Climate and Fisheries: Costs and Benefits of Change

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Abstract: Many records provide the bases for a clearer understanding of the roles of climate regime shifts and short-term perturbations in ecosystem dynamics, hence fisheries responses. Too few have taken the long view of the role of humans in this "Grand Fugue". As one of many predators, it is imperative that humans begin to understand that our various activities are subject to basic ecological principles, such as the concepts of growth limitations imposed by scarcities and habitat debilitations. Most of human history (evolution, growth, colonizations, displacements, resource scarcity, competition for resources) are direct consequences of normal, natural climate fluctuations, and local, regional and global ecological responses. Early fisheries were subsistence levels, with some situations where fishing communities bartered or traded for goods from adjacent highlands or forest cultures. We have also become extremely vulnerable to any persistent climate changes. Following the Medieval Warm period (~900-1180), the onset of the Little Ice Age (LIA) brought changes in regional productivity, disease, and death that began the global transition from Feudal society to the "pay as you go" economics that now dominate the world's major economies. Over the recent two to three centuries humans have swarmed over the remaining terrain, and spread out onto the seas. Modern history relates the continuous growth, expansion and generalized superposition of industrial fisheries onto older coastal subsistence communities, initiating extensive competition, overexploitation, and with resultant dwindling resources and habitat destruction. I have started a Timeline of Fisheries Development that provides a framework of information upon which these facts are derived: <.http://www.monterey.edu/faculty/SharpGary/world/FisheryTimeline.html> I will continue to develop the Timeline, so that others might learn how humans resolve the issues of complex aquatic ecosystems, limited resource sharing, or not.

KEYWORDS: Climate, Fisheries, History, Cultures, Economics, Ecosystems, Environments

1.1 Introduction

For at least several tens of thousands of years, since the Inter-Glacial Climate period before the one within which we are all embedded began, human's have left behind refuse that tells the tale of where we've been, what we have killed, and what we have eaten. Stone age tools, pointed sticks, and various darts, arrows, and barbed shafts have been used to wound and capture fishes, birds and large mammals since humans came on the scene. Humans are, in fact, tool makers first, then hunters, as gathering or gleaning requires little in the way of technology. So, let's take a long-view look into ecosystem changes that have occurred, and what roles humans and climate change have had in these.

We must breeze over the epic reductions in the occurrences and abundances of large land mammals and birds with a brief comment or two. The records clearly tie human colonizations of large islands to the extinctions of the larger land birds and some mammals. The Age of Exploration since 1500 provided several examples of similar patterns, such as the extinctions of the Dodo birds of Mauritius and La Reunion Islands, as well as the slaughter of the Stellar sea cow and various whales populations, in which mostly unknown, unrecorded losses occurred. In modern times, more devastating consequences in aquatic ecosystems have been due to manipulations and pollution of waterways, damming flows, and loss of critical spawning habitats

We would like to focus on the historical evolution of fishing cultures within the recent Holocene Climate period during which we have the most complete record sets of observed aquatic environmental changes. Humanity "civilized", by settling down into what were observed to be relatively stable environments. These locations allowed year-round food production, both animal and vegetable, due to reliable seasonal rainfall and general availability of water, grasslands and fertile farmlands. Also, these important resources could be tended by unique sectors of society, while others focused on artisanal production of tools, building arts, and "civil services". All these requirements were sustained by relatively stable seasonal weather, or climate, over centuries or longer periods, climate changes shifted the centers of possible civilization.

Within the recent two to three thousand years Stone Age lifestyles were systematically displaced over most of Asia's river valleys and some of the coasts and larger islands of the Indian Ocean. This occurred during only a short period before similar processes took place along the Mediterranean and northeastern Atlantic Ocean. Although many modern societies tend to hold historical events at a distance, the Stone Age has only recently ended in many isolated locations around the world. Long before Europe, Asia's river valleys offered opportunities for technical innovations i.e., metalurgy and hardened tools such as metal-tip plows that were amenable to the increased power provided by draft animals of various sizes and endurance, from naturally docile cattle and water buffalo, to camels and elephants.

The rugged and mobile horse cultures of the high country and western boundaries of Asia and Arabia were less interested in producing crops than in continuing to hunt and collect their needs along their migration pathways, as determined by passing seasons, climatic events and other processes. Clearly, the strong seasonal signals and climate changes from the broad ice and glacier expansions of the period from about 40 thousand years until only 11 thousand years before present favored migrant cultures, and their systematic adaptations to constant changes. Similarly, Africa's central plains cultures were preadapted to regular seasonal patterns, and their climate-driven changes. The social chaos that we see across Africa today, famine and disease from floods and drought, are consequence of two more modern patterns. Namely, the loss of trans-territorial tribal mobilities, and Europeanized provincial social systems that are ill-suited for major changes in food availability and water quality due to restricted transportation systems.

Waterways and lakes in particular have been sites of settlements, and both fishing and hunting activities, based on the array of species that either lived in them, or migrated to them, for feeding and breeding purposes. Along the world's ocean coastlines there are dynamics on another, similar time scale. Seafarers evolved slowly, and spread only as their craft would permit. As the majority of early seafarers emerged with the end of the two most recent Ice Ages, changes in the world oceans have tended to erase records of these earlier human actvities and cultural patterns.

As the Ice Ages wax and wane, so do sea levels, rising at least 150 meters or so within only the recent Inter-Glacial, as the Holocene warming that began to thaw the Ice Caps started only about 12 thousand years ago. During post-glacial periods large stretches of the Bering Sea were high and - when not snow or ice covered - dry enough for people to walk, or paddle their hide-covered boats or reed craft eastward from Asia along the shoreline of North America, as far south as Tierra del Fuego. These traveler's individual motivations would likely have included that they needed to keep moving to find food, and minimal competition for whatever resources they encountered.

