THE COMMON GOOD: SALMON SCIENCE, THE CONSERVATION CRISIS, AND THE SHAPING OF ALASKAN POLITICAL CULTURE

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A

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By

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Abstract

Without a doubt, the salmon fishery in Alaska has been at the forefront of natural resource debates and has served as an example of ineffective, misunderstood, and controversial policies, as well as many missed opportunities to better understand the resource. Management of Alaska's longest lasting natural resource industry is contingent upon an evolving scientific understanding of salmon. At the same time, policy has been shaped by political, economic, cultural, and social phenomena. Considering these parts of the historical narrative of the Alaska salmon industry demonstrates the fundamental challenges of fisheries management: reconciling biological limitation, economic demands, and cultural practices. This study contextualizes modern salmon management in Alaska by analyzing early- to mid-twentieth century conservation efforts within these constraints. To begin, some fundamental questions arise in the analysis of salmon management: why did managers make the decisions they did? What were limits faced by managers and the science they relied on? Also, how did political, economic, and cultural forces impact these decisions? By addressing these questions in a historical analysis, a fuller understanding of modern salmon management in Alaska is found. Answering these questions shapes this thesis and supports the argument that economic, political, and cultural factors often influenced changing policies as much as technological advances and ecological understanding did. In particular, Alaska's unique transition to statehood in the mid-twentieth century – a period when huge advances in ecology were underway – highlights how science often took a backseat to other concerns.

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Introduction

> Wherever occurring in their natural state, fish, wildlife, and waters are reserved to the people for common use.
> -*Alaska Constitution* Article VIII, §3

> Fish, forests, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses.
> -*Alaska Constitution* Article VIII, §4

> No exclusive right or special privilege of fishery shall be created or authorized in the natural waters of the State. This section does not restrict the power of the State to limit entry into any fishery for purposes of resource conservation, to prevent economic distress among fishermen and those dependent upon them for a livelihood and to promote the efficient development of aquaculture in the State.
> -*Alaska Constitution* Article VIII, §15

The decline of Chinook salmon in recent years is a modern example of a long-term problem: multiple drainages are seeing disastrously low returns of king salmon. A 2014 press release issued by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service reported the Yukon River, Kuskokwim River, and Cook Inlet (including the Kenai River, the most popular recreational king salmon fishery in Alaska) had experienced "commercial fishery failure[s]."[1] Alaska Governor Sean Parnell quickly asked the U.S. Department of Commerce for a disaster declaration. His request was answered; the three regions experiencing commercial fishery failures were declared disasters and the state of Alaska was slated to receive nearly $21 million in disaster relief funds during the 2014 fiscal year. The conditions for use of the relief funds were ambiguous, but one objective was, according to NOAA Fisheries Alaska Regional Administrator Jim Balsiger, to "restore the fishery or prevent a similar failure in the future."[2] This vague directive

[1] Julie Speegle, "Alaska Salmon Fisheries to Receive nearly $21M in Fishery Disaster Relief Funds," NOAA Fisheries, National Marine Fisheries Service, Alaska Regional Office (February 26, 2014). alaskafisheries.noaa.gov
[2] *Ibid.*

underscores the problem that has plagued the industry in its relations with governments for over a century – how to maintain a sustainable salmon harvest.

Without a doubt, the salmon fishery in Alaska has been at the forefront of natural resource debates, providing examples of ineffective, misunderstood, and controversial policies, as well as many missed opportunities to better understand the resource. Evolving scientific understanding of salmon has played a role in the management of Alaska's most enduring natural resource industry, but is often overshadowed by political, economic, cultural and social factors. Therefore, a careful, historical examination of conflict and change in the management of Alaska salmon reveals important insights into a fundamental issue of natural resource management: how to reconcile biological limitations with competing economic demands and cultural practices. In 1980, Malcolm Haddon, who is currently the Senior Fisheries Modeller at Australia's Commonwealth Scientific and Industrial Research Organisation, stated that "if fisheries scientists have failed, it is in not educating those who make decisions in fisheries management to work within the limits of what is biologically possible instead of within the bounds set by what is economically required."[3]

In the early to mid twentieth century, scientists focused on fundamental biological limitations of salmon populations, and trusted that the public's economic appetite would not overwhelm the seemingly endless natural resource. Like today, managers and scientists were tasked with defining, quantifying, and ensuring the future of this vital natural resource based on incomplete knowledge and constraints imposed by economic and cultural demands. This study contextualizes modern salmon management in Alaska by analyzing early- to mid-twentieth century conservation efforts within these constraints. To begin, some fundamental questions arise in the analysis of salmon

[3] As quoted in Malcolm Haddon, *Modeling and Quantitative Methods in Fisheries,* 2nd ed. (New York: CRC Press, 2011), 7.

management: why did managers make the decisions they did? What were limits faced by managers and the science they relied on? Too, how did political, economic, and cultural forces impact these decisions? By addressing these questions in a historical analysis, a fuller understanding of modern salmon management in Alaska is found. Answering these questions shapes this thesis and supports the argument that economic, political, and cultural factors often influenced changing policies as much as technological advances and ecological understanding did. In particular, Alaska's unique transition to statehood in the mid-twentieth century – a period when huge advances in ecology were underway – highlights how science often took a backseat to other concerns.

Data and Methods

This study was driven by primary source analysis. While the secondary sources provided in the literature review offered an analytical framework and historical background, little primary source research had been done on the Alaskan salmon industry. I focused on archival material such as newspapers, federal fisheries reports, and legislation. Many of the sources were available digitally, allowing me to expand my research beyond what was immediately available at the University of Alaska Fairbanks' Rasmuson Library. The National Oceanic and Atmospheric Administration had digitized and made available annual federal fisheries reports from the late 19^{th} century to the mid twentieth century. These reports provided a majority of policy and management related information and helped with the analysis of legislation.

The environmental policy section of this thesis required analysis of not only legislation, but also economic and fisheries data provided digitally from various federal and state agencies. The Alaska Department of Fish & Game has archived commercial harvest data for salmon that I was able to access.

This study is an interdisciplinary analysis of the Alaska commercial salmon fishery. I apply analytical tools established in the fields of environmental history and political economy. My discussion of the relationship between humans and their environment – specifically, the relationship between fishery managers, scientists, commercial fishermen, and policymakers to salmon and their environment – draws heavily from analytical methods established by environmental historians, which will be discussed in greater detail in the literature review. In chapters four and five I utilize methods established in the field of political economy. For example, I apply the common pool resource theory established by prominent political scientists to analyze the salmon industry and suggest alternatives. In addition to interpretation of historical primary sources and environmental policy, I rely heavily on fisheries science. I worked closely with experts in the field to provide a detailed biological understanding of salmon.[4]

My academic research is complimented by my years of personal experience with the Alaska salmon fishery as a technician with the Alaska Department of Fish and game. This study was inspired by field research involving salmon in Alaska and a passion for fisheries conservation. Having been around fishery science I realized that management is far more complicated than compiling field data. The human element is as complex and dynamic as the resource itself, and an understanding of one requires an understanding of the other. This study aims to demonstrate the human influences on the Alaska salmon industry.

Outline

This thesis is comprised of five chapters. Each chapter tracks the development of ecological understanding and technological ability as applied to management of Alaska's salmon fishery.

[4] I worked with Dr. Megan McPhee, assistant professor at the University of Alaska Fairbanks' School of Fisheries and Ocean Sciences, who specializes in salmon management and conservation to insure accuracy in my discussion on Pacific salmon life histories. I have also discussed fisheries management strategies, ideas for new strategies, and challenges to management with a number of biologists at the Alaska Department of Fish and Game.

Simultaneously, it explores economic and cultural shifts that required alternative approaches to fishery management. The chapter "Salmon Life Histories" demonstrates the biological complexity of salmon as a genus. By exploring various life histories of the five species of Pacific salmon a better understanding of the biological and ecological hurdles in management developed. Interestingly, the complexity and uncertainty of salmon have made ideologically and culturally determined management strategies easier to justify and thus offers a unique opportunity to analyze the effect of cultural values on a natural resource.

The third chapter, "Federal Management During the Territorial Period," explores various aspects of accepted salmon management practices in the early twentieth century. This era was primarily characterized by the introduction of hatcheries to Alaska, the implementation of eradication programs to cull Dolly Varden and other salmon predators in hopes of increasing overall salmon abundance, and the development of an escapement based management system that utilized periodic stream closures. While each of these three main approaches illustrate the development of biological and ecological understanding during the early twentieth century, they also shed light on the cultural, economic, and political concerns of the time. Simple solutions demonstrated limited ecological understanding, but also the struggle to reconcile economic opportunity – represented in this section by the introduction of hatcheries and predator fish eradication programs – with scientific understanding – represented by escapement-based management. In the early twentieth century one suffered to accommodate the other.

These changes in understanding were encouraged by increased technological capability. E.S. Russell's biomass equation from 1931 marked the start of a movement to theoretically quantify salmon populations. However, these attempts to model salmon populations represent the limitations of technology during the time. Complex population models represented more what could be done using differential calculus than actual salmon populations. Despite the limitations, these modeling techniques laid the foundation for fishery science today, and demonstrated the role of technology in not only understanding fish, but in understanding how fish were managed.

The fourth chapter, "Transition to Statehood and State Management," focuses on the establishment of Alaskan management as we know it today. I will discuss whether the State Constitution provided an effective legal and political framework to address reconciliation between biological possibility and economic and political demand. Like the methods it was used to justify--hatcheries and predator fish eradication--the document revealed how and why political and economic concerns could as or more influential than biological and ecological understanding. Similarly, open access, common use, and sustained yield directly demonstrated the relationship between politics and conservation, especially the underlying tensions between Alaskans and federal managers. While there is little doubt that before statehood, Alaskans were placed on the periphery and that the powerful cannery syndicates located outside of the Territory overshadowed regional economic interests, the story of how these issues were integrated into state policy and natural resource management is far more compelling. In many ways, statehood advocates laid the foundation for salmon management as we know it today and it was the direct result of political strife, economic concerns, and the utilization of fishery science to promote an *Alaskan* fishery. By using industrial salmon traps as a case study, the political, economic, and social tensions of the mid-twentieth century can be demonstrated.

The fifth chapter, "Possible Solutions to Management," draws attention to modern salmon management in Alaska. Using the history of the resource in Alaska, we better understand the complexity of working within the confines of biology and economics. This chapter explores a quota-based marine salmon fishery as an alternative to the risk-prone open access harvest strategy that is currently accepted. While we can identify a quota-based management strategy as the most representative of biological and ecological understanding, the political, cultural, and economic concerns pose a great hurdle.

Along with a quota system, this chapter also looks at the possibility of reintroducing fish traps to the Alaska salmon fishery. Though fish traps had been used during federal management in territorial days, they represented outside interests and the exclusion of local fishermen from participating in the resource. While the argument could certainly be made that fish traps were biologically destructive in the context of an open access fishery, they would certainly prove valuable in a quota-based system.

Each example shows various aspects of fishery management while simultaneously demonstrating how strategies changed over time. Hatcheries and predator fish eradication offers an analysis of economic imperatives and escapement-based management, demonstrating the struggle to incorporate ecological necessity into management decisions. Additionally, Fish traps during the transition to Alaska statehood illustrate the power of political and cultural imperatives in fishery management decision-making. When each of those factors are analyzed in the context of developing of technology, biological and ecological understanding, and fishery modeling techniques the complexity of fishery management decisions are emphasized.

Literature Review

Although older histories of the Alaskan salmon industry recognize its economic importance, they do not engage the wider discussion that includes the role of biological understanding and cultural issues that also influence the narrative. These classical arguments are exemplified by works like *The State of Alaska* by Ernest Gruening, *Politics and Conservation: The Decline of the Alaska Salmon* by Richard A. Cooley, “Regulation of Commercial Salmon Fisheries: A Case of Confused

Objectives" by Ralph W. Johnson, and *The Future of Alaska: Economic Consequences of Statehood* by George W. Rogers.[5] These works were written in the same era that they were analyzing. In this sense, these sources embody a mindset that demonstrated attitudes towards the resource and can also be used as primary sources in the narrative of the developing Alaskan cultural and political identity. Overall, however, they presented narrative histories that argued federal neglect of Alaska and the advantages of statehood; an approach that reflected cultural perceptions more than objective analysis.

More pertinent to this thesis are environmental histories from scholars such as Joseph Taylor, David Arnold, Lissa Wadewitz, James A. Lichatowich, and Peter Alagona that engage similar questions. Each argues that culture, politics, and economic concerns influence fishery legislation and management as much as biological and ecological understanding, but few address Alaska specifically. For example, Joseph Taylor, one of the preeminent scholars on salmon history, focuses largely on what makes salmon management so complex. In his article "Well Thinking Men and Women," Taylor addressed the 1924 White Act and the meaning of conservation in Alaska.[6] It was Taylor who noted that early conservationists roughly fell into two camps: efficiency and equity. Herbert Hoover represented efficiency by trusting that the free market was more efficient than government, while Dan Sutherland represented equity in his belief that government should play a stronger role in regulating natural resource industries. Each subgroup had the same goal, but disagreed on how to reach it. Taylor emphasized how looking at the underlying political and cultural motivations ex-

5 Ernest Gruening, *The State of Alaska: The Definitive History of America's Northernmost Frontier* (New York: Random House, 1968), Richard Cooley, *Politics and Conservation: The Decline of the Alaska Salmon* (New York: Harper & Row, 1963), Ralph W. Johnson, "Regulation of commercial salmon fishermen: a case of confused objectives," *Pacific Northwest Quarterly* 55, no. 4 (October 1964), George Rogers, *Alaska in Transition: the Southeast Region* (Baltimore: Johns Hopkins Press, 1960).

6 Joseph Taylor III, "'Well-Thinking Men and Women': The Battle for the White Act and the Meaning of Conservation in the 1920s," *Pacific Historical Review,* Vol. 71, No. 3 (August 2002), pp. 357-387.

pose the paradoxical nature of resource management and conservationist attitudes towards resource development: government is essential in establishing effective conservation policy, while capitalism encourages free market solutions and the limiting of government intervention.

Additionally, in his book *Making Salmon*, Taylor addressed the salmon management crisis head-on. Though the book focused on the Pacific Northwest salmon crisis, his study demonstrated the political complexity of salmon management and the inherent instability of an open access fishery. He argued that when stakeholders have perceived equal rights to the fishery, they defined their relationship to the resource in ways that made them feel they deserved preferential treatment. Thus conflict was all but inevitable. As Taylor pointed out, "the essence of the salmon crisis is the struggle to define and solve a complicated environmental and social problem, but resolution has been elusive because participants have little in common."[7] The major theme throughout the book that was addressed both in the introduction and conclusion was the importance of taking responsibility for past actions in order to ensure successful salmon management in the future. "We need to stop making salmon and to stop blaming other people, " Taylor argued, because "both the problems and the solutions are, and always have been, our collective responsibility."[8] He made a point that hatcheries and superficial quick fixes would not serve as long-term solutions, and that the only answer was to develop a unified conservation front.

While this history revolved around the salmon industry and the role of science in social and cultural relationships, it dealt primarily with human relationships and the near impossibility of managing a resource to any one interest group's standard. Utilization was varied, and each group blamed another for the collapse of the salmon industry. This oversimplification both intensified

7 *Ibid,* 4.
8 *Ibid,* 257.

tensions between stakeholders while simultaneously distracting people from reaching any sort of rational conservation strategy; if one interest group or another could be blamed for the collapse of the industry the burden of comprehensive, management strategies were unnecessary. One simplistic solution to the crisis that Taylor refers to in *Making Salmon* is hatcheries, as the title suggests. Like blaming one group or another, simple solutions to a complex problem were impediments to further understanding of the resource.

The necessity of salmon for ecological health and the emphasis on the human role as members of that ecosystem are a common theme in modern salmon histories. Each study emphasizes the complexity of the resource, places salmon at the center of human analysis, and champions complex solutions to complex problems. James Lichatowich, focusing on the Pacific Northwest, discusses the ecological consequences of the salmon industry as well as the impact of other natural resource industries on salmon. Instead of viewing the salmon industry as an entity independent of others, Lichatowich described the effect of logging, agriculture, and mining on salmon populations. Solutions in salmon conservation extend beyond salmon themselves. He argued that our inherent dependency on, and belief in, technology to fix all of our environmental problems is flawed, and that salmon conservation must return to fundamentals. Producing hatchery-raised salmon is a quick fix that leads to an almost inevitable conclusion: the degradation of wild salmon stocks and resulting ecological damage. Instead, humans need to redefine their relationship to the natural world and establish a new land ethic. The fundamental obstacle to developing a new ethic is technology, but also a fishery that is open to everyone. An open access fishery, however, Lichatowich argued, makes management exponentially more difficult.[9]

9 James A. Lichatowich, *Salmon Without Rivers: A History Of The Pacific Salmon Crisis* (Washington D.C.: Island Press, 1999).

David Montgomery argued similarly in *King of Fish: The Thousand-Year Run of Salmon* where he analyzes the progression of salmon management from its roots in 17th century England to the modern Pacific Northwest. His study emphasizes the need to reevaluate the human relationship to the natural world. His solution to the fisheries crisis is to understand salmon as a member of the same ecosystem as humans. Our actions have much more far-reaching effects than previously believed. These kinds of conflicts tie the new histories together based on emphasizing the inherent complexity of and open access industry and the need for a multi-pronged approach to salmon conservation. He argued that by relying on technology to fix environmental problems like the collapse of salmon runs, we are offering palliatives rather than long-term solutions.[10]

While modern histories often divorce themselves from past works, certain revisionist historians like Stephen Haycox have readdressed many of the questions raised by classical Alaska historians. Haycox produced a study that explored the neglect thesis, which is the notion that the territory of Alaska was economically, politically, and culturally neglected by the federal government. While Haycox wrote that although he does not agree with the neglect thesis, there are remnants that remain useful. Primarily, Haycox argued that Alaska was an American colony in that it was heavily reliant on outside interests, its natural resources (primarily salmon) were managed by the federal government, and the territory was dependent on a single resource at any given time. In this way he aligned with Alaska territorial governor and historian Ernest Gruening tracked Alaska's economic history in relation to the prominent resource extraction industries, but offered a post-colonial model to explain Alaska's past and present. Similarly, Taylor argued that the White Act reinforced the idea of Alaska as a colony, and that salmon were the center of the ongoing debate.[11]

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[10] David Montgomery, *King of Fish: The Thousand-Year Run of Salmon* (Cambridge: Westview Press, 2003).

