	Fish-meal Share of Total Export Income (per-cent)
1916	0.188	1.028	3.50	19.12	10.4	8.07	44.16	24.0	--	--	--
1917	0.350	1.766	5.56	28.05	15.4	7.94	40.07	22.0	--	--	--
1918	0.244	1.122	6.66	30.65	18.9	7.37	33.92	20.9	--	--	--
1919	0.351	1.270	13.19	47.79	24.7	16.52	59.85	30.9	--	--	--
1920	0.447	1.332	18.23	54.30	30.1	5.03	14.97	8.3	--	--	--
1921	0.553	1.433	9.24	23.94	22.2	2.40	6.21	5.8	--	--	--
1922	0.586	1.649	11.77	33.15	25.1	11.40	32.09	24.3	--	--	--
1923	0.678	2.202	15.69	50.99	26.8	16.02	52.05	27.3	--	--	--
1924	0.916	2.800	16.78	51.30	26.7	12.93	39.53	20.6	--	--	--
1925	0.948	2.671	14.94	42.09	26.8	6.11	17.20	11.0	--	--	--
1926	0.600	1.565	15.14	39.53	22.3	11.88	31.02	17.5	--	--	--
1927	0.614	1.678	17.21	47.02	23.5	11.70	31.96	16.0	--	--	--
1928	0.938	2.891	14.28	44.02	20.9	8.87	27.36	13.0	--	--	--
1929	1.269	4.066	12.89	41.30	17.6	8.44	27.06	11.5	--	--	--
1930	2.173	6.187	10.67	30.38	17.6	6.59	18.77	10.9	--	--	--
1931	0.842	2.683	5.60	17.85	10.2	7.73	24.66	14.1	--	--	--
1932	1.159	5.088	7.26	31.85	19.0	5.54	24.31	14.5	--	--	--

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Appendix 5--*Continued*

Year	Guano Earnings (million US$)	Guano Real Earnings (million 1979 US$)	Cotton Export Income (million US$)	Cotton Real Export Income (million 1979 US$)	Cotton Share of Total Export Income (per-cent)	Cane Sugar Export Income (million US$)	Cane Sugar Real Export Income (million 1979 US$)	Cane Sugar Share of Total Export Income (per-cent)	Fish-meal Export Income (million US$)	Fish-meal Real Export Income (million 1979 US$)	Fish-meal Share of Total Export Income (per-cent)
1933	0.951	4.847	11.44	58.29	23.6	6.38	32.50	13.2	--	--	--
1934	0.768	3.134	18.83	76.84	26.8	3.14	12.82	4.5	--	--	--
1935	0.768	2.983	19.26	74.77	26.1	6.14	23.85	8.3	--	--	--
1936	0.846	2.994	22.76	80.50	27.3	6.28	22.19	7.5	--	--	--
1937	1.367	4.493	22.43	73.75	24.3	8.07	26.51	8.7	--	--	--
1938	2.048	7.532	13.55	49.84	17.7	5.61	20.64	7.3	--	--	--
1939	1.434	6.400	14.11	62.96	19.7	7.71	34.41	10.8	--	--	--
1940	1.014	4.837	11.47	54.72	17.4	7.09	33.80	10.8	--	--	--
1941	1.120	5.188	19.27	89.24	25.4	9.27	42.92	12.2	--	--	--
1942	0.393	1.622	8.13	33.54	10.7	17.32	71.40	22.7	--	--	--
1943	0.534	2.021	9.14	34.59	15.1	11.47	43.38	16.2	--	--	--
1944	0.507	1.673	9.26	30.55	11.0	25.90	85.49	30.8	--	--	--
1945	0.356	1.053	21.74	64.38	20.9	33.23	98.41	32.0	--	--	--
1946	0.820	2.218	50.42	136.33	33.3	44.72	120.90	29.5	--	--	--
1947	1.605	3.354	34.66	72.42	22.5	46.52	97.19	30.1	--	--	--
1948	6.848	10.936	42.83	68.40	24.4	35.04	55.96	22.6	--	--	--
1949	6.046	8.421	97.01	135.12	22.9	53.32	74.27	16.4	--	--	--