The recent Interglacial was clearly the second opportunity for such ventures, within known socio-technological capability - underscored by similar strong motivations. That there were remnant cultures from earlier migrations and colonizations along all the America's coastlines and riverways is consistent with recent archaelogical studies in south and central Chile, and even recent data from eastern Canada. Melted ice caps and glaciers created sea level rises to inundate and erased their shoreline habitats, along with any usual signatures such as middens. Strong storm surges and swells would also have removed these in short time.

However, the state of humanity in the previous glacial cycle was such that hunting and gathering were even more primitive, and the tools that were in hand, so to speak, were even less developed than those of the Holocene Stone Age travellers. In fact, the first toggle-hook for fishing purposes was found in remains of a small 25 thousand year old subculture in the Dordogne Valley, of north western Europe.

Meanwhile, the cultures that would have had the option of crossing the north Pacific would have been the very old, independent northern and eastern Asian cultures (Korean, Chi'in, Hokkaido, and Inuit). The patterns of languages and biochemical genetics that recently have been related produce similar scenarios (Svorza-Cavalla et al. 1993). The complexity of the social interactions that evolved in the relatively recent interglacial period along Alaska's coastline and waterways provides useful insights into how these primitive societies coped with climate changes, and one anothers needs.

The evolution of several barter-based systems of resource trade is well documented, with the pre-Colonial southeastern Alaskan region providing the clearest records. Regional coastal communities were quite specifically organized around fishing, hunting, and processing of products, to be bartered with upland tribes for woven baskets, hides, and other necessities that were not generally available within these coastal environments. Smoked and dried fish products were developed, as were Eulachon oil-based products, a remarkable source of vitamins and other nutrients. Fishing villages were located along any and every major waterway, to take advantage of the annual salmon runs, although most of these riverside tribes also hunted and foraged for their necessities. The Haida and Tlingit fish, seal, and whale harvest systems dominated the Southwestern Alaskan coastal waterways and shorelines, and developed quite sophisticated trade systems that let them focus their efforts on preserving specific barterable products, nearly year round.

1.2 Tools in Hand, Ships at Sea

Nowhere do the records of the patterns of human cultural expansion leave such well marked trails as those of as Europe's Age of Exploration, via ships on the sea. Even the rubble left by the "thundering hoards" of Attilla do not carry the same messages. "We are here!" "Do not try to escape!" "You are our slaves!"

However, the problems quickly evolved to "survival" of not only those who were "gifted" an array of unprecendented diseases along with "new social order", but also for all of those immigrants who were variously persuaded to invest in the "opportunities" of the New World, or isolated oceanic islands. Any pre-existing local cultures were placed in great jeopardy by these "invaders". Many of the early European settlements were unsuccessful, and were abandoned. In others, the colonists began to work with the local indigenous groups to learn how to survive the various new challenges that were encountered. In many colonized areas the locals were either enslaved, or killed, and slaves imported from other parts of the world to do the menial and labor intensive farming, crop harvesting, and value-adding processing of crops such as sugar cane and cotton. Fishing, trapping, and hunting were full-time occupations for free men, and participants were recruited from existing European cultures, where opportunities had waned. Many of the New World's fishermen were left over or stranded from various ventures, but most were recruited from North Atlantic island or coastal fishing communities, or east Asia.

The evolution of cod fishing and whaling as Europe progressed from fuedalism to capitalism facilitated the transfers of many seafarers into the New World, and beyond, into the Pacific Islands and Antarctic, as they sought greater resource bases and new riches. The early European whaling industry was the economic equivalent of modern energy corporations. These industries evolved until the discovery of petroleum as a source of energy. After the introduction of gas lighting and eventually electricity, whale oil became an obsolete energy source. Fortunately, this important change occurred before the whales were hunted to extinction. This also left a major sector of independent and rugged seamen - landlocked.

Initially, major motivations for European non-seafaring individuals to migrate to the New World were religious freedom, and the ideal of property ownership. The successes of the latter efforts can be measured by both land and natural resource ownership laws, and in the mode of selection of individuals for leadership roles.

Today, event-driven social crises are often made worse by sensationalized media interpretations and modern agency reactions to natural phenomena, and their societal consequences. Another issue is the new social order that includes the bloom of a quite disparate class of "environmentally concerned interests". These folks (and corporations) have decided that their reverence for the various icons of Nature give them the right to vilify anyone who might remain in the hunter-gatherer, forester or farming phases of society. This has created another dilemma. Why do we point fingers at those working to supply civilization with its basic needs, rather than facing the real issues of over-exploitation and habitat erasures? Why is it that we deny that the major problem is that there are too many people occupying ever more critical habitat, using resources at rates that preclude natural renewal processes? It is apparently easier to vilify those productive people whose faces one rarely sees, rather than look in mirrors - and face the true problems.

Most of the original colonial sites have expanded well beyond historical boundaries. The cultural-overlay processes were more often than not exclusionary, rather than inclusive. The major message was simply "We are here to make new social order, and we are in control." The result has been ecological and social chaos. Why? Because locals were moved out, and no one from beyond the regions that were invaded had any clues as to the time and space scales of the local and regional patterns of climatic and environmental variabilities.

This missing suite of often poorly valued, but critical information led many ancient and modern folk into quagmires of issues - social, and economic. There evolved a general failure to understand the imperatives of constant environmental changes. This led to the mess that we have come to expect from steadily growing human populations, i.e., increased competition between food producers and city-dwellers for limited land and water resources, and a general disdain for laboring social classes.

For example, the United Nations was originally set up after WWII to deal with diverse regional (national) levels of technological, governmental and economic development. The long view was about convergent economic equality (if you believe the Charter). The consequent nearly fifty years has not brought equality, but has mostly helped define those regional and cultural limitations that preclude near-term "development" of equalities, no matter how they were originally defined. Democracy is not generally prevalent, nor often desireable in "lesser developed" societies. Then again, the illusion of democracy in western society, is somewhat interpretive.