[11] Stephen Haycox, *Alaska: An American Colony* (Seattle: University of Washington Press, 2006). Haycox

However, with the new age of Alaska historians like Haycox, renewed interest in the Alaska salmon industry has raised interest in the analysis of salmon management efforts as in Steve Colt's "Salmon Fish Traps in Alaska."[12] In his 1999 study, Steve Colt argued that fish traps were the embodiment of efficiency. Economically, the fish trap was the most practical, marking significant profits when most commercial fishermen operated at a net loss. Managerially, he argued that fish traps are much more efficient as well. Being stationary, officials can simply keep track of operating traps and do not have to chase salmon around the ocean. The main argument against fish traps was that they limited jobs in the fishing industry. While Colt conceded this point, he also pointed out that fish traps were labor intensive. Setting up, maintaining, and operating fish traps required a great deal of work. The jobs that were lost in the fishing industry would have been made up for in the non-fishing aspects of fish traps. Additionally, fish traps operated at a net profit, on average 12% higher than all other fishing methods. In Colt's revision of the efficiency argument, he stated that the best hope for Alaskan salmon and the Alaskan salmon industry was the fish trap; the opposite of the argument made only a few decades earlier.[13]

Arguably, David F. Arnold's work is the only comprehensive study on Alaska history that places salmon at the center. The U.S. focused on natural resource extraction like the Russians before them, he noted, but their sights were set on the millions of salmon they saw flooding inland rivers and streams. In almost an instant, canners moved their operations from the Pacific Northwest to what they saw as the virgin waters of the North Pacific. The native groups in Southeast Alaska were now faced with direct competition for the resource that was the foundation of their subsistence

demonstrated a substantial shift in Alaska historiography. However, other newer histories adhere to traditional narratives of Alaska's past. Klaus Naske's discussion on the salmon fishery in his 2011 study *Alaska: A History* fell in line with the orthodox narrative.

12 Steve Colt, "Salmon Fish Traps in Alaska," *Institute of Social and Economic Research* (Anchorage: University of Alaska Anchorage, 1999).

13 Colt.

economy. In addition to the competition, The United States saw salmon as an *open access resource*, the opposite of strict native ownership rights. Not only had the United States introduced competition for Southeast groups, they completely changed the rules. Instead of being equal members of a market as they had under Russian rule, Tlingits and other groups were exploited by the new American capitalist economy. This open access fishery created social tensions between Americans as well as Natives.[14]

In the early nineteenth century conservationists were divided as to how to best manage this booming salmon industry. Open access, based on the belief that each fisherman should have equal right to the resource, created tensions between different groups. Each fisherman saw the bounty of the ocean as his and saw other fishermen and fishing methods as a threat.

The majority of Arnold's study dealt with fish traps, federal management, and the economic significance of the salmon. He effectively demonstrated how political decisions tied to these other factors affected fishermen, both Native and white. The commercialization of the salmon fishery led Native groups to develop a "mixed-subsistence-market economy," where individuals would return to ancestral fishing spots and put up food for winter, while simultaneously fishing for the market. Whereas white fishermen came to embody the "frontier" ideology: imposing capitalist modes of production on natural systems.

Also valuable to understanding the history of the Alaska salmon industry is the imposition of human borders as a symbolic assertion of property rights. As pointed out in *The Nature of Borders,* Lissa K. Wadewitz explored political boundaries in the open ocean. She discussed that Native groups established boundaries in order to define access and property rights that would (whether

[14] David F. Arnold, *The Fishermen's Frontier: People and Salmon in Southeast Alaska*, (Seattle: University of Washington Press, 2008).

intentionally or unintentionally) prevent overexploitation. Later Euro-Americans also applied borders to the ocean between the U.S. and Canada. While these boundaries are artificial, Wadewitz argued, they have played a critical role in the history of the salmon fishery. Interestingly, both Native and Non-Native borders were drawn through the middle of salmon runs. Wadewitz's study focused on the "relationships between political concepts of space and the ways that people have managed the salmon fishery of the Salish Sea for centuries."[15]

Wadewitz follows a similar structure as earlier salmon histories, such as Taylor's and Arnold's, but applies a new analytical lens by examining the political, economic, and social implications of artificial borders. Like the boundaries that European farmers created for the development of agriculture in New England (see William Cronon's *Changes in the Land*) borders in the Salish Sea illustrate a particular culturally and economically determined approach to land use and resource development.[16]

Wadewitz argued that for Americans and Canadians, the border in the Salish Sea represented different conservation ideologies. The United States managed their side, and the Canadians managed their side. Salmon, on the other hand, did not recognize these artificial borders and crossed back and forth. Thus, the same salmon runs were being managed by two (sometimes contradictory) management strategies. For example, if the salmon fishery were closed on the United States side of the border but not the Canadian side, fishermen from the United States side would sneak over and catch the salmon there. These fishermen became known as bandits or pirates. By discussing differences between Native and Non-Native borders, as well as later American/Canadian political

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[15] Lissa K. Wadewitz, *The Nature of Borders: Salmon, Boundaries, and Bandits on the Salish Sea* (Seattle: University of Washington Press, 2012), 6.

[16] William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York: Hill and Wang, 1983).

borders, Wadewitz demonstrated the difficulties of salmon management. She stated that Native land-claim borders helped conserve the salmon fishery because of the limited access and the practice of sharing the catch. She went on to say, "White newcomers drew borders that revealed the cultural and economic marginalization of salmon and created a new social geography that would remain permeable and contested for decades."[17] Thus, borders had much different conservation and social implications than previous histories explored.

Interestingly, one particularly useful study had nothing to do with Alaska or salmon. Rather, Peter Alagona's book, *After the Grizzly: Endangered Species and the Politics of Place in California,* focused on how political perceptions shape the way humans perceive the natural world.[18] In turn, he demonstrated how the natural world can be used as a political tool. In 1973, the United States Congress passed what many consider the most controversial environmental law with nearly unanimous support: the Endangered Species Act (ESA). Peter Alagona argued that the ESA remains "one of the most formidable and comprehensive U.S. environmental statutes but also the most ambitious biodiversity conservation measure ever enacted by any country."[19] This ambitious conservation undertaking demonstrated a profound shift in conservation ideology and the role of the federal government in conservation efforts.

Alagona's study was motivated by the question: "how did the United States develop a political system capable of producing and sustaining debates in which endangered species serve as proxies for broader cultural conflicts with far-reaching social and economic consequences?"[20] This question was based on the idea that when conservationists describe critical habitat for endangered species,

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17 *Ibid,* 168.
18 Peter Alagona, *After the Grizzly: Endangered Species and the Politics of Place in California* (Berkeley: University of California Press, 2013).
19 *Ibid,* 4.
20 *Ibid,* 3.

the term *habitat* has many different meanings depending on the argument. Thus, Alagona argued that by analyzing endangered species we are better able to understand the complex conservation debate that encompasses political and scientific roles.

While Alagona's study focuses on federal expansion through the lens of wildlife conservation, he raised interesting points regarding the relationship between science and legislation. He noted that even today scientists point to the perceived chasm between science and legislation that hampers effective conservation practices. Alagona's study demonstrated that science and legislation grew together, which he described as "coproduction" or "hybrid concepts." Alagona argued, "today it is impossible to provide a complete definition of either *habitat* or *endangered species* without referring to both science and the law and the relations between them."[21] He then developed his overarching theme of the developing relationship between science and law to describe expansion of federal power.

Interpretations regarding human management of salmon have become more and more complicated as salmon have moved from the periphery – a resource to be exploited – to the center of human stories. Increases in scientific knowledge and developments within the field of history have allowed scholars to revisit classical arguments and redefine the role of salmon and humans within a larger ecosystem. These studies suggest that the dynamism of salmon populations, competing management philosophies and cultural perspectives are all necessary in order to better understand Alaska history.

Drawing from these models, this study engages many of these ideas in order to readdress the role of salmon in Alaska history. It moves beyond classical narratives and follows newer examples that insist it is impossible to separate the history of a resource from its political and cultural con-

[21] *Ibid*, 4.

texts. To borrow from Alagona, each requires the other to develop a more comprehensive, complex narrative.

All of these studies demonstrate the need to analyze humans and the environment as members of the same ecosystem. Taylor, Arnold, Wadewitz, Lichatowich, and Alagona all present content and analytical frameworks that place humans within the ecosystems, and reveal the influence of human politics, culture, and economics on biological and ecological communities. These studies emphasize the need to revisit histories of natural resource development in order to specifically address the disconnect between humans and their environment. The premise that humans exist apart from the natural world implies an omniscience that inhibits objective analysis of natural resource development. A history of the Alaska salmon industry that introduces humans as another predator in a complex ecosystem is representative of the interactions between humans and the natural world. Salmon management represents evolving understanding of the natural world, but also human responses to a dynamic ecosystem.

Chapter 1 Pacific Salmon Life Histories

1.1 Introduction

In 1931 E. S. Russell stated that managing a fishery "is admittedly a difficult task, for the conditions to be taken into account are extremely complex and extremely variable, and the data available are as a rule incomplete and not always easy to interpret in an unequivocal way."1 His declaration is equally true today, and we can use the genus *Oncorhynchus* to illustrate the challenges of management. The intricacies of Pacific salmon life histories are still debated, which in itself is a testament to the complexity of the genus. Interestingly, these complexities and uncertainties make cultural, political, and economic management schemes easier to justify. Fundamental gaps in biological and ecological understanding of salmon provide opportunities for other strategies that are difficult to dismiss on scientific grounds. Throughout the history of the industry, economic demands have competed with scientific understanding. In attempting to understand the human –salmon relationships, one must also understand what salmon biologists know about them as a biotic community. Thomas P. Quinn, a widely recognized expert in the field, provides a comprehensive background in, *The Behavior and Ecology of Pacific Salmon and Trout.*[2]

This chapter describes the life histories of Pacific salmon starting with the juvenile stages and smoltification – the transition period where juvenile salmon physiologically prepare for a life in the ocean – followed by a description of marine feeding behavior and open ocean migration, and finally the homeward migration of adult salmon to spawn. Each stage of a Pacific salmon life histories poses challenges to management and still perplexes fishery scientists.

1 E. S. Russell, "Some Theoretical Considerations on the 'Overfishing' Problem," *Journal du Conseil International pour l'Exploration de la Mer* 6 (1931), 3.

2 Thomas P. Quinn, *The Behavior and Ecology of Pacific Salmon and Trout*, (Seattle, University of Washington Press, 2005). Quinn, a professor of aquatic and fishery sciences at the University of Washington, is an expert on salmon behavior, ecology, and population dynamics.

1.2 Pacific Salmon Life Histories

Within the genus *Oncorhynchus* are the species commonly referred to as the five Pacific salmon species: pink salmon (*O. gorbuscha*), chum or dog salmon (*O. keta*), sockeye or red salmon (*O. nerka*), coho or silver salmon (*O. kisutch*), and Chinook or king salmon (*O. tshawytscha*).[3] While there are numerous inter- and intra-species variations, Quinn clarifies that all salmon species are characterized by *anadromy, homing* and *semelparity*, although not all individuals within a species fit within these analytical confines.[4]

Anadromy, along with homing and semelparity, make salmon especially vulnerable to various environmental changes. *Anadromy* is a life history in which a fish is born and returns to spawn in freshwater, but feeds in the ocean. While most salmon make the long journey downriver to feed in the ocean where they grow to maturity, there are examples of male (and very rare examples of female) coho, chinook, and sockeye salmon that spend their entire lives in fresh water. While they do not grow to the size of salmon that mature in the ocean, there is evidence of reproductive success. These precocious males are referred to as "jacks," or "residual males." Jacks use a 'sneaking' tactic:' smaller males stay out of sight of large males, and race in to fertilize the eggs as the female releases them before they are chased off by the larger males.[5]

Homing is the salmon trait of returning to their natal streams to spawn. This results in genetically isolated populations of salmon with regionally specific adaptations. One species of salmon may have genetically unique traits such as run timing, body size, and energy stores. While homing

3 This study will refer to these five as *Pacific salmon*, though there are three additional species that are members of the genus, and meet all the criteria of Pacific salmon, but are seldom referred to when discussing Pacific salmon: Masu or cherry salmon (*O. masou*), which is found in Japan; Steelhead or, when non-anadromous, Rainbow trout (*O. mykiss*); and Coastal or Sea Run cutthroat (*O. clarkii)*.

4 *Ibid,* 5-6.

5 Nathan J. Mantua, Steven R. Hare, Yuan Zhang, John M. Wallace, and Rovert C. Francis, "A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production," *Bulletin of the American Meteorological Society* (June 1, 1997), 1076.

is generally the rule, like all general assertions regarding salmon, there are exceptions. *Straying* is a phenomenon whereby individuals diverge to explore new habitat in other rivers or tributaries. This may be thought of as a biological insurance policy. If a spawning habitat is blocked, destroyed, or no longer suitable, the population would die off if individuals never diverged from the normal pattern. However, a certain number of offspring are genetically predisposed to straying to ensure future populations. While straying is beneficial to populations, from an evolutionary standpoint, it can be seen as an evolved strategy that increases the fitness of an individual, not the species as a whole.[6]

Semelparity refers to the ability to only spawn once, which is the case for most Pacific salmon. This trait explains the abundance of salmon populations, the dramatic fluctuations due to environmental or human factors, and, along with homing, contributes to relative genetic isolation. The exceptions to this rule are Steelhead and masu salmon, which can be *iteroparous* (able to spawn more than once). Variation among and within the various species of Pacific salmon creates the greatest challenges to salmon management.

In spawning only once, salmon devote all of their reproductive capacity to a single cohort. While producing a vast number of offspring, thus abundant adult populations, this life history also renders the species prone to dramatic fluctuation. Salmon runs are much more affected by environmental phenomena than other commercially viable fish species, and a single event such as a volcanic eruption, landslide, or flood can significantly impact a future run. Since many salmon spend a specific amount of time in freshwater before smolting, a single event (i.e. flooding) could destroy an entire cohort from a stream or river, although straying salmon could then potentially recolonize the stream. The genetic isolation of populations as a result of semelparity and homing

6 Thomas P. Quinn, 6.

is also apparent, because a female's genetic material is concentrated. While there are variations in isolation, especially due to straying and different aged salmon returning to spawn, pink salmon offer an extreme example: pink salmon are characterized by spawning every other year, which means there are even-numbered year populations, and odd-numbered year populations. Each population is completely genetically isolated from the other.[7]

The simple statement that salmon lay their eggs in freshwater overlooks the diversity of habitat salmon juveniles occupy within the freshwater ecosystem. For instance, Chinook salmon typically lay their eggs in the main channels of rivers, while coho and chum salmon usually occupy smaller tributaries. Sockeye salmon spawn in lakes and rivers, but more often in lakes. Pink salmon travel very short distances upriver to reach slower moving side channels.

1.3 Juvenile Stage and Smoltification

After the eggs hatch, they become alevins and will swim deeper into the gravel or other substrate and feed on their yolks until they become juveniles, a process that usually takes no more than a month and a half. Pink salmon juveniles typically travel to estuarine environments immediately, so the population is usually more vulnerable to ocean temperature regime shifts, like Pacific Decadal Oscillation, a temperature regime with positive and negative phases that influences sea surface temperature (SST). Chinook and coho juveniles usually spend two or three years in riverine ecosystems, while chum and sockeye spend less time, from immediate migration to estuarine environments to one or two years.[8]

After they have reached the appropriate age, a process called *smoltification* occurs wherein complex chemical and physiological changes take place that prompt a migration to salt water. As

7 *Ibid*, 6-7.
8 *Ibid*, 159-164.

mentioned above, not all juveniles make this journey, and evidence shows that the 'decision' to migrate to the ocean is largely dependent on environmental factors such as water temperature and food abundance. There are also strong genetic relationships with smolting resulting in some species or populations showing little variation, and others showing large variation. The smolts reach the ocean, where they will feed for one to seven years, depending on the species, until they reach maturity. Ocean feeding patterns, and the salmons' subsequent return to spawn, are the most complicated and least understood stages in their life history.[9]

1.4 Marine Feeding and Migration

In the marine environment salmon mingle with salmon from other drainages. A single shoal of feeding salmon in the Gulf of Alaska could be comprised of salmon from a variety of locations and species spanning from Bristol Bay, South central Alaska, Southeast Alaska, British Columbia, Washington, Oregon, and even to California. This reveals perplexing migration patterns that are not yet understood. Fishermen on the Columbia awaiting the return of Chinook or Sockeye salmon are thus economically and ecologically connected to the open-ocean fishermen in the Gulf of Alaska. This, however, is only part of the story.

Not all Pacific Northwest salmon feed in the Gulf of Alaska. Just as salmon integrate with other schools and species of salmon, they separate from their riverine schools to find feeding habitats. So, as a school in the Gulf of Alaska may represent multiple species of salmon from multiple locations, salmon from a single location might occupy multiple feeding locations in the North Pacific. For example, Chinook salmon originating in the Yukon River may separate to join marine feeding schools in the Gulf of Alaska, Bering Sea, or even as far as Russian waters off the coast of

9 *Ibid.*

Kamchatka. And not all salmon feed in the open ocean; some stay inshore for their entire marine life. Ultimately, these ocean-feeding migrations could span thousands of miles and are thought to be motivated primarily by food availability.[10] Once the salmon reach maturity, members of feeding shoals disperse and the homeward migration begins. Salmon then travel back to their natal streams to spawn.