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Appendix 5--*Continued*

Year	Guano Earnings (million US$)	Guano Real Earnings (million 1979 US$)	Cotton Export Income (million US$)	Cotton Real Export Income (million 1979 US$)	Cotton Share of Total Export Income (per-cent)	Cane Sugar Export Income (million US$)	Cane Sugar Real Export Income (million 1979 US$)	Cane Sugar Share of Total Export Income (per-cent)	Fish-meal Export Income (million US$)	Fish-meal Real Export Income (million 1979 US$)	Fish-meal Share of Total Export Income (per-cent)
1950	2.799	8.245	68.00	200.32	34.3	29.70	87.49	15.0	5.70	16.79	2.9
1951	3.061	8.056	85.60	225.31	33.1	34.50	90.81	13.3	6.10	16.06	2.4
1952	2.338	5.903	79.30	200.19	32.2	33.10	83.56	13.5	7.80	19.69	3.2
1953	1.838	4.611	65.20	163.58	28.6	34.70	87.06	15.2	7.00	17.56	3.1
1954	2.297	6.518	64.80	183.86	25.5	33.00	93.63	13.0	11.20	31.78	4.4
1955	2.706	7.167	68.10	180.31	24.2	37.00	97.97	13.2	11.80	31.24	4.2
1956	2.136	5.364	85.70	215.20	26.8	32.80	82.36	10.3	14.90	37.42	4.7
1957	1.697	3.871	67.80	154.66	20.5	49.60	113.14	15.0	18.40	41.97	5.6
1958	1.801	4.628	75.20	193.19	25.8	33.90	87.09	11.6	17.90	45.98	6.1
1959	0.928	2.526	69.20	188.43	21.4	35.90	97.75	11.1	42.50	115.73	13.2
1960	1.788	4.672	73.10	190.98	16.5	47.40	123.84	10.7	50.00	130.63	11.3
1961	1.625	3.933	79.30	191.90	15.5	63.90	154.63	12.5	69.70	168.67	13.7
1962	1.136	2.577	97.10	220.24	17.5	53.80	122.03	9.7	119.80	271.73	21.5
1963	--	--	91.30	195.63	16.5	63.10	135.20	11.4	120.20	257.55	21.7
1964	--	--	91.20	177.84	13.3	63.50	123.82	9.3	165.70	323.11	24.2
1965	--	--	87.50	146.68	12.8	37.20	62.36	5.4	185.70	311.29	27.1
1966	--	--	85.40	131.34	10.8	46.40	71.36	5.9	205.40	315.89	26.1
1967	--	--	54.70	85.02	7.4	53.00	82.38	7.1	203.40	316.16	27.4

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Appendix 5--*Continued*

Year	Guano Earnings (million US$)	Guano Real Earnings (million 1979 US$)	Cotton Export Income (million US$)	Cotton Real Export Income (million 1979 US$)	Cotton Share of Total Export Income (per-cent)	Cane Sugar Export Income (million US$)	Cane Sugar Real Export Income (million 1979 US$)	Cane Sugar Share of Total Export Income (per-cent)	Fish-meal Export Income (million US$)	Fish-meal Real Export Income (million 1979 US$)	Fish-meal Share of Total Export Income (per-cent)
1968	--	--	55.80	94.78	6.6	62.30	105.82	7.4	232.00	394.07	27.6
1969	--	--	65.10	104.00	7.4	38.90	62.14	4.4	320.40	511.85	36.4
1970	--	--	52.00	79.12	5.0	61.00	92.81	5.9	303.00	461.00	29.3
1971	--	--	45.00	64.10	5.1	69.00	98.29	7.8	267.00	380.33	30.0
1972	--	--	47.00	62.49	5.0	86.00	114.35	9.1	219.00	291.19	23.2
1973	--	--	63.00	76.45	5.7	78.00	94.65	7.0	138.00	167.46	12.4
1974	--	--	97.00	100.75	6.5	194.00	201.49	12.9	202.00	209.80	13.4
1975	--	--	53.00	46.44	4.0	269.00	235.70	20.2	168.00	147.20	12.6
1976	--	--	71.00	64.36	5.3	85.00	77.05	6.3	168.00	152.29	12.5
1977	--	--	48.00	47.61	2.8	78.00	77.37	4.5	184.00	182.51	10.7
1978	--	--	38.00	44.34	1.9	47.00	54.84	2.4	196.00	228.69	9.9
1979	--	--	49.00	49.00	1.3	34.00	34.00	0.9	256.00	256.00	7.0
1980	--	--	72.00	58.15	1.8	13.00	10.50	0.3	195.00	157.50	5.0