Global societal problems still include many more fundamental discrepancies. These include the absolute differences of philosphy that make, for example, the Christian and Muslim cultures incompatible. The most critically divergent basis of these two uniquely parallel cultures is that the modern European cultural common denominator is built upon the concept of usury, where "investors" have a "profit motive" based on consequent or future performance, i.e., investors require a portion (percentage of their investments' gains. Muslim culture, on the other hand, has defined this particular motive as "a sin", and therefore defines such economic requirements as unbecoming of their cultural basis.

Another divergence is that the treatment and roles of individuals, particularly women, in many Muslim communitiues are considerably less than as equals. Many Muslim communities are vested in slavery, multiple wives, and in the general deprivation of various classes of people from many individual options, and equal social status. On the other hand, Muslim religious laws protect certain species from harassement or exploitation, creating significant enclaves or protected areas for many fishes, turtles, and marine mammals. Hence their important roles in the global conservation movements over the last few decades.

Modern civilization has separated the producers from the majority of consumers. Fuedal societies had resolved these issues by the landowners or Barons taking responsibility for both production efforts, and limiting of individual options, so as to achieve some minimal standards of autonomy and sustainability. Even today, in the USA, the important leadership role decisions are more often than not made in back rooms, out of the public eye. National and many State election ballots list mostly candidates for whom only very few of the voters have ever had any interactions, beyond receiving a sequence of "spontaneous" media blitzes, funded by supporters from another, often invisible sector of society. So, who is "In Charge", of Whom?

There are many dichotomies, and confusing labels bantered about, but most of the western world is just a few adjectives away from their feudal roots, as modern "investors" create new markets via new machines, and new Company Stores arise, often employing classes of folks who are simply unable to afford property in the local environment. This is particularly true of coastal communities, where fishing cultures at one time dominated, i.e., Monterey Bay, San Diego, San Pedro, Portland, Providence, Bar Harbor, etc. If this is progress, then we might look forward to many dissatisified working class crowds, as energy costs once again escalate, and housing + commuting costs exceed wages. Asian "Boat People" solved their housing dilemmas by moving onto the oceans and off the very valuable land. But at present, in the New World, most harbors charge fees that would preclude such solutions, and various health and water quality standards will not allow such a pragmatic shift in living arrangements.

1.3 Where to From Here? Maybe Backward.

Where does this begin? Will it end? These questions are the critical elements of the present cultural dilemmas. A close look at China's long history is a lesson in coping (c.f. Bloodworth, 1967, for an unusually insighful exposition of Chinese cultural responses and history). The Chinese have opted for patience. Then, once conditions become intolerable, revolutions occur, on century time scales. Each period of Chinese revolution evolved a Philosopher hero, first from amongst various Legendary Period emperors, that led up to the pre1990 BCE Golden Age and Emperor Yü, who founded the Hsia Dynasty - the first real consolidation of China, as a people. Near the end of their Age of Chivalry (722-481BCE) Confucius (551-479BCE) provided a code of ethics, li, that still dominates much of Asian social behavior.

At the same time Lao Tzu founded Taoism, with its Yin and Yang dichotomies. For over two milennia Emperors were just as likely to derive from the poor masses as from dynastic princedoms. Landlords proliferated, and if they became sufficiently annoying, they were efficiently obliterated, usually by a neighbor, a relative, (or sometimes a starving mob - after another climate-related disaster created conditions that led to mass death and famine). Rural China was dominated by local land owners, and their enterprises were very much vested in food production. At several junctures, China's social unrest and subsequent revolutions evolved, and more consolidation of power took place.

Each new social change inspired new challenges, and new dichotomies. Buddhism was imported from India in the 1st Century AD, providing another layer of social diversity, albeit, a benevolent rather than competitive addition to an already complex society. This was the only philospphy with external roots until Communism was imported early in the 20th Century. The "social homogenization" model of communism changed the roles of everyone. Land ownership was disabled, as was the individual's rights to chose their own faith ethics. Landlords were slaughtered, and China lost their knowledge of food production techniques within its many diverse environments.

Mao's Great Leap Forward - the ultimate Grand Plan - was to create "instant" solutions to the broad spectrum of China's social and technological development. It was implenmented in 1958, under the ideal that "modern" technologies could be spread uniformly across the nation's farmlands, and production increased to ideal levels to create a more efficient, and contented populus. The ignored facts were that China had insufficient trained expertise, little capacity to create the needed machines, and a quite diverse terrain. Unusually severe weather patterns from 1958 until 1960 or so ended up nearly destroying China, as drought, floods, and resulting famine brought death and destruction - and cannibalism back on the scene.

For a huge culture, with diverse regional adaptations and well-structured social groups, the failure of communism as an economic social order was moot. China's inverted social structure - after three thousand years of sorting and selecting - already had intellectuals and scholars as rulers at the apices, and peasants and workers next, with shop-keepers on the lowest rungs. The capitalist had no social value at all.

Democracy has never been valued, as Confucious described long ago in these words: "Heaven placed the people below, and gave them rulers and teachers." Equality was never really a Chinese delusion. This did not keep China from leading the world in many ways, as history records China's many firsts. In the 15th century, while Marco Polo was exploring China on horseback, Cheng Ho was sailing his enormous sailing craft, and huge attendant fleet, along the Indian Ocean's northern boundaries, to "show the flag", and an oppulence that made China's Emperors appear superhuman, and China, itself, all-powerful. At the conclusion of his seventh voyage, a new policy enforced by the new Manchu government was for China to close off its external seagoing activities, and remain within its own bounds for several centuries. (What other decision could one expect of leaders derived from horse people, and disdain for sea travel?)