1.5 Homeward Migration

Migration patterns of Pacific salmon are still largely unknown. Considering the vast expanse of feeding areas in the North Pacific, it is remarkable that salmon that have been in the ocean for years know exactly when to start their migration. Scientists are still unsure exactly how, but salmon arrive within a few weeks of other returning salmon. Because populations and species are mixed at sea, we can deduce that migration timing is not determined by the school as a whole. Secondly, populations from one river system could have marine feeding areas that are hundreds, if not thousands of miles removed from other members of the same population, so there cannot be a genetic clock synchronized with all the other members of the stock that initiates migration. Furthermore, salmon do not follow the same route homeward as they did during the outward migration, which proves that they do not navigate by landmark. These peculiarities illustrate the challenges to fully understanding salmon life histories. As Nathan Putnam et al. have noted, "in the final phase of their spawning migration, Pacific salmon use chemical cues to identify their home river, but how they navigate from the open ocean to the correct coastal area has remained enigmatic."[11] Thus even with the sophisticated technological capabilities fishery scientists enjoy today, critical gaps still make

10 *Ibid,* 243-246.
11 Nathan F. Putnam, Kenneth J. Lohmann, Emily M. Putnam, Thomas P. Quinn, A. Peter Klimley, David L. G. Noakes, "Evidence for geomagnetic imprinting as a homing mechanism in Pacific salmon," *Current Biology* 23, no. 4 (18 February 2013), 312.

salmon management a challenge.

Two main questions scientists ask are: how do salmon know where to go, and how do they know when to go there? While these questions still mystify and perplex, certain hypotheses have been presented that emphasize the salmon's level of evolutionary sophistication. In 1977, salmon biologist W. C. Leggett observed that salmon are "capable of obtaining directional information from the sun, polarized light, and geomagnetic fields…" but there is "...no definitive evidence" that migrating salmon use them as a means of orientation.[12] Two independent studies supported this hypothesis. First, in 2003, Daryl C. Parkyn et al., a research associate professor specializing in ecophysiology and fish behavior at the University of Florida's School of Forest Resources and Conservation, demonstrated in laboratory conditions that salmonids can detect light polarization, which can be used for navigation. Second, Nathan Putnam, a post-doctoral fellow at Oregon State University, and colleages demonstrated the use of geomagnetic imprinting on the outward migration of salmon, which the salmon then recalled to guide their homeward migration. More specifically, the study showed that salmon used a predicted route based on geomagnetic field drift until they were close enough to their natal streams to use chemical cues, such as smell.[13] These results provided the first empirical evidence of geomagnetic imprinting in any species, and Putnam et al. imply that forecasting salmon movements is possible using geomagnetic models.[14]

These findings also imply a much more sophisticated mode of navigation than was previously believed, one that has not been identified in any other species. While sea turtles and some shark species have shown signs of being able to navigate, geomagnetic imprinting appears to be

12 As quoted in *Ibid,* 46.

13 For more extensive reading on polarized light navigation and geomagnetic imprinting, please refer to Daryl C. Parkyn, James D. Austin & Craig W. Hawryshyn, "Acquisition of polarized-light orientation in salmonids under laboratory conditions," *Animal Behavior* 65 (2003), 893-904 and Nathan Putnam, et al.

14 Nathan Putnam, et al, 312.

unique to salmon. It is important to note that while feeding at sea salmon have no visual references. To be able to use polarized light and geomagnetic waypoint finding, fish must have a very precise sense of their longitudinal and latitudinal location. Once the salmon are close enough to their natal stream to identify chemical signatures, smell becomes the primary navigational tool.[15]

1.6 Adult Upriver Migration

Once the salmon reach their natal streams, a series of physiological and chemical changes occur that allow them to adapt, once again, to freshwater. They stop eating once they reach freshwater, they change color, and a majority of their energy is devoted to the development of sexual organs. While all salmon undergo these changes, the rate of change varies by species and distance from their upriver destination. Members of the same species may undergo their morphology at different rates depending on how far they have to travel upriver and the latitudinal location of the natal stream. Salmon in northern regions have different morphological rates than southern regions.

The timing of the migration also varies by species. Generally, Chinook, sockeye, and pink salmon start their migration in the spring, while coho salmon start their migration later in the summer. Chum salmon are the most variable of the five species; they start their migration between spring and late fall depending on the location of the population. Typically, stocks that have farther to travel will start their migration earlier so they can make it to the spawning grounds at the ideal time – early enough to find optimal spawning habitat, but not so early as to exhaust all of their stored energy before they are able to spawn; late enough so that the river is clear of ice and the risk of flooding is reduced, not so late as to risk leaving the juvenile salmon vulnerable to icing before they are physiologically able to survive such conditions.

15 Thomas P. Quinn, 64.

As salmon travel upriver, their bodies deteriorate, and their valuable fat stores are used in place of external food sources. Smaller salmon usually stay close to the bank where the current is weakest, and rest in pools before undertaking the next leg of their upriver journey, especially after a large amount of energy is exerted overcoming obstacles. By contrast, larger salmon (especially chinook) migrate upriver in the deepest sections of the river. Salmon biologists hypothesize that the reduced wave-drag on larger fish in the deeper water makes travel more energy efficient despite higher water flow rates.[16]

The upriver migration requires a considerable amount of energy expenditure. Salmon that must travel longer distances have a higher fat composition upon entering river systems to compensate for the travel distance and required elevation ascent to the spawning grounds. According to Quinn, "migration and reproduction deplete the salmon of almost all their fat and about half their protein."[17] Thus, salmon harvested closer to the ocean have a higher caloric value than those harvested considerable distances upriver.

1.7 Spawning

Once they reach the spawning grounds, females dig nests, or redds, in the gravel using a specially choreographed dance of tail flicks. Males stay close and wait for their opportunity to fertilize the eggs. *Redd* is the term for the entire area in which a single female lays her eggs and is comprised of multiple egg pockets. Once the eggs in one pocket are fertilized, the female then covers them by digging another egg pocket upstream where she will lay the next batch of eggs. The substrate dug up from the new pocket upstream washes downriver and covers the previous pocket. Once she has finished releasing her eggs, she dies, and the cycle repeats.

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16 *Ibid,* 67-84.

17 Richard White, *The Organic Machine* (New York: Hill and Wang, 1995), and Thomas Quinn, 77.

1.8 Predation and Other Environmental Factors

At each stage of the cycle salmon experience varying degrees of vulnerability to exploitation and predation. Quinn has found that the majority of mortality occurs during the juvenile stage in freshwater or estuarine environments. However, exploitation rates in the open ocean are still relatively unknown. While no hard scientific data exists, fishery researchers such as Quinn believe that open ocean mortality is relatively small. As the salmon start their migration back to freshwater and return to estuarine environments where they are more confined, predation by sea lions, whales, sharks, and humans increases dramatically. This is also true as salmon migrate upriver. Shallower water makes them more vulnerable to terrestrial and avian predators like bears and eagles.

One of the most significant contributions to modern understanding of Pacific salmon ecology and population dynamics was the 1997 study "A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production," by Nathan J. Mantua, et al. Mantua discovered an ocean current in the North Pacific that helped explain natural salmon population fluctuations. Pacific Decadal Oscillation, or PDO, is a value of variation in sea-surface temperature (SST) across the North Pacific that alters on a semi regular, interdecadal basis. Examining commercial harvest data, he noticed "a remarkable characteristic of Alaskan salmon abundance over the past half-century has been the large fluctuations at interdecadal timescales that resemble those of the PDO."[18] The results of this study influence how we interpret salmon population dynamics today, and are essential to understanding the natural fluctuations that many early scientists and politicians mistakenly believed resulted solely from human exploitation during the first part of the twentieth century (see figures 1 and 2).

18 Nathan J. Mantua, et al. 1076.

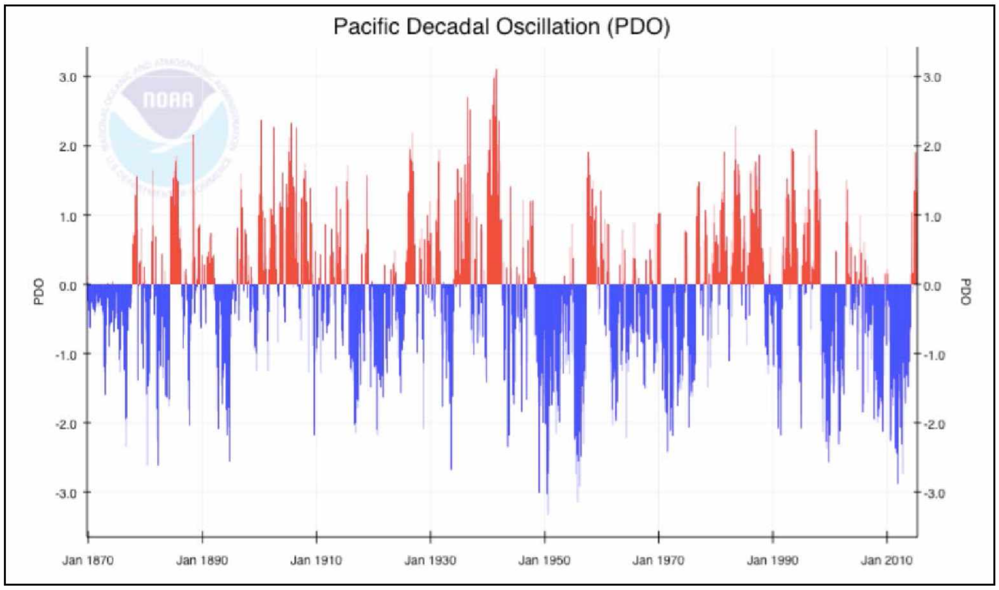

Figure 1: A graphic representation of Pacific Decadal Oscillation demonstrates the positive and negative SST phases of the North Pacific. When compared to a graph of commercial salmon harvest in Alaska, a correlation develops and the influence of the oscillating ocean current is undeniable. Source: "Pacific Decadal Oscillation," National Centers for Environmental Information, National Oceanic and Atmospheric Administration. https://www.ncdc.noaa.gov

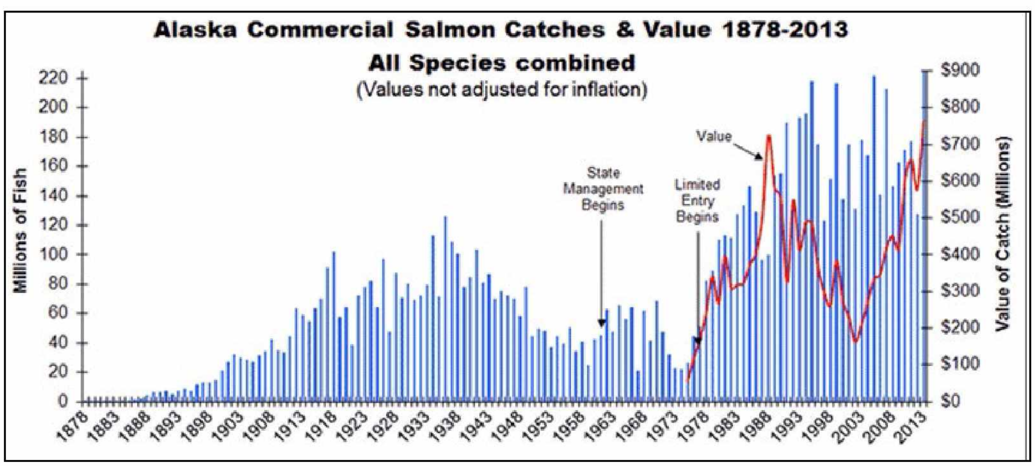

Figure 2: Commercial salmon harvests in Alaska. The fluctuation in populations based on catch data demonstrates the impact PDO has on salmon population numbers. By comparing the commercial harvest numbers to the PDO graph, the population response delay is apparent. Source: "Alaska Commercial Salmon Catches & Value 1878-2013, All Species combined," Alaska Department of Fish & Game, 2015. www.adfg.alaska.gov

Mantua, et al. demonstrated a “bottom up” population influence.[19] The ocean current shifts affect phytoplankton and zooplankton production, which work their way up the food web to large predators like salmon. Mantua postulated: “it is believed that sockeye and pink salmon abundances are most significantly impacted by marine climate variability early in the ocean phases of their life cycles.” He surmised: “If this is true, the key biophysical interactions are likely taking place in the near shore marine and estuarine environments where juvenile salmon are generally found.”[20] This suggests that juvenile salmon are most affected by the shifting temperature regimes, so population responses are usually delayed until the juvenile population returns to spawn years later. Moreover, the weather changes that accompany PDO impact stream flow – warmer temperatures translate to higher stream flow, cooler temperatures translate to lower stream flow – and streams with higher flow typically produce more juvenile salmon. Thus oscillating sea surface temperature (SST) (which affects weather), affects stream flow, and along with changes in estuarine environments, could have a significant impact on salmon populations.[21]

Mantua et al. identified these impacts in a number of factors. A negative PDO, or a southern current shift, could support larger populations of salmon in the Pacific Northwest because cooler conditions hinder reproduction rates of juvenile salmon prey species. Thus, food is more abundant in the Pacific Northwest and support the development of mid-trophic fish. At the same time there would be fewer predators as a result of colder temperatures. The effect of this negative shift on Alaskan stocks is not well understood, but it could be that the negative phase lowers SST so that phytoplankton and zooplankton move farther south, resulting in less food for the juvenile salmon in Alaskan waters. Additionally, the increased number of Pacific Northwest stocks could increase

19 Nathan J. Mantua, et al., 1076.
20 *Ibid*, 1077.
21 *Ibid.*

competition for resources among Alaskan stocks. The positive phase promotes Alaskan stocks because of food availability and limited predation from sharks and other warm-water species. Pacific Northwest stocks are disadvantaged during the positive phase by the reduced amount of food in estuarine environments and increased predation as a result of the warmer currents.

1.9 Conclusion

Mantua et al.'s findings help explain the fluctuation in population numbers observed by early scientists and managers. The fluctuations in salmon population densities are undoubtedly magnified by human exploitation, but are also the result of environmental conditions. As Mantua et al. noted, "management goals…may simply not be attainable when environmental conditions are unfavorable. Conversely, in a period of climatically favored high productivity, managers might be well advised to exercise caution in claiming credit for a situation that may be beyond their control."[22] This cautionary observation demonstrates why simple equations, and even more complex methods of determining quotas, fail to stabilize industrial salmon productivity. As explored in the next chapter, even the best science is limited by available statistics and ecological understanding, technological capabilities, and most significantly, economic demands.

22 *Ibid,* 1078.

Chapter 2 Federal Management, 1884-1959

2.1 Introduction

Thomas Huxley, a prominent nineteenth century scientist and conservationist declared that "…probably all the great sea fisheries are inexhaustible: that is to say that nothing we do seriously affects the numbers of fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case to be useless."[1] Not all conservationists shared Huxley's optimism of a truly inexhaustible resource, however his ideology illustrated a familiar response when confronted with a resource beyond comprehension. By concluding that it was inexhaustible, Huxley not only conveyed a sense of optimism about the future of the resource and the industry, but (perhaps unintentionally) undermined the need to try to truly understand it. The consequences of ***unlimited resource ideology***, dovetailed with most nineteenth century attitudes towards resource extraction, but it had the potential to be catastrophic for salmon. Whereas federal salmon managers in Alaska understood that this resource was relatively finite, they not only struggled to grasp the complexity of the new Alaskan fishery, but also contended with dominant attitudes that prioritized economic gain.

The federal management period (District of Alaska, 1884-1912, Territory of Alaska 1912-1959) can be characterized as a balancing act amongst political, cultural, and economic goals with biological and ecological limitations. Management directives focused on maintaining a certain level of salmon harvested, and so strategies focused on population stability. As such, hatcheries, predator fish eradication, the development of an escapement-based management system, and the start of a growing scientific study of ecology with the purpose of sustained yield, drove policy. Although the study of ecology did not start with Alaska salmon, or even in Alaska, this intellectual

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[1] Thomas H. Huxley, Inaugural address, *Fisheries Exhibition Literature* 4, 22 as quoted in Malcolm Haddon, *Modeling and Quantitative Methods in Fisheries,* 2nd ed. (New York: CRC Press, 2011), 1.

shift represented more holistic understandings of the natural world, and over time, became more influential in management decisions. Hatcheries and predator fish eradication emphasized economic opportunity first by producing salmon at an industrial scale, and second by eliminating threats to the continued viability of the industry. On the other hand, escapement-based management demonstrates the fundamental struggle of reconciling economic opportunity with ecological health. Escapement-based stream closures, as demonstrated through analyses of the Rogue River in Oregon, favored the sustainability of the resource but at the expense of economic opportunity, and so remained controversial. Examination of these approaches highlights the efforts made to implement best practices at the time without compromising productivity.

2.2 Federal Fishery Science and Management

Federal management practices were firmly based on ever-developing scientific understanding. Although maintaining the economic viability of the industry motivated decisions in the first three decades of the twentieth century, the limitations of management capacity can be attributed more to the lack of technology than mistaken scientific understanding. Federal fisheries scientists conducted research and offered industry wide information that furthered the biological and ecological understanding of salmon and so became the leading voice on management strategy that sought to reconcile economic goals with ecological health.

Salmon, however, challenged managers compared to other commercially valuable fish because of their vastly different life histories. Ground fish including halibut, flounder, cod, and rockfish, are relatively long-lived (rockfish have been documented at more than 200 years old) and spawn more than once (iteroparous), resulting in much more stable population dynamics.[2] Salmon, on the

[2] Michael P. Fahay, Peter L. Berrien, Donna L. Johnson, and Wallace W. Morse "Essential Fish Habitat Source Document: Atlantic Cod, *Gadus morhua*, Life History and Habitat Characteristics," *NOAA Technical Memorandum*

other hand, spawn once and are relatively short lived (2-7 years depending on the species), making populations unpredictable and more susceptible to oceanic and local environmental fluctuations. Because scientists and managers were not familiar with populations in constant flux subject to environmental shifts and human activity, they tended to focus on the human impacts in management decisions. Consequently, policies were based more on the desire to establish a false equilibrium than on accommodating salmon-specific population dynamics.