Sources: Felipe Portocarrero S., Arlette Beltrán B., and María Elena Romero P., *Compendio estadístico del Perú, 1900-1990* (Lima: Universidad del Pacífico, Centro de Investigación, 1992), 88-89, 133-134, 140-141, 168-169; "Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962," *MCAG* 54 (1963).

Appendix 6: Cotton and Sugar Cane Production in Peru, 1915-1980

Year	Total Guano Sales (metric tons)	Sugar Cane Area Cultivated (hectares)	Sugar Cane Production (metric tons)	Cotton Area Cultivated (hectares)	Cotton Production (metric tons)
1915	43,678	42,804	2,548,189	--	--
1916	51,211	40,732	2,268,866	55,635	24,603
1917	79,408	45,328	2,200,516	64,060	27,125
1918	72,892	49,804	2,603,263	77,872	30,687
1919	50,926	48,754	2,679,537	88,863	33,558
1920	57,351	49,077	2,884,986	104,287	38,386
1921	54,683	50,847	2,372,175	108,356	40,352
1922	63,743	50,813	2,768,912	111,428	43,120
1923	85,935	53,086	2,830,999	113,560	46,000
1924	109,146	55,736	2,707,204	116,218	46,582
1925	97,411	53,466	2,644,798	118,518	45,467
1926	68,301	53,194	3,231,717	127,863	53,374
1927	72,485	57,039	3,305,167	127,852	53,254
1928	106,271	53,283	3,182,666	114,630	48,682
1929	116,694	77,987	4,648,201	126,883	65,591
1930	92,453	53,050	3,418,112	133,688	58,695
1931	73,531	50,311	3,517,192	126,890	50,700
1932	88,686	50,064	3,317,484	123,065	52,573
1933	115,402	60,308	3,729,389	130,481	60,228
1934	131,840	51,453	3,380,204	148,517	74,144
1935	127,051	52,841	3,271,048	162,088	85,175
1936	133,595	53,262	3,320,727	165,530	83,617
1937	143,903	52,610	3,102,768	157,021	81,498
1938	148,514	52,880	2,974,123	190,792	85,885
1939	137,105	53,803	3,448,874	177,483	81,872
1940	121,152	54,933	3,953,682	180,135	82,871
1941	114,422	51,279	3,887,758	169,911	71,354
1942	83,220	51,700	3,965,091	156,284	69,847
1943	89,445	47,746	3,517,977	124,866	56,781
1944	78,284	49,193	3,496,477	132,112	67,153
1945	90,853	50,830	3,491,390	136,862	70,488
1946	102,126	50,576	3,292,010	138,104	71,262
1947	148,301	50,346	3,476,978	120,005	65,069
1948	168,473	48,750	4,102,423	124,635	61,361
1949	161,550	50,228	4,050,991	147,055	67,194