Meanwhile, the Europeans began to arrive. Long sea voyages, new trade routes, and colonization changed the world. Diseases were also traded, such that plagues and famines were more generalized, and particularly devastating to Europe's closely housed "civilized" folk. The onset of the Little Ice Age created regional shortages, and poor crops, inducing various abundant rodents to cohabit with human hosts, creating conditions for rapid spread of disease vectors, and consequently, devastating death rates.

Oddly enough, these plagues and diseases caused a general labor shortage in Europe, and a mass exodus from rural life into cities, making it possible for the reduced labor forces to bargain for their services. Competition for laborers changed the way Europe did business, and as a consequence of the original ventures out onto the oceans, more of the displaced rural communities were motivated to move to new situations - at home, and abroad. All this can be attributed to the general cooling that took place starting in the 12th century. So, we can see that climate is a powerful economic force, on any scales (Braudel (1982).

Biologists, particularly Darwinian ecologists such as myself, have learned most from comparing species responses and ecological interactions to diurnal, seasonal, and longer time scale weather patterns. We have no doubt that climate is one of the most persistent modifiers of options that occurs. Our main sources of climate information beyond the recent century or so of meteorological observations include a long list of proxy, or by-products from climate-related processes.

These proxy measures are usually calibrated using real-time monitoring, or through isotope dating techniques. Bioindicators include tree ring growth patterns, sediment laminae with various species tracers, coral growth patterns and associated isotopes, and even fish remains (c.f., Soutar and Isaacs. 1974; Soutar and Crill 1977; Baumgartner et al. 1989). Through spectral analysis of fish scale-deposition series Baumgartner et al. (1992) found that sardine and anchovies abundances tend to vary over a period of approximately 60-70 years throughout the entire recent record of nearly 2000 years. In fact, most of geologic history's recent transitions are named after characteristic faunal shifts.

1.4 So, What's New?

Also quite useful are the trace elements that are specifically derived from solar sources such as berylium 10, or ratios of cosmogenic and terrestrial isotopes, specifically carbon 14/12 and oxygen 18/16 isotopes. Glen Shen from the University of Washington, and other paleoclimatologists have discovered a 400-year history of El Niño events by measuring precise amounts of isotopes in the corals of the equatorial Pacific (Shen et al. 1987). By measuring traces of oxygen-18 isotope in corals from Academy Bay, in the Galapagos Islands, researchers were also able to know when El Niño events began and ended. Many isotopes vary with rainfall. For example, the oxygen-18 isotope from skeletal coral decreases by 0.22 percent for each one degree K rise in water temperature.

Trace elements like barium and cadmium are sensitive indicators of upwelling, or not, that can also be linked to ENSO phenomenon. Changes in manganese can be used to record the reversals of the normal equatorial trade wind flow, which signals changing climatic regimes. Differences in isotopic carbon can show changes in rainfall, or cloudiness. For example, a 323-year history of carbon-14 from a coral on the Great Barrier Reef has revealed significant decadal changes. The Urvina Bay coral sampled from the Galapagos Islands began growing in the year 1586 AD and was six meters long when sampled. The average interannual range of the isotope variation reflects a temperature range of about 2 degrees C. The warmer than average intervals were: 1650 to 1680, 1700 to 1800, 1860 to 1880; with cooler periods from 1600 to 1650, 1800 to 1825, and 1920 to 1950. These measures provide a wide range of useful climate information.

An important concept has emerged from studies of various temporally sequenced, laminated materials such as tree rings, ice cores from old glaciers, and lake sediments. We learned that climate changes on all time scales, from annual to millennial, and that the recent few centuries have been amongst the least dynamic, creating an illusion of expected "climate stability". Yet, every few years, the El Niño – Southern Oscillation "events" remind us that climate stability is a myth – or wishful thinking. Scientists have speculated that ENSO events have been similar over the recent hundred years as over the past thousand years. The ecological consequences are manifold, including everything from seasonal flooding and cloud cover that modifies terrestrial productivity, wind speed and direction, thus ocean upwellings, to turbidity-related light levels. The consequent ecological cascades of energy and materials are dramatically affected, on time scales ranging from seasons to millennia. In the midst of all this interaction stands Everyman, with his growing array of technologies, and ever more-hungry masses trying, to cope with all the variations.

1.5 Basic Patterns of Climate Change

Climate change and resultant changes in local contexts are the underlying bases for most of humanity's dilemmas with ecological interactions. Humans fear those many Earth System processes over which we have little or no control. Yet, we too often forget that these often have major beneficial side-effects, even compared to those engineering feats and mass manipulations with which we have already modified entire watersheds, river flows, estuaries and wetlands, and coastal oceans.

A good place to start learning about these benefits is with a look at the larger picture of what we know about the global temperature situation from paleoclimatic climate data, proxies for various climate states, and resulting measureable processes and analogs. These are quickly summarized in three graphics.

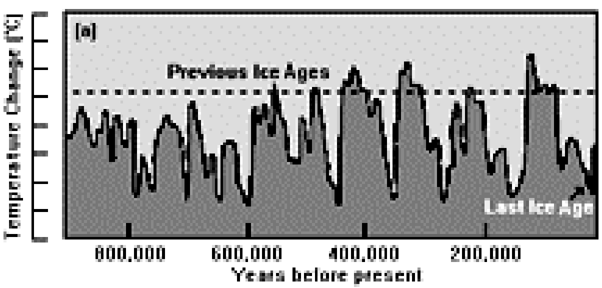

Figure 1a The first is a 900,000 year long picture of the changes in the Earth's surface temperatures, as interpreted by many paleo-scientists, from various proxy records in sedimentary rock strata, laminated ocean bottom sediments, specially selected high and low latitude ice cores, and, more recently, tree rings, and other time-sequenced laminae.