Scientists, having seen significant population collapses in Pacific Northwest salmon fisheries by the early 1900s, were well aware of the limits of resource exploitation. At the Conference of Governors in 1908, President Theodore Roosevelt, representing the relatively new voice of conservation, warned that the nation's natural resources were "in danger of exhaustion if we permit the old wasteful methods" to continue.[3] For many conservationists such as Roosevelt, the application of contemporary scientific knowledge was the answer to sustainable use of resources. Many Americans agreed and had growing faith that scientific fixes could accommodate the demands of industrial society.[4]

Consequently, federal managers concerned that increased pressure from the cannery operations would lead to population collapse chose to supplement wild populations with hatcheries. In Alaska, economic incentives for hatcheries included tax cuts to canneries that released hatchery-raised salmon. As a result, commercial fishermen were harvesting salmon at rates only hatcheries could sustain. Hatcheries contributed to misplaced confidence in managers' ability to stabilize what

NMFS-NE-124 (Woods Hole, Mass.: Northeast Fisheries Science Center, U.S. Department of Commerce, September 1999), 2.

3 *Proceedings of a Conference of Governors in the White House, Washington, D.C., May 13-15, 1908* (Washington, D.C.: Government Printing Office, 1909, 3 as quoted in David F. Arnold, *The Fishermen's Frontier: People and Salmon in Southeast Alaska* (Seattle: University of Washington Press, 2008), 75.

4 Joseph E. Taylor III, "'Well-Thinking Men and Women': The Battle for the White Act and the Meaning of Conservation in the 1920s," *Pacific Historical Review* 71, No. 3 (August 2002), 362.

was actually a much more complicated situation, as discussed below.

Perhaps ironically, with increased salmon harvest because of hatcheries, more canneries opened in Alaska, most of which were capitalized, owned, and operated by extra-local businesses. These canneries employed migrant seasonal workers instead of residents, furthering Alaskans from participating in what they perceived as their own resource. The presence of outside interests in the form of canneries and their migrant employees fostered resentment towards outside interests that included skepticism towards the federal government's policies that seemed to favor big business over local participation.

2.3 Hatcheries

Hatcheries represent one of the primary strategies of the federal management period to cope with declining salmon numbers. One public statement to the Alaska newspaper, the *Petersburg Weekly Report*, suggested that hatcheries were the only possible way to ensure the salmon industry's future commercial viability.[5] However, they did meet some resistance. In 1915, Hugh H. Smith, the United States Commissioner of Fisheries, reported that in Alaska, "the plan of operating private hatcheries is not looked upon with favor at the present time." [6] In order to encourage private industry to take part in the large-scale effort, government provided economic incentives, or "hatchery rebates," at the rate of "40 cents for every thousand red or king salmon fry released;" roughly equivalent to the tax on ten cases of canned salmon.[7]

This policy had a fundamental flaw, as pointed out by David F. Arnold in *The Fishermen's*

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[5] M. S. Perkins, "Drastic Action Necessary," *The Petersburg Weekly Report* (Friday, November 19, 1920).

[6] Hugh H. Smith, "Salmon Hatcheries," *Report of the United States Commissioner of Fisheries for the Fiscal Year 1915* (Washington D.C.: Government Printing Office, 1917), 21-2.

[7] *Ibid.*

Frontier: People and Salmon in Southeast Alaska.[8] Salmon rebates were based on the number of fry released, not the number that actually supplemented wild salmon populations. Furthermore, the policy placed no onus on industry to understand the ecological consequences of their actions; hatchery operators focused too much on the number of eggs and juveniles produced, and not enough on explaining why they did not return as adults. Today, studies have shown that since homing is genetic, some hatchery fish will return to their ancestral streams, and others may stray to colonize new habitat. Hatchery-produced strays have a number of adverse effects on wild populations. First, hatchery fish are inbred, and therefore lack the genetic diversity of wild populations. When hatchery strays breed with wild populations, this inbreeding and lack of genetic diversity can limit the long-term success of the wild population. Secondly, the overabundance of hatchery strays could limit resources available to wild populations and increase competition for spawning sites. Finally, hatchery-raised salmon have a serious effect on commercial harvest reports and escapement counts because they provide a false sense of returning wild salmon populations, and encourage increased exploitation that is not environmentally sustainable.[9]

Additionally, hatchery operations focused on supplementing the profitable sockeye and chinook fisheries and disregarded naturally occurring population abundances in less economically desirable species. For example, in Southeast Alaska pink salmon are the most abundant salmon species, and by releasing sockeye and chinook fry by the millions, as Arnold pointed out, hatchery operators "sought to impose an unnatural order upon the fishery based on market considerations rather than the region's natural history," thereby contributing to ecological imbalances.[10]

[8] David F. Arnold, *The Fishermen's Frontier: People and Salmon in Southeast Alaska* (Seattle: University of Washington Press, 2008).

[9] Peter Westley, Post-doctoral fellow, University of Washington, Affiliate Faculty, University of Alaska Fairbanks School of Fisheries and Ocean Sciences, "Homing and Straying of Anadromous Pacific Salmon," PowerPoint presentation (12 September 2013).

[10] David F. Arnold, *The Fishermen's Frontier: People and Salmon in Southeast Alaska* (Seattle: University of

The problems in the early twentieth century continue to today, and the hatchery debate is still heated. Professor of Aquatic and Fishery Sciences at the University of Washington, Thomas P. Quinn noted that, though hatcheries are perceived as a way to counter overfishing and return runs to their original abundance, "such efforts masked the decline of wild populations and often accelerated [overfishing] by encouraging fishing levels that only hatchery runs could sustain."[11]

However controversial, hatcheries dominated the twentieth century management landscape and were, and still are, seen as a tool to sustain a booming industry. David R. Montgomery, author of *King of Fish: The Thousand-Year Run of Salmon*, attributed the success of these fishery engines to two major factors: "they pumped cash and resources into facilities run by fish commissions; and they avoided the political problems associated with dealing with the known environmental causes of salmon decline."[12] Hatcheries represented an answer to what were seen as human-initiated population fluctuations and met the goals of scientists and managers, who sought to reconcile economic stability with accepted conservation practices of the time. The simple solution to any fluctuation was: make more fish. By the 1920s, hatcheries were an accepted conservation practice, and were seen as the symbol of scientific ingenuity and man's ability to harness nature.

2.4 Predator Fish Eradication

Along with hatcheries, federal management included aggressive predatory fish eradication to try and increase the number of salmon. [13] In the *Report of the Commissioner of Fisheries,* Commissioner George M. Bowers reported, "the duties of the agents at the salmon fisheries in Alaska

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Washington Press, 2008) 86.

11 Thomas P. Quinn, 321.

12 David R. Montgomery, *King of Fish: The Thousand-Year Run of Salmon* (Cambridge: Westview Press, 2003) 161.

13 Today predator control represents an oversimplified answer to an extraordinarily complex problem, but at the time conservationists accepted it as a key part of wildlife management.

have primarily to do only with the various phases of the salmon industry." Tangentially, the work done with the Alaska salmon fisheries "afford[ed] opportunity for a survey of the other fisheries as well."[14] Bowers explained, "the almost equally important study of the creatures that... act as enemies to those of economic value."[15] Nature thus represented a battleground: animals with economic value were favored, and those without were seen as natural enemies.

In 1913, Dolly Varden, were "so abundant as to be a great nuisance and very destructive to salmon spawn," and became the target of eradication.[16] Deemed undesirable as human food, scientists like Dennis Winn declared the species "detrimental to the salmon industry," and endorsed eradication programs.[17] The United States Bureau of Fisheries, and the newly established Alaska Territorial Fish Commission, worked together to wage a war against these enemies of the salmon.

"We are thoroughly convinced," Dennis Winn, a field biologist with the Bureau of Fisheries, argued in 1921, "that the predatory fishes…constitute one of the most serious menaces facing the salmon industry," specifically to hatchery-produced juveniles.[18] In an effort to minimize predation on juvenile salmon in the Bristol Bay area, in 1921 alone roughly 10,000-13,000 Dolly Varden and rainbow trout were eradicated from the Wood River, and about 4,150-5,500 from the Naknek River. As efforts continued into the 1940s, the totals eliminated statewide climbed to the hundreds of thousands annually.[19] The perceived success of these efforts was so great that Winn recommended

[14] Millard C. Marsh, "The Fisheries of Alaska in 1907," *Report of the Commissioner of Fisheries for the Fiscal Year 1907 and Special Papers,* (Washington, D.C.: Government Printing Office, 1907), 1.
[15] George M. Bowers, *Report of the Commissioner of Fisheries for the Fiscal Year 1907 and Special Papers,* (Washington, D.C.: Government Printing Office, 1907), 10.
[16] Hugh M. Smith, "Alaska Fish and Fur Industries," *Report of the United States Commissioner of Fisheries* (Washington, D.C.: Government Printing Office, 1914), 35.
[17] Dennis Winn, "Destruction of Predatory Fishes in Bristol Bay Region," *Report of the Commissioner of the United States Bureau of Fisheries* (Washington, D.C.: Government Printing Office, 1922), 31-2.
[18] *Ibid,* 37.
[19] *Ibid,* 32-3. Though the number of fish eradicated is presented in pounds in the report, I divided the total weight provided (35,000-40,000 and 16,600 respectively) by the average weight of 3-4 pounds per fish. Ward T. Bower "Alaska Fishery and Fur-Seal Industry in 1936," *Report of the Commissioner of the United States Bureau of Fisheries* (Washington, D.C.: Government Printing Office, 1937), 7, "During the year [1936] 31,012 Dolly Vardens were

that predatory fish eradication be continued to the greatest extent possible.[20] Well into the 1930s, the Territory of Alaska and cannery owners paid per-fish bounties totaling approximately $15,000 annually for Dolly Varden to "bona fide residents of Alaska."[21] Eradication efforts benefitted canneries and provided income to Alaska residents.

The negative perception of Dolly Varden extended beyond the scientific community. In a statement similar to that of Winn, a contributor to the *Petersburg Press* (Alaska), wrote that "the Dolly Vardin [sic] trout is the most destructive enemy that the salmon has," and portrayed Dolly Varden eradication as essential to ensuring future salmon runs.[22] This sentiment persisted in 1936, as expressed in a letter from a Juneau attorney, Frank N. Foster, to Forest Ranger Wyckoff that accompanied a resolution to Congress requesting that the Alaska Game Commission be allowed to regulate and conserve game fish, except for Dolly Varden, which fed on salmon fry and spawn.[23]

By 1939, Commissioner Ward Bower declared that eradication efforts "resulted in a marked improvement in the runs of red salmon in the regions."[24] Predatory fish eradication programs appeared to have immediate benefits; however, scientists failed to recognize the ecological benefits of Dolly Varden, and the benefits to salmon specifically. Juvenile salmon fed on the eggs of other resident fish; by eliminating such a large stock of eggs, managers reduced nutrients available to economically important species, such as salmon. Additionally, removal of predators left more juveniles in a particular area, which led to greater competition for resources. As the life histories show,

destroyed in the Yakutat district and 208,799 in the Cook Inlet district."

20 *Ibid,* 37.

21 Ward T. Bower, "Alaska Fishery and Fur-Seal Industry in 1934," *Report of the Commissioner of the United States Bureau of Fisheries* (Washington, D.C.: Government Printing Office, 1935), 2 and Ward T. Bower "Alaska Fishery and Fur-Seal Industry in 1935," *Report of the Commissioner of the United States Bureau of Fisheries* (Washington, D.C.: Government Printing Office, 1936), 7.

22 Jack Nelson, "Fifteen Years of Watching and Fishing the Dolly Vardin Trout in the Streams and Rivers Outside Points in Southeastern Alaska," *Petersburg Press* (February 8, 1929).

23 "Conservation of Sport Fish Urged," *Petersburg Press* (Petersburg, Alaska), March 6, 1936.

24 Ward T. Bower, "Alaska Fishery and Fur-Seal Industries in 1938," *Report of the Commissioner of the United States Bureau of Fisheries for the Fiscal Year 1939* (Washington, D.C.: Government Printing Office, 1940), 93.

greater competition for fewer resources results in earlier smoltification, or the process of juvenile salmon becoming smolt and heading to the ocean. Consequently, the smolt were smaller and more vulnerable to the stresses of migration, competition from larger smolt originating in other rivers or streams, and marine predators, resulting in drainage specific population declines.[25]

Threats to target species extended beyond predatory fish to other species of salmon. Fishermen were encouraged to remove the threat of competition to preferred salmon species, which included chum, coho, and pink salmon, to promote the runs of the prized Chinook and Sockeye, or redfish. In 1913, Hugh Smith noted a significant increase in Sockeye and Chinook populations which "ow[ed] largely to the great increase in the catch of cheaper grades of salmon."[26] This development, along with the belief that predatory fish were one of the greatest threats to salmon, demonstrated a significant ecological misunderstanding. The misunderstanding lay not in willful ignorance, but was based on limited comprehension of salmon biology and in widely held ecological beliefs about predator/prey relationships.

Today scientists recognize a number of variables involved in salmon population abundances, but federal managers in the first half of the twentieth century thought more of simple causal relationships. Perceptions of simple relationships stemmed in part from limited ecological knowledge, and scientists often relied on a single data source to gauge success: the yields in the salmon industry. Commercial harvest reports served as the sole mode of salmon population data collection well into the twentieth century. As Malcolm Haddon, Senior Fisheries Modeller at Australia's Commonwealth Scientific and Industrial Research Organisation noted, "…it was at least three decades into the twentieth century before mathematical treatments of aspects other than simple summaries

25 Thomas P. Quinn.
26 Hugh M Smith, "Alaska Fish and Fur Industries," *Report of the Commissioner of the United States Bureau of Fisheries for the Fiscal Year 1913* (Washington, D.C.: Government Printing Office, 1914), 34.

of catch-per-unit-effort were considered."[27] While useful, the data set is problematic when used without supplementary data collection.

Of course, the economic value of salmon, rather than overall ecological health, was the primary motivation for conserving the resource, a view emphasized by a correspondent for the *Rogue River Courier* that salmon were "valued for their economic worth only."[28] And because it was believed that the populations could be manipulated by adding more fish via hatcheries, or eliminating a single environmental factor such as predators, other environmental components were overlooked. Over time, however, as conservation science and salmon science became more sophisticated, federal management would consider other strategies.

2.5 Escapement-Based Management

A third effort to control salmon populations looked at escapement-based management strategies. Scientists understood the value of allowing salmon to return to their native spawning grounds, but primarily as a function of propagation. In the 1914 Bureau of Fisheries Report, Ward T. Bower emphasized the benefits of closing certain rivers and streams completely to commercial fishing. "One of the best methods of a meeting a threatened decrease in the supply of salmon," Bower argued, "is by closing streams or waters to commercial fishing, so that the natural spawning grounds will not be disturbed or encroached upon by fishermen."[29] Closures lasted for days, months, and even years depending on the severity of the circumstances. While managers throughout the twentieth century, and even today, use similar closure systems, the later systems have been much more dynamic, and have relied less on subjective observation and limited data and more on comprehensive model-

[27] Malcolm Haddon, 2.
[28] "Ashland and the Fish Question," *Rogue River Courier* Daily Edition (Grants Pass, Oregon), January 2, 1917, 2.
[29] Ward T. Bower and Henry D. Aller, "Alaska Fisheries and Fur Industries in 1914," *Report of the United States Commissioner of Fisheries for the Fiscal Year 1914* (Washington, D.C.: Government Printing Office, 1915), 8.

ing methods that account for a variety of human and non-human factors. Instead of the periodic, escapement-based closures practiced today, managers in the early twentieth century relied on extended closures that eliminated commercial fishing opportunity. Though the managerial decisions were influenced heavily by the scientific knowledge of the time, fishermen who witnessed rotting salmon corpses along the riverbank had difficulty coming to terms with what they saw as waste.

Commercial fishermen saw prolonged closures as both ecologically and economically damaging. A reporter with *The Seattle Star* described "the yearly tragedy of the salmon run."[30] He declared: "were it not for the annual catch a disastrous waste would occur." He reasoned that since "the laws of nature have doomed it to die when the season of propagation is at an end…the capture of salmon under conservative regulations fits in quite happily with nature's scheme."[31] This position not only demonstrated a limited understanding of salmon biology and ecology, but of "nature's scheme."

In 1915, residents who lived near Oregon's Rogue River experienced the type of river closure described by Bower for two years. Commercial fishing was suspended with the hope that the salmon run would return to its former abundance. Commercial fishermen and residents watched as salmon filled the Rogue River, spawned, and died. One correspondent with the *Rogue River Courier* demanded "the right of the people to use the salmon upon the table instead of allowing the fish to rot upon the banks of the river."[32] Fishery biologists know today that salmon serve a vital function in riverine ecosystems and that these rotting corpses are crucial to maintaining a healthy environment, but to commercial fishermen who understood little about these ecosystems, the rotting

30 "Seattle Fishermen Sail Forth to Meet Salmon on Their Annual Pilgrimage," *The Seattle Star* (Seattle, Washington), July 6, 1914, 3.
31 *Ibid.*
32 "Ashland and the Fish Question."

fish represented waste and a negative profit margin.

The value of dead salmon to an ecosystem may not have been thoroughly understood, but an inkling of their value was recognized by sport fishermen. An unnamed contributor to the *Rogue River Courier* described the effects of closing the Rogue River to commercial fishing, and the influx of salmon into the system. He observed "the steelheads, the sport fish of the stream, feeding upon the spawn of the salmon and upon the decaying flesh of the dead salmon…"[33] Though he did not connect all the dots, this recreational fisherman described a critical function of salmon: delivering marine derived nutrients to an inland riverine ecosystem.

This availability of food for the steelhead meant that they were not interested in rising to a fly and were almost impossible to catch by sport fishermen. To recreational outdoorsmen, dead salmon ruined the sport fishing experience. "The poorest sport fishing ever had in the Rogue," the contributor complained, "was upon the two years when the stream was closed to all forms of commercial fishing."[34] Salmon numbers were so vast that resident species did not need to look far for food. Supporting the argument presented by previous contributors, this fisherman concluded, "properly regulated commercial fishing not only saves to the people the food value of the [salmon]… but…improves the sport fishing as well."[35] Fundamentally, the contributor urged an exploitative salmon conservation program because, in the words of ecologist Aldo Leopold, "the wild things he [fished] for [had] eluded his grasp, and he hope[d] by some necromancy of laws, appropriations, regional plans, reorganization of departments, or other form of mass-wishing to make them [easier to catch]."[36]

33 "Grants Pass and the Rogue Fish Question," *Rogue River Courier* Daily Edition (Grants Pass, Oregon) January 2, 1917, 1.
34 *Ibid.*
35 *Ibid.*
36 Aldo Leopold, *A Sand County Almanac* (Oxford: Oxford University Press, 1949).