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Appendix 6--*Continued*

Year	Guano Sales (metric tons)	Cane Area Cultivated (hectares)	Cane Production (metric tons)	Cotton Area Cultivated (hectares)	Cotton Production (metric tons)
1950	221,342	53,226	3,697,087	134,396	73,468
1951	243,708	54,566	3,961,421	160,207	83,231
1952	236,492	52,208	4,169,758	189,869	96,305
1953	241,937	55,041	5,403,665	204,992	96,042
1954	270,056	55,890	5,813,000	209,169	111,876
1955	309,563	56,923	6,097,566	217,473	104,939
1956	312,620	61,546	5,876,384	226,995	115,083
1957	272,534	62,082	6,077,792	239,235	105,399
1958	149,379	61,751	6,840,208	237,627	114,571
1959	108,879	66,749	6,543,824	235,928	115,831
1960	114,620	69,204	6,837,832	252,355	130,499
1961	126,201	69,204	6,837,832	255,000	131,110
1962	130,429	73,892	7,247,077	275,000	145,642
1963	190,350	75,130	7,697,310	260,000	146,775
1964	195,293	76,440	7,390,920	260,000	141,331
1965	--	83,190	7,498,940	227,800	130,918
1966	--	83,460	8,463,380	203,976	121,308
1967	--	82,890	7,942,800	180,425	88,649
1968	--	79,150	7,272,300	166,235	100,825
1969	--	76,533	6,411,900	188,610	88,631
1970	40,516	78,864	7,531,318	143,825	91,480
1971	41,277	86,575	8,309,447	136,325	81,747
1972	51,564	83,595	8,611,668	127,580	75,655
1973	57,687	85,736	8,772,386	134,660	81,543
1974	17,047	89,831	9,183,620	148,190	90,013
1975	3,310	91,475	8,927,700	133,670	72,357
1976	353	92,885	8,791,542	98,290	56,786
1977	32,286	93,096	8,825,477	110,782	57,726
1978	36,747	92,871	7,970,198	118,044	76,194
1979	33,344	91,551	7,034,212	134,719	92,912
1980	25,826	89,023	5,598,088	149,017	97,947

Sources: Felipe Portocarrero S., Arlette Beltrán B., and María Elena Romero P., *Compendio estadístico del Perú, 1900-1990* (Lima: Universidad del Pacífico, Centro de Investigación, 1992), 40, 42; “Anexos: Guano explotado: Cantidades de guano solicitadas por la agricultura nacional y ventas realizadas a esta industria, guano exportado, ley media azoada y fosfatada del guano vendido a la agricultura nacional, y utilidad fiscal durante los años 1909-1962,” *MCAG* 54 (1963); *MCONAFER*1 (1965), 3, 6; S. Zuta and L. A. Flores, “Oceanography Development in Peru,” in *Oceanography: The Past*, ed. M. Sears and D. Merriman (New York: Springer-Verlag, 1980), 645; PESCA-PERU, *Qué ha hecho y adonde va PESCA-PERU* (Lima: n.p., 1982), 12.

Appendix 7: Regional Distribution of Guano *Rico* in Peru, 1911-1960 (metric tons/share)