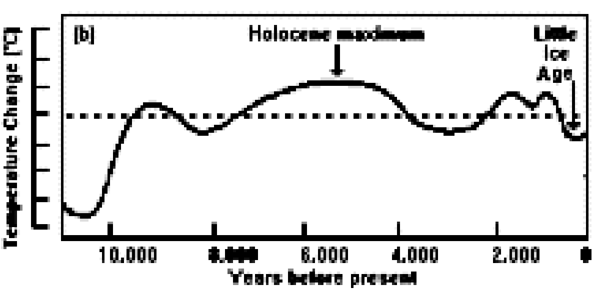

Figure 1b The second example is a shorter time series, starting to the right of the arrow in the lower right corner of the above Figure 1a, above. The recent 14,000 years, called the Holocene period, is a period of Glacial melting associated with the most recent emergence from a clearly defined Ice Age Event.

The shift of Holocene climate was relatively abrupt, and has cycled about an approximately 4C mean rise, since about 11,000 year before present. This was the mild climate period that supported the dawn of civilization.

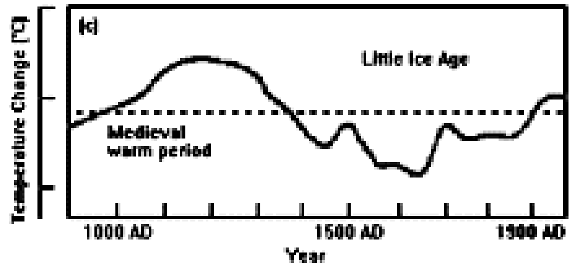

Figure 1c The third image is the record of the last 1,100 years, since beginning of the Medieval Warm Period, when most local societies were self-sustaining. The most recent perturbation from this warming trend is the period that has been called the Little Ice Age. Its effects lasted from ~1450 to ~1850 +/-100 years), depending upon where on Earth people were, and the weather they were accustomed to.

Note that the Earth's most important situation is that it is in a relatively warm state (warm enough to maintain liquid water, hence life as we know it) with occasional sharp excursions into cold states, not the other way around. Figure 1b is a relatively highly smoothed record of temperature variations. Higher resolution data sets from ice cores of the Greenland Ice Sheet Program (GISP) have been studied, to yield more insights, and suggest a more interesting tale about Viking history during the so-called Medieval Warm period, identified in Figure 1c (above).

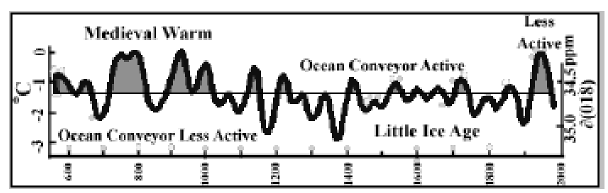

Figure 2 is a plot of paleoclimatic information in the form varying isotopic composition of the ice from cores of Greenland's glaciers. The per mil deviation of the concentration of the heavy isotope 18O in ice compared to standard Mean Ocean Water. Annual ice layers were laid down at a rate of about 30 cm per year throughout this GISP ice core that was 430 m long. Broecker's (1991) Ocean Conveyor periods are noted, too.

Dansgaard et al. (1975) studied the GISP climate records for hints about what caused the collapse of the Greenland colony, and other events in European history. Exploring the North Atlantic, Iceland was discovered by Norse Vikings and colonized in 871,. Over a century later Eric the Red led 25 Viking ships to colonize Greenland in 981AD. This colony was eventually frozen off the land during the Little Ice Age. The last Norse colonist was found dead outside his hut in 1540 by a Dutch seafarer. Thus we arrive at the stark reality of climate and society.

The study of this GISP ice core started a major revolution in thinking about where to find important climate records, as well as how to calibrate various climate proxies, and use them to study human impacts of climate change. Even the smoothed record from 554 AD till 1974 AD (= 1420 years) demonstrates 20 approximately 70 year cycles. Since 1000BP, the core demonstrates approximately 63 year periodicity. Again, spectral analysis shows strong 55-60 year cycles throughout the 1400 year record. These values correspond well with the periodicity of the Length Of Day (or 1/Earth's Rotation rate) cycles described by Klyashtorin (1998), suggesting some common causal process or processes set(s) the pendulum in motion. What these are remains to be discovered.

important general facts seem to be emerging from studies of Earth's history. Hoyt and Schatten (1997) provide a thorough review of our knowledge of solar processes, observations, and interpretations of these in climate contexts. Like my own, their intentions were – besides informing – to stimulate more observations to achieve better overall understanding. The sun is a mighty engine, emitting energy and particular isotopes, e.g., 14C, 16C, and 18O, that record solar activity, and that can be measured in laminated ice cores and sedimentary materials. These isotopes have short half-lives, limiting the time scale for which they are useful.

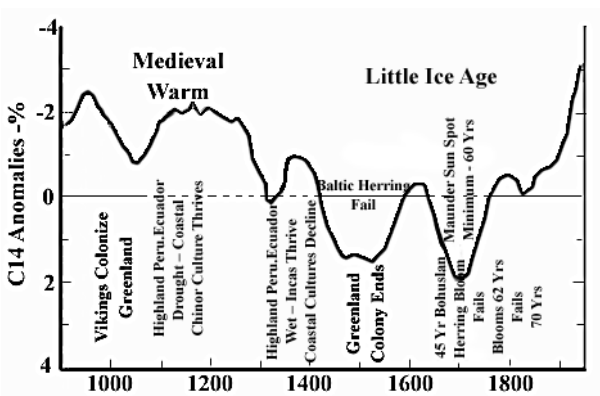

Figure 3 combines the proxy 14C solar activity record of the last 1,100 years. Note that the axis for the solar activity proxy - C14 production - has been reversed. The Maunder minimum refers to the period 1645 – 1715 when very few sunspots where observed on the sun. In this period the production of C14 was very high in agreement with a low solar activity. The periods of approximate rise and fall of colonies of people in both Greenland (Svenmark et al., 1987), and Northern Peru (Thompson and Thompson, 1991) since the Medieval Warm Period are noted using text.