Limiting marine derived nutrients to a riverine ecosystem had a compound effect on salmon runs. Not only were commercial fishermen limiting the number of adults returning to spawn, which resulted in fewer offspring, but the juvenile salmon born the year before depended on the eggs from spawning salmon and the flesh of salmon carcasses for nutrients. By encouraging commercial harvest to deprive the sport fish of nutrients, forcing them to find food elsewhere (thus making them more likely to bite artificial lures), the *Rogue River Courier* contributor was also unknowingly recommending depriving juvenile salmon of the same nutrients.

Interestingly, river closures were not accompanied by estuarine fishing closures, which sparked heated preferential treatment debates throughout the twentieth century. This raised a management concern: while managers closed fishing completely in the river itself, commercial fishermen could still harvest salmon in the estuarine environment in the vicinity of the closed river. In fact, some industrious fishermen would spook salmon back down river by various means such as nets, noise, or simply fishermen methodically walking in a line downstream to the estuary where they harvested the fish legally.[37] Though the practice of closing rivers but not their estuaries was internally inconsistent, ecological and population related information was sparse, and the contradiction was overlooked. Conservationists still saw the ocean as an infinite resource base, and an observation-based management system required, by definition, collection of observable data.

Not only do the various components of this example demonstrate early conservationists' emphasis on resource use, but they also highlight incongruities in human responses to management decisions. Commercial fishermen viewed such management inconsistencies as evidence of incompetency. Yet people who depended on the resource often had unrealistic expectations of scientists and managers. Scientists were expected to allow just the right number of salmon to return to the

[37] Ward T. Bower and Henry D. Aller.

spawning grounds; any more and the salmon were wasted, any less and there would not be enough salmon to ensure future runs. Fishermen asserted that "properly regulated commercial fishing," and "conservative regulations" would ensure future salmon runs. Yet science was not capable of enabling a successful industry based on conservative regulations alone. Although managers attempted to reconcile economic imperatives with ecological health, they lacked the tools to do so.

Furthermore, tactics such as hatcheries, predator eradication, and stream closures did not account for the complexity and variability of salmon stocks or the larger ecosystem they occupied. While periodic use of these measures proved effective for long-lived species like rockfish, cod, or halibut, salmon life histories made these strategies both economically and ecologically impractical, and in most cases counterproductive because they threatened future runs. With the inability to estimate salmon population numbers accurately, or predict future population functions, salmon biologists and managers were ill-equipped to implement escapement-based management strategies. Thus during the first decades of the twentieth century, federal management was bound to experience uneven outcomes.

2.6 E.S. Russell, Quantitative Modeling, and Ecology

By the late 1920s, more and more managers and scientists recognized the shortcomings of their efforts. U.S. Bureau of Fisheries Commissioner Hugh Smith urged "radical revision" of current salmon regulation owing to dwindling salmon runs that would be the worst on record two years later. [38] Scientists may have been overreaching when they stated that salmon were "at the most critical period of their history," but it was nevertheless true that the fisheries remained "sub-

[38] Hugh M. Smith, "Alaska Fisheries Service," *Report of the United States Commissioner of Fisheries for the Fiscal Year 1919* (Washington, D.C.: Government Printing Office, 1920), 49.

ject to laws which [had] been shown to be obsolete and inadequate."[39] Legislation was not merely "obsolete and inadequate;" it asked the impossible. Scientists lacked the technology and modeling techniques to quantify salmon stocks, thus they could not keep up with economic demands and legislative decisions.[40]

The methods for controlling the dynamic and complex salmon fishery had yet to be developed.. Salmon life history-specific management required accurate population estimates, and an escapement-based management system. Yet, until the 1930s, scientists could rely on little more than speculation and wishful thinking, a conservation strategy that Alaska's territorial governor Ernest Gruening years later said was "by guess and by God."[41] This is not to suggest that experiments were not undertaken, substantial data was not collected, or that efforts were totally misguided. Managers simply could not interpret the vast amount of information they collected. Industrial salmon harvesting required vastly different management strategies than earlier fisheries. The first step towards more sophisticated fisheries management, that sought to incorporate multiple factors, came in 1931 when Edward Stuart (E. S.) Russell, a biologist and ecologist with the Ministry of Agriculture and Fisheries in London, sought to explain mathematically the "overfishing problem."[42]

Though inadequate by today's standards, Russell's equation for estimating total biomass of a fishery laid the foundation of a new era in fisheries management. For the first time, a mathematical equation made population modeling possible. As Malcolm Haddon explained, Russell's equation did not account for "the effects of other species (competitors, predators, etc.), the physical environment

39 *Ibid.*

40 E. A. Fulton, A. D. M. Smith, and A. E. Punt, "Which ecological indicators can robustly detect effects of fishing?" *ICES Journal of Marine Science* 62 (2005), 540-51 as quoted in Malcolm Haddon, 3. Exact quote reads: "Unfortunately, the legislation requiring such evaluation has developed ahead of the science needed to provide appropriate assessments."

41 Ernest Gruening, *The State of Alaska* (New York: Random House, 1968), 401.

42 Edward Stuart (E. S.) Russell, *The Overfishing Problem* (University Press, 1942).

in which the species lived, which can include everything from El Niño effects to pollution stress, and special structuring of the fished stock," yet Russell's biomass equation marked a substantial turning point in fisheries management. [43]

Of Russell's many contributions to the field, perhaps one of his greatest was his holistic understanding of fisheries that incorporated the idea of salmon population dynamics as part of a wider eco-system. As he noted, "from the point of view of a rational classification of the sciences fishery research is, by reason of its methods and standpoint, simply a branch of ecology."[44] Russell contextualized fisheries science with something other than simple equations. "The sea and its problems are one," he argued, "what happens in one little corner cannot be interpreted without reference to what is going on elsewhere; what happens in [one location], for instance, depends to a large extent upon the set of currents, and they in their turn are linked up with a general circulation of waters."[45] Based on Russell's insight, management shifted from locally exclusive models to regionally inclusive endeavors. Russell's insight would help scientists and managers understand the natural world, but would also introduce new questions that demanded answers. Though Russell's biomass equation and ecological argument were in their infancy and not universally accepted at the time, they demonstrated a new conceptual framework to interpret the natural world that offered the possibility of reconciling economic opportunity and ecological necessity with a new degree of precision.

Federal management slowly incorporated more ecologically- minded strategies, and the 1930s became a transition period when managers slowly discarded older techniques for newer measures. However, conservation strategies often developed ahead of the technological and scientific data

[43] Malcolm Haddon, 3.
[44] E. S. Russell, "Fishery Research: Its Contribution to Ecology," *Journal of Ecology* 20, No. 1 (Feb. 1932), 128.
[45] *Ibid,* 129.

collection methods required to implement them, or else were put in place alongside older methods. Practices such as predatory fish eradication and extended river closures continued, even as scientists and managers understood new methodologies grounded in more complex understandings of ecology.

Prior to 1931, escapement-based management was often overly optimistic. Escapement goals of 50 percent were common, but early managers had no way to determine population size aside from catch-per-unit-effort data.[46] In short, they did not know, nor did they have an effective way to estimate, total numbers of salmon. Fifty percent was an arbitrary target because managers could boast meeting escapement goals without knowing the number of salmon that equaled 50 percent of the run!

While catch-per-unit-effort data helps determine population size, and remains in use today, it plays just one part in a complex equation. On their own, these statistics provide limited information, and are highly variable depending on capture efficiency, location, equipment type, etc. However, Russell's biomass equation introduced in 1931 allowed managers to estimate total run numbers and adjust escapement goals based on specific stocks.

The next steps towards a better ecological understanding of salmon came three years after Russell's fisheries ecology argument surfaced. Salmon biologists began noticing trends relative to environmental conditions. In 1935 – coincidentally the same year that the Alaska Legislature passed an act that created an Alaskan advisory committee tasked with supplementing federal scientific efforts – biologists, in a groundbreaking study, tried to evaluate how natural factors affected each year's runs.[47] A number of substantial developments in salmon management resulted: the identification

[46] "Alaska Fisheries Service," *Report of the Commissioner of the United States Bureau of Fisheries* (Washington, D.C.: Government Printing Office, 1936), 99 stated, "a consistent program has been followed, the main objective of which is to assure an adequate escapement of brood fish to maintain a maximum supply. A breeding reserve of 50 percent of the salmon runs is regarded as the minimum requirement." Though, as mentioned in the main text, scientists were unsure of the number to take 50 percent of to ensure maximum sustained yield.

[47] Ward T. Bower, "Alaska Fishery and Fur-Seal Industry in 1935," *Report of the Commissioner of the United States*

of several natural factors, the evaluation of those factors, and the first truly proactive management strategy was sought that would incorporate these estimates ahead of making management decisions rather than reacting to population declines through more traditional methods.

In two separate locations within the Territory of Alaska researchers discovered indications that changes in natural conditions in which young fish develop greatly influence salmon population abundance.[48] Managers and scientists now recognized that salmon management started at the juvenile stage, not the adult stage. By understanding the conditions that affect juvenile salmon, salmon conservationists were able to better understand population dynamics. In combination with Russell's relatively new biomass equation, scientists could more accurately predict future salmon runs, the key to effective salmon management.

The third, and probably most significant result of this 1935 study was the identification of natural population fluctuation. For the first time in the history of salmon management, scientists understood fluctuation to be, at least in part, a natural occurrence rather than based only on human take. In 1935, armed with an enlightened ecological understanding and new methods of analyzing data, fisheries scientists began to study daily catch records, seeking primarily to determine periodic changes in abundance and run timing.[49]

Over the following two decades, scientists made significant breakthroughs in understanding Pacific salmon life history, ecology, and population dynamics. Fluctuations that had been deemed unnatural only a few years earlier began to be accepted as part of population cycles. Understanding both natural and human forces in the cycles was critical to establishing effective regulations for the

Bureau of Fisheries for the Fiscal Year 1936 (Washington, D.C.: Government Printing Office, 1937), 11, and Ward T. Bower, "Alaska Fishery and Fur-Seal Industry in 1935," 17.
48 *Ibid.*
49 *Ibid.*

conservation of salmon.[50] Salmon conservationists realized that salmon life histories required specific management strategies, and that to utilize the run effectively for commercial harvest while ensuring future runs, a much more dynamic, proactive management strategy was required.[51] These changes were not solely the direct result of Russell's work; as Russell himself argued, no phenomena exist in isolation. However, it is fair to state that the shift reflected what Russell's work embodied: a more informed approach that recognized the interconnectedness of human and environmental factors.

2.7 Conclusion

Pacific salmon conservation efforts during the federal era of management underwent many changes. Although the fundamental role of the federal fishery manager during the early twentieth century, just as it is today, was to reconcile political, cultural, and economic desires with biological realities, tactics shifted over time in response to economic pressure and growing ecological understanding. Hatcheries, predator fish eradication, and the development of an escapement-based management system offered three examples of management policies under these conditions. Importantly, before Russell, and the growing acceptance of eco-system, rather than species-specific management, the lack of quantitative precision resulted in strategies that often favored economic goals over biological concerns. By the mid-twentieth century, technology enabled increased precision in fishery management, and when combined with quantitative modeling allowed for more informed management directives.

Simultaneously, while the value of salmon remained largely economic, it also accrued ideological importance. As addressed in the next chapter, Alaskans targeted federal mismanagement and blamed outsiders for declining populations. In this way, political, cultural, and economic pres-

50 *Ibid.*
51 See Malcolm Haddon quote on page 5.

sure would all come into play in the transition to statehood and how the state would regulate its fishing industry.

Chapter 3 Transition to Statehood and State Management

3.1 Introduction

In the decades leading to statehood, a small but growing number of Alaskans urged greater local control of the fishing industry, a goal that would be achieved in 1959. However, for managers, the two-decades from 1940 to 1960 were a frustrating period in federal salmon policy. Increasing ecological understanding accompanied progressive fishery legislation. Yet the technological ability to effectively implement these ambitious policies remained out of reach. Complicating the situation, as support for Alaskan statehood grew, anti-federal salmon rhetoric hindered federal managers and policymakers alike. Federal attempts to manage the resource were seen as affronts to territorial sovereignty. Eventually, federal managers would be disempowered when the state took over, and new regulations would be written into the state constitution.

3.2 The 1940s – Increased Analytical Sophistication in Salmon Management

World War II interrupted the momentum of fisheries and scientific advancement. The salmon fishery continued on a limited scale, however scientific study was essentially suspended during the war.[1] This was due largely to the loss of government allocations for fisheries research, and the difficulty of recruiting qualified personnel to conduct research in Alaska, because their abilities were required by the military or foreign services.[2] In 1945, as the war wound down, the U.S. Fish and Wildlife Service resumed limited studies and were back to full steam by 1947.

Fishery science at this time was largely motivated by salmon industry objectives., As U.S. Fish and Wildlife Director Albert M. Day noted, "little opportunity [was] afforded for work in

1 Albert M. Day, *United States Fish and Wildlife Service, Division of Fishery Biology Annual Report for the Fiscal Year 1947* (Washington, D.C.: Government Printing Office, 1947).

2 *Ibid,* 2.

the developmental field or in the fundamental field of pure science."[3] Nevertheless, the U.S. Fish and Wildlife Service conducted studies of salmon "of the highest theoretical importance."[4] Day understood that practical understanding of salmon biology and ecology would encourage further development within the scientific fields. "The purpose kept in mind," Day argued, "is the discovery and development of means and systems of managing fishery resources to assure their complete utilization and permanent productivity."[5]

Hidden in Day's language was the theoretical precursor of what is today called *maximum sustained yield*. "Complete utilization and permanent productivity" demonstrated a sophisticated concept of natural resource management that was a step towards reconciling economic demand with ecological sustainability. Maximum sustained yield is the maximum amount of a biotic community that can be taken while maintaining the long-term viability of the population. Though the concept represented a best-case scenario and demanded scientific precision that was impossible at the time, the idea incorporated a much more responsive management approach than that of earlier decades. It acknowledged that in order to manage a fluctuating, abundant fishery, management regimes had to reflect elasticity and developments in the scientific understanding of Pacific salmon life histories, population dynamics, and ecology.

For instance, managers and scientists in the 1940s realized that simple catch-per-unit-effort data was not sufficient for accurate population estimates and did not reflect the complexity of salmon population dynamics. Substantive claims regarding salmon runs required multi-source data compilation such as fishing intensity, preceding population abundances, escapement, and age composition. By 1947, scientists were able to make *simple* predictions regarding salmon runs and, with the help

3 *Ibid*, 3.
4 *Ibid*.
5 *Ibid*, 4.

of fishing effort data, could determine the fishing pressure that the runs could maintain.[6]

Sophisticated management practices resulted from increased biological understanding with new sampling and analytical capabilities, but one of the most significant developments was the inclusion of ecological breadth into regional fisheries. In March of 1952, the U.S. Fish and Wildlife Service consolidated California, Oregon, and Washington, and Alaska to create a single Pacific Salmon Investigation. While territorial representatives who disfavored federal management of Alaskan salmon fisheries saw the gesture as a form of neglect, U.S. Fish and Wildlife Service Director, John L. Farley provided a much more practical, ecologically based rationale for the consolidation: "since a single service unit handles all Pacific salmon research, similarities and differences in form, in migratory and spawning habits, in reaction to environment, and in mortality factors between many individual stocks are more easily detected and understood than they would be with several small units."[7] This idea harkens back to Russell's 1932 argument that the ocean does not consist of isolated regions, but is a collective unit, and one cannot understand one area without understanding adjacent regions. He demonstrated that an understanding of ecology is essential for fishery biologists.

The new emphasis on ecological context gave rise to a conservation ideology that would influence future perceptions of natural resource development, but that would not always be put into practice. In 1949, with the publication of ecologist Aldo Leopold's *A Sand County Almanac*, the idea of ecological responsibility and the necessity of a land ethic became more well-known. He stated that ethics rests on the premise that "the individual is a member of a community of interdependent parts…the land ethic simply enlarges the boundaries of the community" to include

6 *Ibid.*

7 Albert M. Day, "Pacific Salmon Investigations," *Branch of Fishery Biology Annual Report for the Fiscal Year 1952,* Washington, D.C. (October 1952), 26 and John L. Farley, "Pacific Salmon Investigations," *Branch of Fishery Biology Annual Report for the Fiscal Year 1954,* Washington, D.C. (October 1954), 44.

the natural world.[8] Leopold's ideology tied together key themes that related to fishery science and argued for an ecologically-based paradigm that would come to influence resource management more and more in the post-War period.

Ecological contextualization of biotic communities demonstrated sophisticated interpretations of the natural world. The overall health of the environment was accorded value beyond the marketplace. Thinking about the natural world as consisting of an intricate web of interconnected parts made each member of that community integral to the well being of the whole. For instance, managers began to comprehend the environmental harm caused by predator eradication programs. In a 1937 letter to T.D. Peffley, Aldo Leopold insisted that game managers now saw "vermin campaigns," like those targeting Dolly Varden in the early twentieth century, as "not only useless, but actually harmful to conservation."[9] Scientists recognized predator species like Dolly Varden as providing an ecological service instead of a disservice. Leopold explained the ecosystem as an ecological pyramid comprised of various layers of the biotic community: the top layer represented the apex predators, the layer below them their prey, the layer below that the prey of the prey, etc. He noted that "the pyramid is a tangle of chains so complex as to seem disorderly, yet the stability of the system proves it to be a highly organized structure," and to remove a predator like the Dolly Varden would disrupt the entire system.[10] "It is only in recent years that we hear the more honest argument that predators are members of the community," Leopold noted, "and that no special interest has the right to exterminate them for the sake of a benefit, real or fancied, to itself."[11] Yet he also observed that, "this enlightened view [was] still in the talk stage," and "the extermination of predators

8 Aldo Leopold, 204.
9 Aldo Leopold, "Letter to T.D. Peffley," in *A Sand County Almanac & Other Writings on Ecology and Conservation.*
10 *Ibid,* 253-4.
11 *Ibid,* 247.