Region	1911-12	1915-16	1920-21	1925-26	1930-31	1934-35	1941	1945	1950	1956	1960	1966[o]
Piura[a]	0	5	674	1,007	1,342	4,222	4,487	3,743	17,501	27,547	10,239	7,597
		<0.1%	1.0%	0.9%	1.1%	3.2%	3.7%	4.2%	6.7%	8.0%	9.3%	9.0%
Lambay-	1,251	3,479	7,520	7,682	9,700	10,333	12,740	8,998	28,871	35,794	9,055	2,374
eque[b]	6.5%	7.9%	11.6%	7.2%	7.6%	7.7%	10.4%	10.2%	11.1%	10.3%	8.2%	2.8%
Jequete-	0	0	445	2,126	1,429	868	838	1,716	10,360	14,608	6,519	1,895
peque[c]			0.7%	2.0%	1.1%	0.6%	0.7%	1.9%	4.0%	4.2%	5.9%	2.2%
Chicama/	4,227	12,574	9,914	11,129	23,808	19,519	16,394	8,184	27,898	30,491	8,463	9,912
Moche[d]	22.0%	28.7%	15.2%	10.4%	18.7%	14.6%	13.4%	9.8%	10.7%	8.8%	7.7%	11.7%
Chimbote[e]	3,455	2,778	2,332	3,662	3,146	4,187	4,057	3,380	10,483	13,845	4,510	3,313
	18.0%	6.3%	3.4%	3.4%	2.5%	3.1%	3.3%	3.8%	4.0%	4.0%	4.1%	3.9%
Supe[f]	3,326	6,057	4,669	11,457	9,750	12,544	4,238	3,322	12,719	20,510	2,367	1,805
	17.3%	13.8%	7.2%	10.7%	7.6%	9.4%	3.5%	3.8%	4.9%	5.9%	2.1%	2.1%
Huaura[g]	1,274	2,906	8,104	9,351	7,204	12,413	6,073	5,254	13,108	13,655	3,125	2,245
	6.6%	6.6%	12.5%	8.7%	5.6%	9.3%	4.9%	6.0%	5.0%	4.0%	2.8%	2.7%
Chancay[h]	1,873	2,978	6,236	8,951	8,352	9,181	8,247	5,308	13,487	12,835	3,073	2,783
	9.8%	6.8%	9.6%	8.3%	6.5%	6.9%	6.7%	6.0%	5.2%	3.7%	2.8%	3.3%
Lima[i]	1,875	3,888	11,668	18,694	12,628	20,226	21,889	14,744	39,079	48,359	13,244	14,280
	9.8%	8.9%	17.9%	17.4%	9.9%	15.1%	17.8%	16.7%	15.0%	14.0%	12.0%	16.9%
Cañete[j]	1,943	5,041	4,202	11,110	10,564	16,940	9,708	5,433	15,238	15,101	2,843	3,757
	10.1%	11.5%	6.5%	10.3%	8.3%	12.6%	7.9%	6.2%	5.9%	4.4%	2.6%	4.4%
Chincha/	170	519	1,919	8,804	3,400	10,991	15,270	9,627	37,061	55,566	16,125	7,087
Pisco/Ica[k]	0.9%	1.2%	2.9%	8.2%	2.7%	8.2%	12.4%	10.9%	14.3%	16.1%	14.6%	8.4%
Arequipa[l]	1,719	1,932	5,203	6,149	4,812	6,300	9,499	9,314	14,751	17,461	6,535	6,214
	9.0%	4.4%	8.0%	5.7%	3.8%	4.7%	7.7%	10.6%	5.7%	5.1%	5.9%	7.3%

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Appendix 7--*Continued*

Region	1911-12	1915-16	1920-21	1925-26	1930-31	1934-35	1941	1945	1950	1956	1960	1966[o]
Highland Regions[m]	0	0	0	206 0.2%	164 0.1%	297 0.2%	1,392 1.1%	908 1.0%	5,002 1.9%	22,298 6.5%	17,074 15.5%	18,464 21.8%
Total[n]:	19,178	43,784	65,091	107,398	127,565	134,024	122,763	88,259	259,958	344,995	110,096	84,618

Source: "Anexos: Detalle de la distribución y venta del guano en los puertos; de las existencias que quedan en los mismos para la próxima campaña; de la tara, mermas y siniestros habidos durante el año, y del guano vendido en el exterior," *MCAG* 3-51 (1912-1960); *MCONAFER* 5 (1967), 10, 31, 35, 39.

[a] *Piura*: ports of Paita and Sechura; Piura and Chira river valleys.

[b] *Lambayeque*: ports of Pimentel and Eten; La Leche, Lambayeque (Chancay), Reque, and Saña river valleys (near Chiclayo).

[c] *Jequetepeque*: port of Pacasmayo; Jequetepeque river valley (between Chiclayo and Trujillo).

[d] *Chicama/Moche*: ports of Malabrigo/Chicama, Huanchaco, and Salaverry; Chicama and Moche river valleys (near Trujillo).

[e] *Chimbote*: ports of Santa, Chimbote, and Samanco; Santa, Lacramarca, and Nepeña river valleys.

[f] *Supe*: port of Supe; Fortaleza, Pativilca, and Supe river valleys.

[g] *Huaura*: port of Huacho; Huaura river valley.

[h] *Chancay*: ports of Chancay and Huaral; Chancay river valley (north of Lima).

[i] *Lima*: ports of Callao, Bujama/Mala, and Chucuito; Chillón, Rímac, Lurín, Mala, and Omas river valleys.

[j] *Cañete*: port of Cerro Azul; Cañete river valley (south of Lima).

[k] *Chincha/Pisco/Ica*: ports of Tambo de Mora and Pisco; San Juan, Pisco, and Ica river valleys.