The 14C isotope data plotted in Figure 3 shows that the sun's energy emissions are not at all constant. The variation in the 14C production is caused by changes in solar activity. When solar is high the production of 14C is low, due to the shielding effect of the solar wind against Cosmic Rays. The Medieval Warm was an "optimal" climate period, when most European societies were able to be self-sustaining. North Sea herring fisheries records appear following the 15th century collapse of the Baltic herring, and indicate the rise of the Hansa, a regional collaboration between Scandanavian and northern German merchant classes. The Hanseatic League was the first northern European trade organization.

Entire regional ecosystems switch production with each change in dominant forcing regime to another, from the 18.6 year lunar tidal cycle to fifty or more year wind-driven production cycles. Explaining these dynamic patterns, by tracing the forcing backward, from the regional ocean ecosystem dynamics, into the oceans, the atmosphere, and beyond, has been the quest of many fisheries ecologists over the last century (reviewed in Sharp 2000 – in press). Many have searched for the general mechanisms that induce the transitions from one faunal assemblage, to another.

Thus, we are beginning to understand more about the dominant wind-related forcing of the upper ocean, and the resulting responses of ocean ecosystems. The most notorious of these species oscillations are those that involve anchovies and sardines (i.e., California, Peru-Chile, Benguela-Namibia, Spain-Morocco, and Japan-Sea of Japan). The first major modern sardine recolonization after a collapse was described by Kondo (1978) as he documented the revival of the Sea of Japan sardine population from two refuge colonies along the western shores of Japan. Valdivia (1978) provided the first insights into the links between ENSO and the Peruvian anchoveta catch. Sharp and Csirke (1983) revisited similar pattern changes in distribution, species composition and abundance all over the globe. Kawasaki (1983, 1991, and this volume) provides seminal interpretations of the synchrony of Pacific sardines off California, Japan, and western South America. This stimulated many authors to document their regions' patterns of fish population rises and declines, along with descriptions of these fishes (as reviewed by Sharp 1988, Sharp and McLain 1993a, b, Bakun 1996).

More recently, with the formation of the Pacific PICES organization, the North Pacific's high latitude fisheries have been studied more thoroughly, with more attention paid to Climate Dynamics, winds, tides and other non fishery-related ocean and ecosystem forcing (c.f., Lluch-Belda, 1989, 1992, Francis and Hare, 1994, Beamish 1995, Bakun, 1996, Mantua et al., 1997). Schwartzlose et al. (1999) documented and compared the recent century's rises and falls for all the extant sardine/anchovy supporting ecosystems, as well as the changes in life-history properties, or survival strategies. There is a singular message about diverse modes for "coping" with climate-driven variabilities.

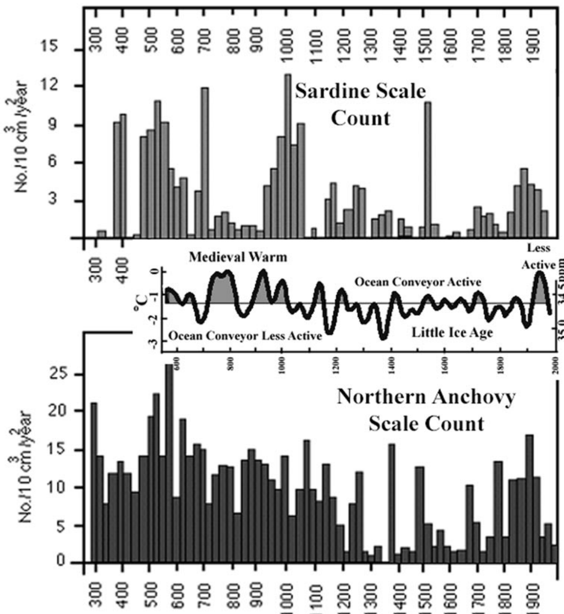

Figure 4 is a plot of the Santa Barbara Basin sardine and anchovy scale counts (as described by Baumgartner et al. (19920 with the 14C record from Figure 3 embedded on the same time scale. Note the coherence of the sardine scale record with warming periods, inferred from the 14C proxy for solar intensity. Needless to say, whatever happened to the Warm Earth after the 11th century has had profound consequences on the production of the California coastal ocean. (c.f., Kawasaki, this volume

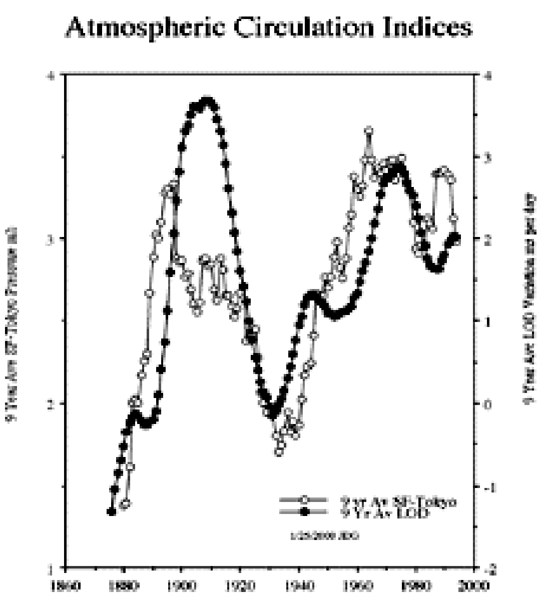

Figure 5 shows the relationship of Length of Day and sea level pressure of Tokyo, over the recent 125 years. Goodridge (1999) analyzed possible connections for the North Pacific's east-west links, as he showed that the extreme weather events across California's large latitudinal extent were directly affected by offshore ocean temperatures. The pattern in the Pacific could be attributed to similar forcing to that responsible for the decadal scale oscillations of sea level pressure measured at San Francisco and Tokyo.