[went] merrily on."[12] Indeed, Leopold's perception of predators as important members of a much larger, more intricate biotic community was still more ideology than policy put into practice. Thus, despite the growing acceptance of ecologically driven views like that of Leopold, Alaska salmon management regimes were slow to respond largely due to economic demands placed on the industry.

Furthermore, even though models had been developed to represent salmon populations and help scientists determine abundances, escapements, and run forecasts, computer-modeling capabilities of the time remained unsophisticated. Computers were rudimentary machines in the early 1950s, capable of little more than basic mathematics. Scientists and statisticians used differential calculus to create simplistic models to represent the natural world. As Malcolm Haddon observed, without the help of computers that later modelers relied on, parts of the model structures "were determined more by what could be solved analytically than because they reflected nature in a particularly accurate manner."[13]

Biological and ecological information that grounded salmon management had begun to change. Yet scientists and managers in the 1940s and 1950s were still tethered to outdated management strategies and by the inability to model dynamic populations. Thus they continued to carry out many of their conservation efforts based on earlier methods. The salmon collapse experienced in the late 1940s until the mid 1950s (discussed below), then, was arguably not the result of scientific incompetence, but the perfect storm of biological, ecological, and environmental factors magnified by a management system unable to carry out more enlightened scientific ambitions.

In 1949, only two years after the U.S. Fish and Wildlife Service had resumed normal salmon research in Alaska, a cadre of territorial leaders became increasingly vocal against federal

[12] *Ibid.*
[13] Malcolm Haddon, 13.

management. Alaskans, such as Governor Ernest Gruening, believed that "like the mastodon," government conservation had "become handicapped by its own dimensions."[14] To justify territorial participation in the Alaska salmon management arena, Gruening pointed to the federal managers' "inability to carry out not only the primary conservation function but to understand and satisfy the important social and economic implications of the task."[15] That year the Territorial Legislature developed the Alaska Department of Fisheries to assist in conservation and management decisions to ensure future salmon runs, promote the ownership and management of fisheries by Alaska residents, and work alongside the U.S. Fish and Wildlife Service. Gruening, however, overestimated the role territorial fishery managers would play. Though the territory established the Alaska Department of Fisheries to prepare for Alaska's taking control of the salmon resource from the Department of the Interior upon statehood, the department served little more purpose than symbolically asserting territorial sovereignty.[16] Legislative efforts to take control of Alaska's resource remained stymied, and territorial fisheries managers had no real authority.

3.3 The 1950s Salmon Population Collapse

By 1953, the commercial salmon harvest had reached a thirty-two year low.[17] The population collapse of the 1950s lasted roughly a decade and was the bottom end of a gradually declining commercial salmon harvest starting in 1937, which marked the greatest harvest year under federal management valued at over $500 million. Coincidentally, 1960 marked the lowest commercial salmon harvest since the early twentieth century, worth roughly $100 million. That same year, Alaska salmon management authority was transferred to the Alaska Department of Fish & Game.

[14] Aldo Leopold.
[15] Ernest Gruening, *The State of Alaska* (New York: Random House, 1968), 406.
[16] *Ibid.*
[17] The lowest since 1911, excepting 1921.

The dramatic increase in commercial harvest in the following years can be attributed both to salmon abundances and the implementation of a completely open access fishery. This system, while lucrative in the short term, proved unsustainable.

The collapse that occurred in less than a decade prompted federal action. That year, President Eisenhower declared the Alaska salmon industry a "disaster area." As Gruening pointed out, "designation of a 'disaster area' by the federal government customarily followed [a natural disaster]… usually referred to as an 'act of God.'" What made this "disaster area" unique was that, according to Gruening, the salmon collapse was far from an act of God; this was a "failure of a federally managed resource, attributable, rather, to the acts of man."[18] This diagnosis, however, was a simplified rendering of a complex ecological phenomenon. The naturally fluctuating population abundances of Pacific salmon relative to environmental conditions may have been exaggerated by acts of man, but also were undoubtedly products of the natural world.[19] However, the collapse served to reinforce Gruening's argument for statehood – a move he saw as imperative in order to rescue Alaska from its subordinate status and save the industry from outsiders.[20] In particular, industrial methods of capturing salmon, in the form of fish traps, became a powerful example of "colonial" oppression used by proponents of statehood to rally support.

3.4 Fish Traps and Alaskan Political Culture

James Mackovjak's study *Alaska Salmon Traps* provides a nuts-and-bolts understanding of the industrial fish traps themselves.[21] Mackovjak stated that there have historically been two types of fish traps: fixed and floating. Both are comprised of basic components including a lead, which

[18] Ernest Gruening, 405.
[19] All quotations from *Ibid.*
[20] *Ibid.*
[21] James Mackovjak, *Alaska Salmon Traps* (Gustavus: Cross Sound Innovations, 2013).

extends from shore out into an estuary about 600 feet, where the main body of the trap is stationed. The main body consists of *hearts* (pens in the shape of a heart with straight edges with the pointed end creating an opening to another heart or the holding pens), and the number of hearts depends on the trap, but most traps consist of an inner and outer heart. The hearts act as funnels that both force salmon to continue to the holding pens and prevent their escape. The holding pen is the last segment of the trap and farthest from shore. It is from this point that the salmon are loaded onto boats and brought to sale. It is as simple a capture method as could be designed, and, in the words of their opponents, operated with "brutal efficiency."[22] The only difference between fixed and floating traps was that fixed traps were made up of long poles driven into the ocean floor and required significant energy and capital to assemble at the beginning of the season and disassemble at the end. This early, costly method soon gave way to the then-modern, economically efficient floating traps that were fixed using cables with anchors. At the end of the season, the anchors were weighed and the traps were simply pulled to their overwintering site in a nearby bay or other protected area.

Fish traps were more efficient than any other harvest method. They required little effort to operate once established, and the salmon literally swam right into them. Salmon migrating along the coast happened upon the lead and, when confronted with the obstacle, the salmon followed the net to find an alternate route, swimming into the first heart where they were trapped. Unable to swim back the direction they came, they continued on to the second heart, and farther still to the holding pen where they stayed until the commercial boat loaded them using a specialized net called a "brailer."[23]

Fish trap operators started each season scouting for prime real estate where they would spend

[22] Steve Colt, "Salmon Fish Traps in Alaska," *Institute of Social and Economic Research* (Anchorage: University of Alaska Anchorage, 1999), 12.
[23] James Mackovjak, 4.

their summer. Despite the apparent ease of fish trap success as described by anti-trap advocates in the 1950s, the capture method was disadvantaged in their immobility. They were bound by the three fundamental rules of real estate: location, location, and location. In his work titled *The Alaska Salmon Trap: Its Evolution, Conflicts, and Consequences,* H.C. Scudder stated that "a matter of a few feet in the location of the tailhold could mean the difference between success and failure."[24] The successful placement of a fish trap would largely have been associated with favorable ocean currents and the distance and direction the freshwater was traveling once it contacted the ocean. To be sure, the direction and presence of freshwater slicks in an estuary would dictate migration patterns of the salmon returning to spawn.

Once salmon have traveled hundreds or possibly thousands of miles through the open ocean, and are within a certain distance of their natal streams, the scent of fresh water takes over as their primary navigational tool. Salmon have the remarkable ability of being able to follow the scent of their specific drainage to its mouth. Research has shown that smell is such a strong navigational tool that it influences salmon behavior.[25]

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[24] H.C. Scudder, *The Alaska Salmon Trap: Its Evolution, Conflicts, and Consequences* (Anchorage: Alaska State Library Historical Monograph Series, 1970) as quoted in Steve Colt, 10.

[25] Thomas P. Quinn, "Migrations in Coastal and Estuarine Waters," *The Behavior and Ecology of Pacific Salmon & Trout* (Seattle: University of Washington Press, 2005), 63-65. Once salmon start to catch the scent of fresh water in the ocean their travel patterns have a much more significant vertical component, sometimes traveling hundreds of feet in the water column, swimming from depths of hundred of feet to about 10-15 feet (or shallower), only to almost immediately descend again. Biologist Thomas Quinn tried to make sense of this seemingly erratic travel behavior. While one possible reason would be to feed, a much more plausible explanation is the navigational component. As the warmer water from the rivers enters the ocean, a natural separation occurs: the warmer, fresh water stays towards the surface, and the cold ocean water stays below. The first whiff of fresh water scent could be at a slightly greater depth the farther away from the river the salmon is, simply because the warmer, fresh water and colder, salt water have had more time to mix. But as the salmon close in on their natal river systems, the fresh water and salt water become more distinct, creating a more defined layer as they travel closer. This would explain why salmon would be found in shallower water as they near their natal rivers, but it does not account for the bizarre behavior of traveling such great distances in the water column. The reason exemplifies the power of smell as a navigational tool; the salmon are enhancing the smell of fresh water, and thus are able to precisely identify their specific river among the others. In order for salmon to isolate the smell of their target river, they have to enhance their ability to differentiate between the plethora of freshwater sources. An example used by Thomas Quinn is that the smell of a bakery is much more powerful when you first walk in the door than if you have been there for any amount of time. Same with salmon, the smell is more powerful if they are constantly being re-exposed to the scent of the stream to which they are navigating than if

Understanding that scent is the primary navigation tool of salmon once they are within smelling distance of their river helps clarify why fish trap location is so important. Where the river and ocean meet – the river delta –there is very little mixing of fresh and salt water. The river flows unopposed mostly for its entire length until it hits the wall that is the ocean. The energy produced by the rushing water is suddenly met by the energy of the ocean, and when two opposing forces collide the results can be dynamic. The fresh water, instead of continuing in a straight line out into the ocean, is diverted and continues near-shore gradually mixing with the ocean. This phenomenon creates a near-shore freshwater scent trail that extends for miles. Salmon, following the scent to their river, will travel the last leg of their marine journey relatively close to shore where the scent of the river is strongest. Fish traps, with their leads extending out hundreds of feet from shore, lay directly in the path of migrating salmon. However, prevailing ocean currents, river velocity, and ocean temperature would all have played a role in precisely how successful a trap was. Salmon generally follow the strongest scent trail back to the river, and placing a trap outside of that stream would have yielded marginal success. The most profitable fish traps would have lain – however unknowingly – in the path of the strongest freshwater slick. Thus, as verified in H.C. Scudder's account, a matter of feet could be the difference between success and failure.

However efficient they were, fish traps came to symbolize something much more sinister for statehood advocates. Fish traps, during the years of federal management, were primarily owned by canneries, which were owned by outsiders. Alaska fishermen and many Alaskans in general identified them as an emblem of federal oppression of Alaska's then-most profitable resource. [26] In 1954, Ernest Gruening stated, "transfer of the fisheries to Alaska would spell the banishment of the

they simply traveling in the portion of the water column that is higher proportion of fresh water. Smell, quite simply, is such a vital navigational tool that it influences salmon *behavior*.

[26] Ernest Gruening.

fish traps by its people," who would then be "set free." [27] Another anti-trap politician said that fish traps were the "most murderous and iniquitous instruments that ever were devised by the human brain to destroy natural life."[28] This emotionally charged language was common regarding fish traps. However the arguments opposing their use were based more on what fish traps *represented* than fish traps themselves. Fish traps were a symbol of federal mismanagement, encroachment of outside industry into Alaska's resources, and the establishment of a property-rights-based commercial fishery. These concepts clashed with notions of open access for all to Alaska's resources – a stance popular with residents.

The territory of Alaska had long opposed federal attempts to limit entry into Alaskan fisheries, believing that the federal government did not have the authority to tell them whether they could or could not fish. While the open access fishery stayed relatively intact during the federal tenure, fish traps came to represent an attempt to create private property in the ocean. Though there were never explicit property rights, the presence of fish traps certainly implied such rights. . Fish traps, being fixed throughout the season, made it impossible for the seiners to work around them. In fact, there were laws provisioning a 300 foot berth around fish traps where commercial fishing vessels were not allowed to operate, creating exclusive fishing zones. This, many Alaskans pointed out, established exclusive rights to the resource. The federal mandate supporting such exclusivity became a serious point of contention. Many like Ira N. Gabrielson of the Alaska Territorial Department of Fisheries believed that no one was "entitled to a vested right to a natural resource."[29]

Vic Fischer, delegate to the Alaska constitutional convention recounted, "the use of traps to catch salmon had been a gut issue that energized the fight for statehood, traps being the ultimate

27 *Ibid,* 407.
28 Congressman William Sulzer, as quoted in *Alaska Salmon Traps.*
29 As quoted in *State of Alaska,* 394.

symbol of the absentee cannery owners who were responsible for devastating the territory's fisheries and impoverishing coastal communities."[30] Gruening also acknowledged their symbolic role in establishing statehood: "…the issue of fish traps – the territory's most visible psychological and physical symbol of outside control – descended as a legacy of territorial history."[31] Indeed, Alaskans in general, not just the commercial fishermen, took up arms against the despised fish traps, and sought to end the traps' "reign of terror."

Alaskan economist George Rogers argued that the "anti-trap case ha[d] been emotionally distorted to the point where even Alaskans who have never seen one would readily brand them as 'fish killers' and look upon them as the very embodiment of evil in this world."[32] Economist James Crutchfield verified Rogers claims: "The years of discrimination and political frustration led Alaskans to articulate the question of control of the fisheries on a straight 'we-they' basis that left little room for rational discussion of the biological and economic complexities of the resource and the industry."[33] Indeed, the Alaska salmon fishery had become a political hot button issue, and the emotionally charged rhetoric used by statehood advocates left little room for discussion regarding alternate fish trap implementation methods.

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30 In James Mackovjak, vii.
31 *State of Alaska,* 533.
32 George Rogers, *Alaska in Transition: the Southeast Region* (Baltimore: Johns Hopkins Press, 1960).
33 James Crutchfield, as quoted in Steve Colt.

Figure 3: By 1948, the anti-fish trap rhetoric had gained a political foothold in Alaska. For statehood advocates, eliminating fish traps became a public necessity. Source: "Fish Trap, Alaska's Enemy No. 1," 1948, Russ Dow papers, Archives and Special Collections, Consortium Library, University of Alaska Anchorage, UAA-hmc-0396-14o-f12-53.

Along with associating fish traps with outside business interests, statehood advocates saw the resource as being managed by an agency that did not have a vested interest in the success or failure of the industry, and that did not have to endure the economic hardships that resulted from poor management decisions. The future of the salmon industry, and the territory itself, was in the hands of transient, non-permanent policymakers.[34]

Therefore federal management was vilified. For instance, with the passage of the North American Fisheries Act in 1954, the tide of environmental policy shifted. Heralded as one of the first international fishery agreements, the United States, Canada, and Japan collaborated to develop a policy to protect property rights in their respective fisheries. By prohibiting Canada and Japan from fishing in Alaskan waters, pressure on Alaska's salmon industry and the salmon themselves

[34] See Peter A. Coates, *The Trans-Alaska Pipeline Controversy: Technology, Conservation, and the Frontier* (Cranbury: Associated University Presses, 1991), 38.

was reduced significantly. While the biological and ecological impact of the act may have been minimal, given that salmon stocks do not respect political boundaries, the political implications were great. The United States had taken a step towards exclusivity of a resource on an international stage.[35] While this particular exclusion had the potential to benefit Alaskans, it had the whiff of exclusivity that offended pro-Alaskan ideology.[36]

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35 North Pacific Fisheries Act of 1954, Aug. 12, 1954, ch. 669, 68 Stat. 698 (16 U.S.C. 1021 et seq.).

36 Despite the seemingly unanimous dislike for fish traps, their advocates did not hesitate to defend their use. The late Ralph W. Johnson, professor of law at the University of Washington published a rebuttal to the anti-fish trap movement in 1964 titled "Regulation of commercial salmon fishermen: a case of confused objectives," five years after their abolishment in Alaska. In this heavily referenced source, Johnson argued for the economic viability of fish traps, stating, "they make salmon catching absurdly easy and can be operated at 1/20 to 1/30 the boat-catching costs." Johnson argued that commercial salmon fishing from a boat – which he believed was "as obsolete as the buffalo hunter" – as opposed to fish traps "makes economic sense as a temporary palliative for an unemployment problem; it makes economic nonsense as a permanent industry in a competitive society in a competitive world." Johnson introduced fish traps as a solution to an economically vulnerable industry, and he may have been onto something. By removing the emotional distortion of cultural connotations Johnson found that fish traps were a potential solution to underlying problems inherent in current salmon management strategies.

Most important to the analysis of the economic viability of fish traps is a thorough understanding of the data from when fish traps were operational. Steve Colt's study titled "Salmon Fish Traps in Alaska," was the first thorough economic analysis of fish trap operations in Alaska in the mid twentieth century. Colt found that fish traps saved roughly $21.51 million in 2014 dollars per year, or about 12 percent of the ex-vessel value. While Colt found that from an economic standpoint fish traps were largely beneficial, he noted that an economic drawback was that there were significant startup costs for operation. Based on testimony collected by industry experts, the annual cost of installation varied from $4,000 to $40,000 per year per trap – between roughly $34,500 and $355,000 in 2014 dollars according to the United States Bureau of Labor Statistics – depending on location and whether the trap was fixed or floating (floating traps had a significantly smaller annual installation cost). Additionally, depreciation meant replacing about 1/3 of the traps annually, and 2/3 of the traps every five years.

Another drawback was that participation in the fishery was limited to roughly 420 traps. Since fish trap success depends largely on precise positioning, and there are only a finite amount of optimal locations, per-trap production is greatly reduced as more traps enter the industry. Colt argued, "trap operation was very attractive when the new technology was first introduced, the best locations were used, and average yields exceeded 100,000 fish per trap," but as more fish traps entered the industry, profits began to dwindle, and "only when the number of traps was reduced from the all-time high level of 799 (in 1927) to about 420 (throughout the 1930s and 1940s) did the traps show cost savings." Despite the downsides, fish trap operation was largely successful as an economic endeavor. Once the initial investment was made, operation costs were marginal. Each trap required only a few attendants, and the operation of the trap required little effort.