[l] *Arequipa*: port of Mollendo and agencies in Arequipa and Vitor; Chili and Vitor river valleys.

[m] *Highland regions*: agencies in Huancayo, Jauja, Tarma, Cuzco, Huaraz, Huánuco, Yungay, Puno, and Cajamarca.

[n] Total includes other minor regions not listed.

[o] Includes guano *rico*, ground guano *rico*, and guano "*balanceada*" ("guano *rico*" manufactured by combining guano *pobre* and imported ammonium sulfate to produce a standard product with 12.5 percent nitrogen, 9.5 percent phosphoric acid, 1.5 percent potassium content by weight).

Appendix 8: Ranking of Coastal Bird Colonies by Guano *Rico* Production, 1909-1966

Rank	Guano Bird Colonies	Guano Production (metric tons)
1.	Grupo de Islas Chincha (Norte, Central, Sur)	1,182,722
2.	Isla La Vieja[a]	793,842
3.	Grupo de Guañape	733,184
4.	Grupo de Santa Rosa	654,419
5.	Isla Don Martín	384,442
6.	Grupo de Asia	351,573
7.	Grupo de Pescadores	345,136
8.	Isla Macabí	343,714
9.	Grupo de Ballestas	338,570
10.	Grupo de Santa	312,758
11.	Grupo Huaura/Mazorca	250,306
12.	Grupo Pachacámac	214,668
13.	Puntas San Juan[a,b], San Nicolás[a], y Tres Hermanas[a,b]	197,655
14.	Grupo San Lorenzo	188,333
15.	Isla Lobos de Tierra	142,773
16.	Punta Culebras[a,b]	144,011
17.	Punta Coles[a,b]	94,177
18.	Isla Tortuga	91,626
19.	Punta Salinas[a,b]	89,325
20.	Islotes y Puntas del Norte (Anconcillo)[a]	77,652
21.	Punta Lomas[a]	60,974
22.	Islotes y Puntas Chala, Atico[b], Ocoña, Islay, Hornillos, Playa, Pescadores, y Saltadero	59,461
23.	Isla Lobos de Afuera	49,730
24.	Morro de Sama	41,169
25.	Islotes y Puntas Jesús y Cocotea	36,534
26.	Puntas Chancay y Grita Lobos	30,560
27.	Isla Blanca del Norte	28,093
28.	Puntas Lomitas[a,b] y Ollero[a]	23,903
29.	Punta La Chira[a,b]	23,861
30.	Islotes y Puntas del Sur[a]	18,039
31.	Islotes y Puntas de Cerro Azul	13,344
32.	Punta Litera[a,b]	13,343
33.	Islotes Sombrerillos	12,076
34.	Isla Blanca Sur u Ovillos	10,405
35.	Islas Hormigas de Afuera	9,912
36.	Isla Palominos	8,612
37.	Punta Malabrigo[a,b]	6,566

Continued on next page

Appendix 8--*Continued*

Rank	Guano Bird Colonies	Guano Production (metric tons)
38.	Punta Cerro Negro[a]	6,135
39.	Punta e Islote Tartacay	3,165
40.	Isla El Frontón[a]	1,872
	Total (all islands and points):	7,394,434

Source: *MCONAFER* 5 (1967), 47.

[a] Ninety percent or greater of total guano *rico* on this particular territory was produced after 1946.

[b] Protected by isolation walls built by CAG after 1946.