More such studies are needed, to help understand the climate and ocean production patterns, but those studies that we have in hand tell an important story about the changes that induced European expansion, and the shuffle of political influences since the cooler era began.

Another interesting link is that of Length of Day and Upwelling off California's coast. Local winds are the dominant forcing of ocean upwelling. We know that upwelling is forced by surface wind speeds, and their directions, but what controls these?

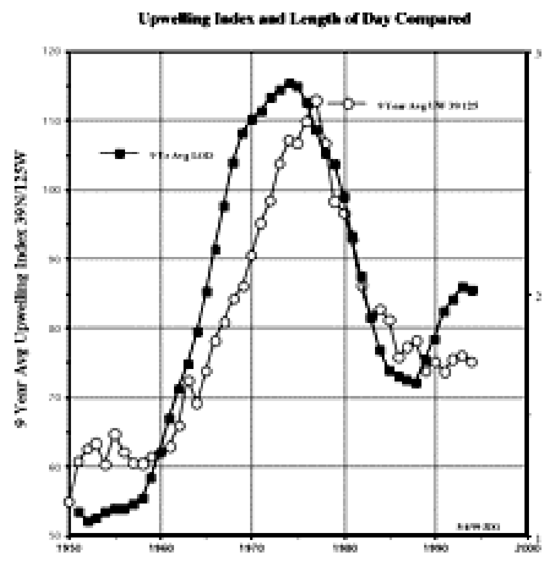

Figure 6 is a plot of Length of Day and the Upwelling Index off San Francisco California. Both were created using nine year running averages, and their ranges scaled to match.

Note also that the LOD and Upwelling, as well as the sea level pressure differences are in synchrony with the Warm/Cold see-saw of ocean surface temperatures that affects the marine faunas of the North Pacific Ocean.

This information, and the final graphic - Figure 7 - tell us is that there is direct wind-driven forcing that occurs in synchrony with LOD, in accord with Klyashtorins recent (in press) ACI/E-W atmospheric indices. We are also looking at the possibility that LOD and the Atmospheric Climate Index (ACI) described by the Russian atmospheric scientist, Girs, in 1971.

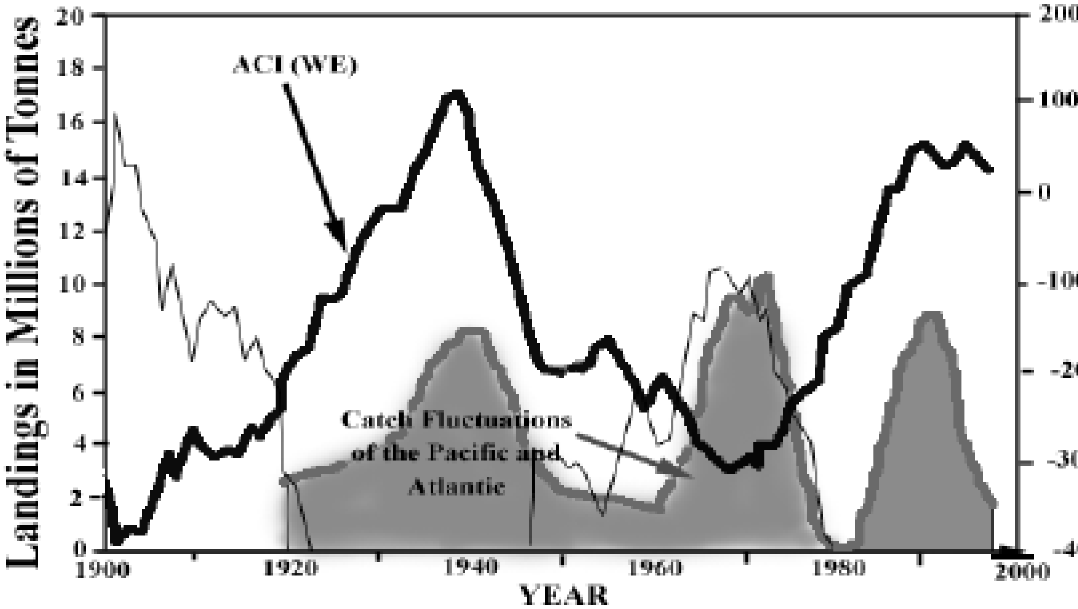

Figure 7 shows the Atmospheric Climate Index of Girs (1971) updated by Klyashtorin and Nikolaev (in review) compared with the catches of the major fisheries of the North Atlantic and Pacific Oceans (c.f., Figure 8, below).