Additionally, since the fish are stored in a live pen, fish trap operators were able to "smooth their flow of raw fish to the production lines during periods when the fisheries were closed for conservation or during natural swings in the run," creating the possibility of a consistent income in a traditionally inconsistent industry. Colt's study created a foundation for understanding the economic aspects of historical fish trap operations. But these economic advantages do not take into account a quota system like ITQs, which have the potential to accompany the fish trap model flawlessly. Colt saw an economic advantage to fish traps in that they were the closest things to an exclusive fishing zone given that boats were not allowed to operate within 300 feet of the trap. By eliminating competition in a given area, and partially dealing the problem of subtractability – the perception by fishers that any fish not caught by them will be lost to another fisher – fish traps were the first step towards what would be today considered progressive conservation ideologies. The problem of subtractability is discussed in the main text below.

3.5 Statehood

The extent that federal management played in the decline of the salmon population in the 1950s could not be demonstrated empirically, but as Gruening noted, "depletion was associated primarily in the minds of the fishermen with the existence of fish traps,"[37] and fish traps became hugely symbolic. In fact, Alaska residents were so enraged by the fisheries issue that in 1955 when voting to ratify the constitution, more people voted to abolish fish traps than to ratify the constitution itself![38] And there is little doubt that Alaska's constitutional delegates directly opposed federal mandates resembling vested rights to the resource by provisioning against "exclusive right or special privilege." Open access harvest strategies were written into Alaska's Constitution, and Ordinance number 3, which banned fish traps in Alaska, was passed, "as a matter of immediate public necessity, to relieve economic distress among individual fishermen and those dependent upon them for a livelihood, to conserve the rapidly dwindling supply of salmon in Alaska, to insure fair competition among those engaged in commercial fishing, and to make manifest the will of the people of Alaska."[39] The establishment of local preference in the Alaska Constitution demonstrated the economic imperatives of the new state. Thus, with statehood, Alaska's fishery management regime shifted to reflect Alaskans' demand for ownership and control of the resource. Just as knowledge of salmon biology and ecology was advancing, Alaskans' commitment to an open access resource hindered the implementation of sustainable practices, including the use of the efficient fish trap.

Where as federal managers understood that unlimited participation in the industry was not sustainable, Alaskans saw federal policies as nothing less than attempts to exclude residents from

37 *Ibid,* 392.
38 Ordinance number 3 read: "Shall Ordinance Number Three of the Alaska Constitutional Convention, prohibiting the use of fish traps for the taking of salmon for commercial purposes in the coastal waters of the State, be adopted?" and passed by a 10 to 1 margin: Ordinance Number 3, Alaska Constitution, and Vic Fischer, in James Mackovjak.
39 "The Constitution of the State of Alaska," Ordinance No. 3.

participating in the harvesting of a resource that they viewed as theirs.[40] The solution, therefore, was to allow unlimited participation in Alaska's salmon bounty with the assumption that Alaska's commercial fishermen would not take more than their share. The new state explicitly declared the salmon resource an open access industry; Article VIII, Section 15, as adopted with statehood in 1959 reads: "no exclusive right or special privilege of fishery shall be created or authorized in the natural waters of the State."[41] At last, Alaska was in control of its own resources.

However, by the end of the 1960s, the salmon populations were once again in dire straights with commercial harvest for all species dropping to around $100 million by the early 1970s, from its peak of $300 million only years earlier.[42] The state's solution was to alter the open access mandate. In 1972, the Alaska Legislature amended Article VIII, Section 15 by adding a clarification to the original writing. The second sentence stated, "This section does not restrict the power of the State to limit entry into any fishery for purposes of resource conservation, to prevent economic distress among fishermen and those dependent upon them for a livelihood and to promote the efficient development of aquaculture in the State."[43] While the two statements "*no exclusive right or special privilege* shall be created or authorized in the natural waters of the State," followed by the provision that the State can create exclusive right or special privilege by limiting entry "for the purposes of resource conservation…" could be interpreted as contradictory, they also represent the shifting political and economic needs of the state.[44] Instead of contradicting open access, Section 15 is better understood as an attempt to reconcile economic demands and ecological sustainability.

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[40] See Richard Cooley, *Politics and Conservation: The Decline of the Alaska Salmon* (New York: Harper & Row, 1963), Ernest Gruening, *The State of Alaska* (New York: Random House, 1968), George Rogers, *Alaska in Transition: the Southeast Region* (Baltimore: Johns Hopkins Press, 1960).

[41] Alaska Constitution.

[42] See "Alaska Commercial Salmon Catches & Value 1878-2013 – All Species Combined," graph produced by the Alaska Department of Fish and Game.

[43] *Ibid.*

[44] "The Constitution of the State of Alaska," Article 8, Section 15.

These steps to mitigate the problems associated with an open access resource, however would prove temporary and the inherent problems associated with an open access industry continued.

3.6 Open Access and “Tragedy of the Commons”

Departing from the narrative momentarily, a closer look at how resource management ideology has evolved helps explain why this resource is so difficult to manage. It was not until 1968 that the problems associated with open access resources were given a name: “the tragedy of the commons.”[45] Garrett Hardin, a human ecologist, wrote the foundational essay on resource exploitation that identified fundamental flaws in open access land use ideologies and the resulting ecological consequences. In his telling, Hardin asked the reader to imagine a field – a commons in England – where farmers let their cows graze. This was sustainable if all the farmers allowed one cow to graze, but their rational self-interest prompted them to allow two cows to graze. Eventually, the commons was destroyed because the farmers saw the profitability of taking as much for *themselves* as they could or see it go to someone else. Hardin believed that this mentality is inherent in humans, and that one solution to the problem is to eliminate the commons. By creating private property the problems associated with the commons were averted. In other situations Hardin recommended coercion, or regulation, to discourage people from pursuing their immediate personal interests.[46]

Hardin’s thesis began a discussion that continues to this day. Scholars like anthropologist Katja Neves-Graça argue that the deterministic portrayal of human behavior conflates human behavior with capitalist incentives and does not take into account non-capitalist relationships with the natural world like native subsistence users.[47] Even supporter Arthur F. McEvoy, author of *The*

[45] Garrett Hardin, “The Tragedy of the Commons,” *Science* 162, no. 3859 (13 December, 1968).
[46] *Ibid.*
[47] Katja Neves-Graça, “Revisiting the Tragedy of the Commons: Ecological Dilemmas of Whale Watching in the Azores,” *Human Organization* 63, No. 3 (2004).

Fishermen's Problem: Ecology and Law in the California Fisheries, 1850-1980, was hesitant to accept Hardin's argument without slight revision. Though McEvoy largely supported Hardin's notion of tragedy of the commons to explain the current fisheries crisis, he veered away from asserting that selfish, individualistic behavior is inherent. "The competitive individualism that Hardin believed inevitably led to 'the tragedy of the commons' might not be a generic failing of the human species," McEvoy argued, "but rather the specific historical consequences of the social changes that followed the advent of modern capitalist modes of production and social organization."[48] Despite the criticisms of Hardin and his controversial argument regarding human behavior, even his skeptics acknowledged that the open ocean is the ideal modern representation of the commons with all its attendant problems.

Scholars who study open access industries, specifically fisheries, point to the lack of defined property rights as a major cause for overfishing. Like the farmers in England sharing the commons, commercial fishermen on the open ocean aim to harvest as much as possible to maximize their own economic gain with little consideration of other users or the economic or ecological sustainability of their actions. To paraphrase McEvoy, this is not a fundamental human flaw, but the rational self-interest essential to economic success in a capitalistic system. "Fisheries simply provide a laboratory example of the problem of environment because…in most cases it is impossible to consign their husbandry to private owners as if they were cropland or stands of timber," he noted.[49] Elinor Ostrom, a Nobel laureate in economics, furthered the argument that "a basic problem leading to massive overfishing in the oceans is the lack of *any* property rights for the many commercially valu-

48 Arthur F. McEvoy, *The Fishermen's Problem: Ecology and Law in the California Fisheries, 1850-1980,* (Cambridge: Cambridge University Press, 1986), 12.
49 *Ibid,* 14.

able species in the open ocean."[50] She asserted that the way to effectively manage common pool resources was to establish recognizable structures of property rights or ownership. Privatization, which could take on multiple forms and is not bound by Hardin's notion of resource ownership, would avert degradation of the resource.[51] This is not to say that individuals treat their own property with more restraint. They merely would only have the right to harvest a smaller portion of the population, and without fear of someone else reaping the profit. Privatization would help prevent individuals from infringing on the development opportunities of others, Ostrom argued.

Though scholars understood that open access resources encouraged overharvesting by 1968, there was still little consensus as to *why*. Hardin pointed to fundamental human behavior, but later scholars like McEvoy and Neves-Graça veered away from the oversimplified, deterministic explanation. Hardin identified the rational self-interest as predicated by capitalistic ambitions, but failed to identify the economic, social, cultural, and political complexity of resource extraction by simply assigning the negative consequences to inherent human behavior. He recognized a solution in privatization or regulation, but without contextualizing the complexities of an open access resource, his solutions did not provide a comprehensive framework for problems posed by the real world. The underlying problem of the commons was not inherent human behavior as Hardin believed, but a fundamental concept within the industry itself: *subtractability*.

In her 2005 book *Understanding Institutional Diversity,* Elinor Ostrom identified this underlying economic phenomenon that encouraged behaviors like hoarding and overharvesting; subractability, according to Ostrom, "refers to the extent to which one individual's use subtracts from the availability of a good or service for consumption by others."[52] Quite simply, if another's behavior

50 Elinor Ostrom, "The Challenge of Common Pool Resources," *Environment* 50, no. 4 (2008), 12.
51 *Ibid.*
52 Elinor Ostrom, *Understanding Institutional Diversity* (Princeton: Princeton University Press, 2005).

affects one's participation in a specific activity – if someone else's success negatively affects the success of another – we are much more inclined to maximize our own profit to ensure our success, thus overharvest. Ostrom's concept supports the established argument within the field that behavior resulting in the tragedy of the commons is not inherent human behavior, but a consequence of the social, political, and economic complexities of a capitalist system. If we think of subtractability in terms of a private resource, like timber on a plot of land, we can see the distinction. If each lumber company X is given a plot of timber to harvest, timber company Y's activity on the next lot does not affect that company X's ability to harvest lumber, thus eliminating the problem of subtractability. However, if there are no property rights, and company X and Y are competing for lumber on a single hillside, both are much more inclined to overharvest because every tree that company X harvests will earn it more profit. To make the analogy similar to that of salmon fisheries, we must add the factor of *indetermination*. If company X and Y are competing for an indeterminate amount of trees, they harvest without reservation. Without assurance of the resource's future viability, the compulsion to harvest is limitless, and overharvest is all but inevitable. In the current open access system, all the commercial fishermen are competing for an *indeterminate* amount of salmon, which only compounds the existing problem of subtractabiliy, resulting in a phenomenon called the "race to fish."[53]

The "race to fish" phenomenon was specifically referenced in an article published in *The Economist* titled "A Rising Tide: Scientists find proof that privatizing fishing stocks can avert disaster."[54] The article argued that under the current open access systems where total catch cannot be limited, "fishermen have an incentive to work harder and travel farther, which can lead to over-

[53] A Rising Tide: Scientists find proof that privatizing fishing stocks can avert disaster," *The Economist* (2008). http://www.economist.com
[54] *Ibid.*

fishing: a classic tragedy of the commons."[55] The ramifications of the race to fish are not limited to a simple tragedy of the commons dynamic, however. With a sudden rush of fishermen, fish stocks are subjected to a significant amount of pressure in a very short amount of time, spurred by the economic anxiety of an indeterminate resource. Concentrated stocks of economically desirable fish like halibut and salmon are harvested at unsustainable rates, and populations left fallow for the rest of the year. When fishermen return to the processors with a year's worth of fish during a window lasting only a few short days, the market is saturated and the price value of individual fish is diminished. So, this race to fish, which is a direct consequence of an open access resource, proves both ecologically and economically damaging. Managers saw the consequences of this phenomenon in the Alaskan halibut fishery, and have recently adopted a quota system to avoid both the race to fish and associated economic consequences.[56]

Economist and University of Alaska Anchorage professor Steve Colt in his article for the Institute of Social and Economic Research titled "Salmon Fish Traps in Alaska" addressed a second inherent problem with open access industries: "the economic theory of open access resources makes a strong prediction that additional entry will occur whenever the average *revenue* product of output is positive for an individual."[57] This theory has been called the zero-profit hypothesis, and predicts that open-access industries have a zero-profit equilibrium. That is, when participation is open to all, individuals will continue to join when there is economic incentive. This results in participation

[55] *Ibid.*
[56] *Ibid.* Both of the current ITQ systems in Alaska were specifically referenced in the article as an example of the shortcomings of the previous systems, and the promise of the new quota-based fishery: "The Alaskan halibut and king crab fisheries illustrate how ITQs can change behavior. Fishing in these waters had turned into a race so intense that the season had shrunk to just two to three frantic days. Overfishing was common. And when the catch was landed, prices plummeted because the market was flooded. Serious injury and death became so frequent in the king crab fishery that it turned into one of America's most dangerous professions...
After a decade of using ITQs in the halibut fishery, the average fishing season now lasts for eight months. The number of search-and-rescue missions that are launched is down by more than 70% and deaths by 15%. And fish can be sold at the most lucrative time of year—and fresh, so that they fetch a better price."
[57] Steve Colt.

to the point where there is a zero profit margin. Once the fishery becomes saturated, fishermen are forced to leave the industry, so as to "maintain a constant average economic profit level of zero."[58] Thus, open access industries are not just harmful to the resource itself, but to the economic stability of the resource. Alaska salmon fishermen have managed to avoid the zero profit equilibrium, not because of the effectiveness of the open access ideology itself, but because of rising real prices. "The periodic need to exit the industry has been minimized, but only by luck," Colt explains.[59] In short, rising real prices have delayed the inevitable consequences associated with the zero-profit equilibrium, including the loss of jobs resulting from an oversaturation of the industry. The unavoidable truth is that to develop a biologically and ecologically sustainable commercial salmon harvest, Alaskans must solve the underlying problems of subtractability, the race to fish, and the zero-profit equilibrium inherent in an open access resource – a task well beyond eliminating a few lines of the Constitution.

3.7 Quotas and the Elimination of the Commons

The current system of limited entry in Alaska simply controls the number of fishermen who can participate in a fishery, but does not restrict the number of fish they can harvest. Managers can only limit the catching potential of the commercial fleet, not the catch itself. In the words of Ralph W. Johnson, "everyone has his chance, if he promises to fish with one hand tied behind his back."[60] Proponents of a limited entry system like Johnson, saw a limitation of participants in the industry as a way to reinvigorate the salmon population. "The real answer" to the fisheries question,

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58 *Ibid.*
59 *Ibid,* 30.
60 Ralph W. Johnson, "Regulation of commercial salmon fishermen: a case of confused objectives," *Pacific Northwest Quarterly* 55, no. 4 (October 1964), 141.

Johnson argued, "lies in limiting the number of fishermen."[61] Given the information available to Johnson, this was a step in the right direction, but would later prove ineffective as a long-term solution. While the limited entry system had immediate benefits – as Johnson predicted: "All would, in fact, be assured of an increased income within a very short time…" – the long-term consequences would not be dissimilar from a completely open access fishery. Even limited entry results in a race to fish.[62] Thus, because both Ostrom's notion of subtractability and Colt's zero-profit hypothesis have not been addressed, Alaska's current limited entry system is not economically or ecologically sustainable. Since only the number of fishermen can be limited and not the total catch, the problem of subtractability still encourages the incentive to race to fish. The only difference is that there are fewer boats competing. Over the course of the limited entry system the few participants spend more money on gear to increase their catch rates. Limited competition means more fish to share among participating boats, so more capital can be invested in gear and personnel, increasing overall efficiency.

The idea that each fisherman is competing with every other for an indeterminate amount of salmon encourages a race to fish – just like in an open access system – and the same inclination to overharvest. Also like the open access system we encounter Colt's zero-profit hypothesis; instead of the *number* of fishermen resulting in a zero-profit equilibrium, it is the dramatically increased cost-per-vessel that drives the system. With the economic consequences of subtractability, the race to fish, and a zero-profit equilibrium come long-term ecological consequences, many of which Alaska is currently experiencing.

Not surprisingly, the state of Alaska faced another salmon crisis in the early 2010s, which

61 *Ibid.*
62 "A Rising Tide: Scientists find proof that privatizing fishing stocks can avert disaster."

yielded such dismal Chinook salmon runs in the Yukon, Kuskokwim and Cook Inlet drainages that the federal government allocated $20.8 million in disaster relief funds at the request of governor, Sean Parnell. Much of the disaster relief funds went directly Yukon River and Cook Inlet region fishermen received much of the relief funds to "compensate them for losses incurred from the Chinook Salmon Disaster during 2012."[63] Even as management strategies have adjusted, it remains clear that the future of salmon fishing in Alaska rests on the ability of managers and fishermen to balance economic needs against what is ecological sustainable.

3.8 Conclusion

Analyzing scientific and technological developments alongside the political, economic, and cultural tensions surrounding the salmon industry shows how natural resources like salmon are affected by political, cultural, and economic desires as much as biological and ecological science. Fish traps serve as the primary example of how both federal and state managers interpreted and implemented economic and political demands with respect to biological and ecological limitations. Federal managers, who were supportive of the industry as a whole and encouraged participation by outside interests, created opportunities for fish traps, and sought to reconcile large-scale economic demands. The territory of Alaska, on the other hand, was concerned with local participation and profits, and their management and legislative decisions reflected that. While federal and territorial objectives differed in scope, both were practicing the management principle of balancing economic opportunity against ecological realities.