Appendix 9: Fish and Fishmeal Production and Exports in Peru, 1953-1997

Year (El Niño Event Strength)[a]	Anchoveta Production (metric tons)	All Other Fish Species Production (metric tons)	Fishmeal Exports (metric tons)	Fishmeal Export Income (million US$)
1953 (M+)	37,112	50,360[b]	27,700	7.0
1954	43,028	65,640[b]	40,600	11.2
1955	58,707	71,030[b]	47,300	11.8
1956	118,726	83,590[b]	61,000	14.9
1957 (S)	325,624	98,270	97,700	18.4
1958 (S)	737,019	109,670	137,200	17.9
1959	1,908,698	138,480	338,500	42.5
1960	2,943,602	143,770	575,400	50.0
1961	4,579,708	158,910	849,900	69.7
1962	6,274,624	152,620	1,219,500	119.8
1963	6,423,244	148,680	1,199,700	120.2
1964	8,863,367	127,870	1,565,500	165.7
1965 (M+)	7,242,390	126,930	1,581,400	185.7
1966	8,529,821	143,440	1,421,700	205.4
1967	9,824,624	--	1,812,400	203.4
1968	10,262,661	177,000	2,404,100	232.0
1969 (M-)	8,960,460	182,000	1,886,700	320.4
1970	12,276,977	204,000	1,873,000	303.0
1971	10,276,600	227,300	1,750,000	267.0
1972 (S)	4,447,200	356,000	1,524,000	219.0
1973 (S)	1,512,800	776,300	348,000	138.0
1974	3,583,400	535,700	629,000	202.0
1975	3,078,800	318,900	781,000	168.0
1976 (M)	3,863,100	473,800	592,000	168.0
1977	792,100	1,699,200	436,000	184.0
1978	1,187,000	2,243,300	483,000	196.0
1979	1,362,700	2,276,700	657,000	256.0
1980	720,100	1,977,000	417,000	195.0
1981	1,225,200	1,475,900	315,000	141.0
1982 (VS)	1,720,400	1,776,500	616,000	202.0
1983 (VS)	118,400	1,418,600	205,000	80.0
1984	23,000	3,265,400	401,000	137.0
1985	844,260	3,365,900	508,000	118.0
1986	3,481,870	2,047,700	716,000	206.0
1987 (M)	1,764,640	2,783,700	732,000	223.0
1988	2,701,100	3,897,300	812,000	357.0

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Appendix 9--*Continued*

Year	Anchoveta Production (metric tons)	All Other Fish Species Production (metric tons)	Fishmeal Exports (metric tons)	Fishmeal Export Income (million US$)
1989	3,718,700	3,041,491	1,095,000	410.0
1990	2,926,408	3,850,375	1,093,000	339.0
1991	3,080,992	3,724,121	1,123,000	441.0
1992 (M)	4,869,966	2,544,171	993,000	427.0
1993	7,009,534	1,917,784	1,568,000	545.0
1994	9,800,223	2,097,066	2,221,000	713.0
1995	6,558,108	2,258,869	1,816,000	712.0
1996	7,463,147	1,977,440	1,610,000	836.7
1997 (VS)	5,923,000	1,947,800	1,924,500	1,027.0
1998 (VS)	1,205,600	4,347,700	669,600	394.4
1999	6,732,000	1,698,900	1,481,300	532.9
2000	9,372,200	1,094,100	2,343,800	860.5

Sources: Felipe Portocarrero S., Arlette Beltrán B., and María Elena Romero P., *Compendio estadístico del Perú, 1900-1990* (Lima: Universidad del Pacífico, Centro de Investigación, 1992), 46, 138-141; Richard Webb and Graciela Fernández Baca, eds., *Anuario estadístico: Perú en números 1999* (Lima: Cuánto, 1999), 756, 1226; Peru, Superintendencia Nacional de Aduanas, "Aduanas: Información estadística--exportaciones, Peru: Segun sectores económicos 1997-2001," [cited 6 Mar. 2001], available from http://www.aduanet.gob.pe/aduanas/informae/supme1.htm; Peru, Ministerio de Pesquería, "Resúmen general del desenvolvimiento de la actividad pesquera, 1997-98," [cited 6 Mar. 2001], available from http://www.minpes.gob.pe/cuad_anua98.htm; idem, "Resúmen general del desenvolvimiento de la actividad pesquera, 1999-2000," [cited 6 Mar. 2001], available from http://www.minpes.gob.pe/boletme2.htm.

[a] El Niño event strength as determined by W. H. Quinn and V. T. Neal, "The Historical Record of El Niño Events," in *Climate Since A.D. 1500*, rev. ed., ed. Raymond S. Bradley and Philip D. Jones (London: Routledge, 1995), 623-648; M- = weak, M = moderate, M+ = moderately strong, S = strong, VS = very strong.

[b] Excludes dried and salted fish production; no data available.

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Vita

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