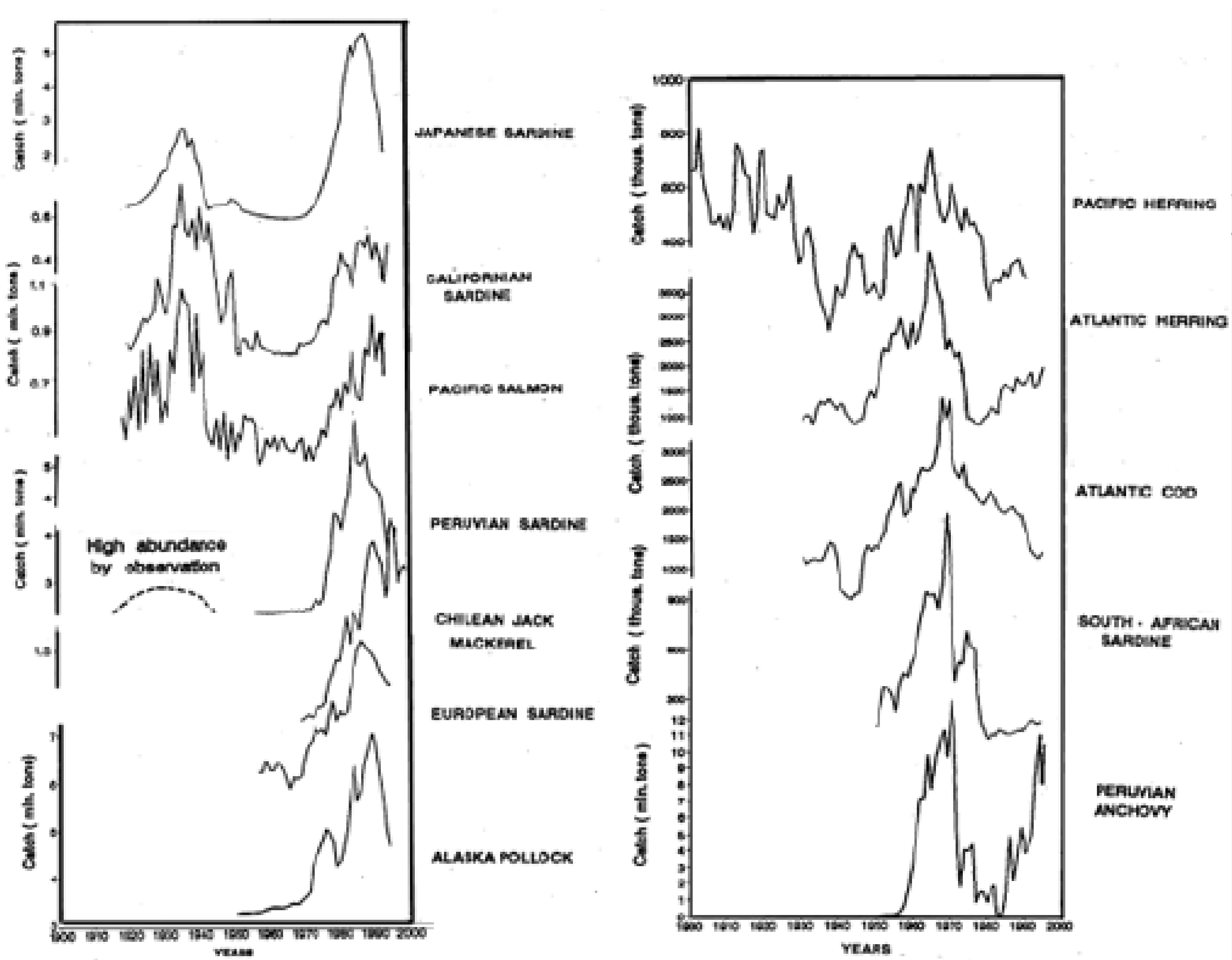

Figure 8 Catch records of the major Warm and Cold epoch fisheries of the Atlantic and pacific oceans (Klyashtorin and Nikolaev, submitted for Publication in the Encyclopedia of Human Ecology, K. Watt, editor.)

These last several graphics tell us is that there is direct wind-driven forcing that occurs in synchrony with changing LOD. We are well aware that upwelling, and downwelling, occur in direct response to the changes in dominant surface wind speed and direction, in accord with Klyashtorin and Nikolaev's revised (c.f., Girs 1971) ACI/E-W atmospheric climate indices. This also suggests that it would be possible to track, and even forecast expected changes in fisheries species composition and production, using the two indices, LOD and ACI. This is a major breakthrough, and long awaited contribution to fisheries science, and resources management - that is "IF" we can break into the inner sanctum of the present priesthood of Stock Assessment.

Conclusions:

The bottom line from all of these observations is that there should be no big surprises involved whenever climate changes follow the historical insolation and related forcing patterns of environmental change - volcanism and various anthropogenic perturbations aside. We have good records, direct and indirect, for many changes that have affected regional ecosystems, and society as it has advanced. We know that there is much more to resource management than only fisheries catch and effort regulation. If accounted for, the losses of critical habitats such as mangroves, wetlands and dammed rivers, then the need for all declines in production from regional fisheries to be blamed on fishing activities dwindles. That is not to say that over-fishing is not a primary cause of fish population declines. Yet, the vilification of fishermen, in lieu of the appropriate attribution of causality is long overdue. A more realistic system of proactive rather than reactive management actions taken that would more directly deal with all other causal processes, and restrain, or remediate their consequences, as well. Critical goals are to cope with ineveitable changes - and not lose options.

Management of the world's fisheries resources is inherently difficult because the focus, to date, has been on controlling fishing effort - or stock enhancement via hatcheries. Neither has kept pace with the declines due to other causes, nor are they likely to in the near future. Until controls are placed on the flow-through at all market places and processing facilities, opportunitic fishermen will continue to service these profit centers, despite efforts to curb certain sectors, while ignoring others. This dilemma has been the source of much of the failure of fisheries management of high seas and distant water fisheries. Beyond these issues lie the limitations of resource assessment models, and the continued use of parameterizations based on poorly representative data sets and underlying assumptions, particularly those involving stabilities and average behaviors. It is also time that the science matured, and that scientists got back aboard fishing vessels, in order to learn what really goes on - at sea and at the docks.

Acknowledgements:

Many of the ideas that have been presented herein are a result of a series of collaborations, across the globe, as various ideas emerge, often after lying fallow on library shelves for decades. Leonid Klyashtorin has unveiled Russian geophysics literature, and merged his own empirical observations with those of many others. I celebrate the vast role that Professor Tsuyoshi Kawasaki and his colleagues have played in creating a dialogue about the synchrony - and differences - of blooms and collapses of regional coastal pelagic fishes. They have provided inspiration for learners of all nations involved to discover various differences that make each marine ecosystem respond somewhat uniquely to the continuous climate changes that affect them. The post-retirement enthusiasm and creativity of climatologists such as Dr. James Goodridge and others, provides a unique longer-horizon empirical basis for others such as myself to continue our quests for more inclusive answers. I can only hope that some day that others will be able to look back and appreciate what these works have provided. We are close to obtaining our goal, of true fisheries forecasts, on at least the decadal scales that matter most.

- GDS

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