63 "$7.8 Million in Fishery Disaster Funding Set to Arrive in Alaska," Press Release from the Office of Congressman Don Young (AK), 15 August, 2014. www.donyoung.house.gov

Chapter 4 Possible Solutions for a Sustainable Industry

4.1 Introduction

Fishery managers and scientists today are faced with pressures similar to those faced by federal managers in Alaska during the early 20th century. Management regimes reflect what is politically desirable as much as what is biologically and ecologically possible. The challenge of fishery management is not only staying current with the developing biological, ecological, and technical understanding, but acceptance in society as well. This chapter explores contemporary issues within the industry with a focus on modern fisheries management, possible solutions to what remains an erratic industry, and challenges specific to Alaska.

4.2 Fishery Management in an Oil Economy

Alaska statehood ushered in significant shifts in salmon research and management, expedited by the development of the Alaska petroleum industry. A decade after Alaska was ratified as the 49th state in the union, the state stumbled upon the greatest economic opportunity in Alaska history. Oil fields on the North Slope became the economic backbone of the new state, and the Alaska "oil economy" was born.[1] The new oil economy had far reaching effects on all aspects of Alaska's economic development. Between the years 1969 and 1987, the Alaska oil industry had profits exceeding $42.6 billion.[2] Prominent Alaska historian Claus-M. Naske observed that "petroleum ha[d] driven Alaska's economic growth since 1970, and oil revenues ha[d] paid most of the government's general expenses and supported thousands of public and private sector jobs since the late 1970s."[3]

1 Claus-M. Naske, *Alaska: A History,* (Norman: University of Oklahoma Press, 2011), 349.
2 *Ibid,* 353.
3 *Ibid,* 352.

Additionally, many of these funds were allocated to state-sponsored research endeavors, including the newly established Alaska Department of Fish and Game (ADF&G).

The discovery of oil proved a fortuitous turn of events for the young state. After a decades-long battle attempting to establish Alaskan economic autonomy, oil provided the opportunity for Alaska to operate with much less federal influence. Consequently, salmon research, which had traditionally been funded by the federal government, could be managed exclusively by ADF&G. Where Alaska had once relied on the private sector to provide a majority of salmon research funds, the oil industry allowed Alaska to move away from industry-specific pursuits.

The oil industry also had indirect consequences on the Alaska salmon industry. With the development of a new oil economy, the attention of the general public was directed North. Oil provided a temporary reprieve from an over-dependence on Alaska's salmon resource. Consequently, less pressure was placed on the development of the salmon fishery, and salmon populations rebounded. The prosperity of the salmon industry continued until the oil recession of 1998-1999.

By December of 1998, oil had plummeted in per-barrel value, and prices were the lowest on record since tracking began in 1949. In 2000, Alaska reported a fiscal deficit of about $1.1 billion and major oil companies were forced to downsize operations. Simultaneously, the salmon industry was affected by decreased population numbers, reduced demand by Asian markets, and competition from the far-cheaper farm-raised salmon. The recessions in both the oil and salmon industries resulted Alaska's increased demand on natural resource extraction to cover its losses. For the next few years, the salmon industry was marked by booms and busts, but the consequences of the oil recession on the Alaska salmon industry became manifest a decade later, prompting Governor Sean Parnell to turn to the federal government for disaster relief funds.[4]

[4] *Ibid*, 376.

4.3 Alaska Salmon Disaster

The salmon industry has undoubtedly shaped Alaska's political culture and economy, and commercial fishing has become a cultural venture as well as an economic one. Harvesting salmon from a seiner symbolizes what it means to be Alaskan – independent and rugged - and participating in Alaska's longest lasting natural resource industry is a point of pride. Economically, salmon fishing remains an important contributor to the state economy. In 2013 alone, the Alaskan salmon industry harvested more than 220 million fish with a total value nearing $900 million.[5] According to StatsAmerica, a service of Indiana Business Research Center at Indiana University's Kelley School of Business, commercial salmon fishing accounts for 38% of Alaska's cumulative fishing, hunting, and trapping exports.[6] At first glance it appears that business was booming, but statistics can be misleading. When the total catch was broken down by species, the data shows that of the more than 220 million salmon harvested in 2013, about 300,000 were Chinook salmon with a value of less than $10 million.[7] These shockingly low numbers were due to both significantly reduced population numbers and strict closures on the Chinook salmon fishery. Chinook salmon populations have been so low in recent years that they have been declared a disaster by the United States federal government and $20.8 million in disaster relief funds were slated for the 2014 fiscal year. This story is not new and certainly not unique. As the history of Alaska salmon industry demonstrated, population fluctuations are endemic. The Alaska salmon industry is the picture of a boom-and-bust enterprise, and often this economic cycle is accompanied by ecological and biological degradation; economic

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5 Alaska Department of Fish and Game, "Alaska Commercial Salmon Catches & Value 1878-2013, All Species Combined." http://www.adfg.alaska.gov

6 "USA States in Profile: Alaska," *StatsAmerica* (Bloomington: Indiana University Kelley School of Business) last updated 18 March, 2015. www.statsamerica.org. Alaska is ranked number 1 in fishing, hunting and trapping exports with a 2014 value of 2,365,556,655, 45.9% of the state's total North American Industrial Classification System (NAICS) exports.

7 Alaska Department of Fish and Game, "Alaska Commercial Chinook Salmon Catches & Value 1878-2013." http://www.adfg.alaska.gov

booms mean more fishermen, more gear, and more opportunity at the expense of the biological and ecological communities. During the periods of naturally low population numbers, the heaving fishing pressure during productive years exacerbates the problems of an already stressed population. Attempts have been made to relieve the industrial stress placed on the resource by limiting participation and gear type by legislation, but the long-term consequences are not dissimilar from an unregulated resource.

In this era of heightened ecological awareness and booming technological capabilities, the development of a sustainable industry is feasible, if not expected. In an interesting twist, a viable solution to the modern salmon crisis in Alaska could be to go back to technology that was banned more than fifty years ago: fish traps. But resolving the modern fisheries dilemma would require marked changes in not only legislation, but also how Alaska's commercial fishermen understand their relationship to the salmon resource. Common use must be revisited with a special eye to contemporary understandings of open access resource development and surrounding problems.

The history of Alaska's salmon fishery shows all too clearly the consequences of an open access resource. The scholarship of Elinor Ostrom and Steve Colt points to specific shortcomings in accepted ideologies. Now, just like in the late 1960s, and the 1950s before that, Alaskans must find a solution to the salmon question that transcends biological, ecological, and economic interests.

To begin, moving beyond the simple problems associated with the commons, subtractability and the zero-profit equilibrium must be taken into consideration. Analysis of the problem will show that adoption of an Individual Transferrable Quota (ITQ) and the implementation of a system using industrial salmon fish traps could be a solution that is ecologically, biologically, and economically sustainable. The ITQ has gained favor in the fisheries community; it eliminates the open access ideology by assigning property rights to a portion of the fishery. In one fell swoop subtractability and the zero-profit equilibrium are eliminated.

Since entry into a specific fishery is limited, and participants are given quotas that they are not to exceed, fishermen no longer compete with one another. Quite simply, one fisherman harvesting his quota has no affect on another fisherman harvesting his. Suddenly, there is no longer an economic incentive to outcompete other fishermen, and no longer a race to fish. Rather, it is in the fisherman's best interest to harvest his quota with as little cost to him as possible and at times when fish have the highest value, which addresses the zero-profit equilibrium and encourages a consistent supply of fish to assure the highest quality and highest price-per-fish. With the elimination of inter-vessel competition for the resource, and the desire to fill the quota at as little cost as possible, the economic equilibrium is *profitable* and the problem of overfishing mitigated.

Furthermore, ITQs open other economic sectors to the fishing industry. Since quotas can be leased, sold, or transferred, the dealings in quotas can be as economically lucrative as the harvest itself. These programs have succeeded in Australia's lobster fishery, Alaska's crab fisheries, and more recently in the Alaska halibut fishery. The transferrable quota system empowers local participants and develops a stronger local connection to the resource. No longer are fishermen the only participants in the industry.

Despite the promise of ITQs and the economic and ecological benefits of adopting them, the current boat-based salmon harvest poses complex problems involving feasibility and implementation, specifically in establishing realistic, pre-season quotas. Case studies of successful ITQ systems in Alaska are the halibut and crab fisheries, but unlike those species, salmon spawn only once, so overharvesting a single run has compounded effects. This semelparity results in significantly greater salmon population abundance fluctuations than in iteroparous species, such as halibut and crab. Thus, establishing quotas on the basis of maximum sustained yield as mandated by the

Alaska Constitution is much more complicated. A strong surge of salmon could indicate a strong run, but it could also indicate a weak run arriving earlier than usual. In short, it is all but impossible for managers to assign realistic harvest quotas before they receive initial harvest data indicating the strength of the run.

Furthermore, given the wide marine migration patterns of salmon, there is no way to establish drainage-specific selective harvest methods, which would be essential in maintaining the fishery during drainage-specific population concerns. For instance, given that the Yukon, Kuskokwim, and Cook Inlet drainages are experiencing dangerously low Chinook salmon population abundances, it would be in the managers' best interest to relieve the pressure of commercial fishermen on the threatened stocks. However, boat-based capture methods such as seining make any sort of species-specific harvest impossible. Despite assigning quotas to the fishermen that would appear conservative, if a large portion of the harvested fish is from a low-density stock the consequences could be severe. So even if managers *could* issue pre-season quotas to commercial fishermen, they would not be able to account for which stock was being harvested. Where a relatively strong Chinook run may allow for higher quotas, threatened runs would allow for small quotas – perhaps no quotas would be issued altogether.

4.4 A New Management Regime

Though political and economic roadblocks would make implementing an ITQ incredibly difficult, a comprehensive solution may involve going back to a capture method banned after Alaska statehood in 1959. Fish traps could answer a number of questions posed by salmon managers and the commercial salmon industry. By establishing fixed traps in strategically selected locations, the Alaska salmon industry would be able to effectively implement an ITQ system and, for the first time, implement a management system that is completely economically and ecologically sustainable.

Like current ITQ systems, the trading of quotas in the commercial salmon fishery could introduce diverse economic opportunity in areas that traditionally depended heavily on commercial fishing. The advantages of localizing economies for both environmental and ecological sustainability are gaining a foothold in the global environmental economic discussion. Just as Ernest Gruening advocated for the localization of the Alaska salmon industry believing that local participation would strengthen the resource, Frank Alcock, assistant professor of political science at New College of Florida and director of the Marine Policy Institute at Mote Marine Laboratory, argued empowering local participation would be both environmentally and economically beneficial.[8] By giving local preference in the commercial salmon industry, and developing comprehensive legislation to prohibit a big-business takeover, introducing fish traps and an ITQ system would allow for a developed, complex rural economy that could participate in global trade. An alternative would be a Community Fishing Quota (CFQ) depending on the number of participants or investors per fish trap. CFQs would resemble a cooperative or community program where the community as a whole would own the quota, which could then be left intact or divvied up among individual community members. Empowering local economies would in turn strengthen regional and national economies while simultaneously promoting sustainable harvest.

The ecological benefits would not be limited to the indirect benefits of promoting greater stewardship through the empowerment of local economies. Direct ecological benefits of a fish trap based salmon fishery are substantial. The National Institute of Occupational Safety and Health reported that between the years 2000 and 2009, the average annual number of commercial fishermen participating in the Alaska commercial salmon fishery was more than 34,000, creating a commercial

8 Frank Alcock, "Sustainable Trade Begins at Home," *World Policy Institute* (2008), 54.

fleet of staggering proportions. The sheer number of fishing vessels has environmental consequences, one of the most obvious being the burning of fossil fuels. In his 1964 article, Ralph Johnson stated that in the year 1963 there were more than 30,000 United States and Canadian commercial fishermen participating in the Alaska salmon fishery – not much different than the 31,300 in 2014 according to United States Bureau of Labor Statistics – and that with fish traps "roughly 27,000 of them were unnecessary; they could have stayed on shore without any reduction in the total catch and with a distinct improvement in the management of the resource."[9] Based on Johnson's figures, fish trap operation could harvest the same amount of fish as 27,000 commercial salmon fishing vessels using only the fuel required for the boats needed to empty the trap's live pens.[10]

Not only would fish traps significantly reduce the carbon footprint of the salmon fishing industry, they would reduce the ecological footprint as well. Because fish traps are fixed – regardless of whether they are designated a fixed or floating trap – there is minimal ecological disturbance. Since fishermen compete with other marine species like whales, seals, and sharks for salmon, fishing vessels often come into direct contact with them. Aside from the by-catch of seine boats, the boat activity negatively affects the behavior of marine predators. When discussing the ecological consequences of whale watching in the Azores, Katja Neves-Graça pointed out that "often whale-watching boats produce too much underwater disturbance (noise), leaving the whales disoriented…

[9] Ralph W. Johnson "Regulation of commercial salmon fishermen: a case of confused objectives," *Pacific Northwest Quarterly* 55, no. 4, (October 1964).

[10] An equally important issue that the elimination of those 27,000 fishermen would address is fatal and nonfatal injuries associated with commercial fishing. The U.S. Centers for Disease Control and Prevention National Institute of Occupational Safety and Health produced a report titled "Fatal Occupational Injuries in the U.S. Commercial Fishing Industry: Risk Factors and Recommendations, Alaska Region" (http://www.cdc.gov/niosh/docs/2011-103/pdfs/ak_cfid_summary_ev.pdf) reporting that between the years 2000-2009 there were 39 fatalities associated with the Alaska salmon fishery. The institute reported Full-Time Equivalents (FTEs) in the Alaska salmon industry was 34,287 with an annual fatality rate of 115 per 100,000 FTEs between the years 2000-2009. Non-fatal injuries are difficult to estimate because statistics are not available for self-employed fishermen, and according to the U.S. Bureau of Labor statistics represents roughly 50 percent of commercial fishermen. For more information regarding the U.S. Bureau of Labor Statistics, see "Facts of the catch: occupational injuries, illnesses, and fatalities to fishing workers, 2003–2009." http://www.bls.gov/

this can potentially affect their social lives, their capability to feed themselves, or their ability to nurture their offspring. Some argue that such stresses can actually compromise the ecological resilience of whales and that, as such, whale watching might have serious negative impacts on the long-term welfare of the species."[11] Though she was discussing the ecological impact of whale watching specifically, commercial salmon fishing produces similar ecological consequences; both industries place themselves in close proximity to marine predators, both produce significant noise, and the commercial salmon fleet has the added stress of *competing* with the marine life for the salmon resource. Fish traps would eliminate such disturbances and would occupy water unfit for whales. The direct ecological benefits of fish traps in nearly eliminating the carbon and ecological footprint of the commercial salmon industry would compound the tremendous ecological and biological benefits of effective management and regulation. Additionally, effective management in the new system would bolster economic development and encourage the sustainable growth of the industry.

Transitioning to an ITQ or CFQ system would mean an ideological shift in the role of salmon management; an already dynamic strategy would have to include the ability to forecast salmon population abundances at a heightened level of precision –and farther in advance – than is possible with technology currently available. While a quota system would have significant benefits, the limitations – as discussed previously in the complexity of establishing realistic quotas – are undeniable. However, the difficulty of managing such a dynamic resource would be mitigated by the use of fish traps. Not only would salmon managers be better informed as to real-time population information gathered from fish traps using state of the art equipment, but they would be able to establish realistic quotas, better protect threatened species of salmon from overharvest, and more

11 31,300 fishermen in 2014 reported by U.S. Bureau of Labor Statistics. www.bls.gov. Neves-Graça, Katja,"Revisiting the Tragedy of the Commons: Ecological Dilemmas of Whale Watching in the Azores," *Human Organization* 63, No. 3 (2004), 290.

efficiently regulate participants in the industry.

Fish traps employ a holding pen where the salmon gather and are kept alive until they are loaded onto a tender. The ability to keep captured salmon alive for a period of time makes dynamic management strategies possible like never before. In the current system of management, initial population estimates are based largely on the commercial harvest. In fact, the only way to verify population run size is to count in-river escapement, which means that the salmon have already navigated the gauntlet of nets and are no longer harvestable. Unfortunately, with commercial fishing vessels there is little opportunity to determine the size of the harvest until the fish have been killed.[12] By using live pens, managers could collect the same data without threatening the entire run, mitigating the risk of ambitious harvest rates before proper information has been gathered. State of the art DIDSON imaging sonar could be installed on each trap to provide precise, real-time information regarding the number of fish in each trap. DIDSON sonar produces video-quality sonar readings that are so precise they can determine fish length.[13] That information could be shared with managers throughout the state instantaneously and allow them to develop more precise population data at a high level of efficiency. Based on the information provided to the managers, they could determine the strength of the run before a single salmon is harvested. Based on initial numbers, they could then designate a quota that would ensure sustainable escapement.

Live holding pens have more than one management benefit. If at any time managers find that population numbers have taken a turn for the worse, they could immediately disseminate a closure in which the fish currently being held in traps would be released immediately. To imple-

[12] Commercial harvests are not necessarily indicative of the size of the salmon run. For example, a large initial catch could indicate a large run, or an average run that has arrived early. Initial population estimates usually come with a wide margin or error, and they can only be verified in river, at which point it is too late for commercial harvest.

[13] "DIDSON," Echoview, (2014). http://www.echoview.com

ment such a system harvest would have to be highly organized. For example, there would be a precise date and time when each trap was allowed to harvest the salmon being held in the pens. Once managers were satisfied that a sustainable population had been established, they would allow traps to harvest their catch. These harvest dates would be scheduled pre-season in increments that allowed for population estimates, while also accounting for the need to harvest the salmon to prevent overcrowding in the pens.

In order to ensure that the salmon run is harvested proportionally – that is, ensuring that not only early fish are harvested, for example – fish traps could have openings. Towards the end of the federal government's salmon management in Alaska, United States Fish and Wildlife Service Director John L. Farley proposed limiting fish trap operation to certain times of day ensuring proportional abundance. A similar system could be adopted under a quota system with fish traps. Such a regulation would be easy to implement. It would only require operators to close the openings into the first hearts so that the salmon simply swam around. The ease of closure would mean they could be quickly and efficiently implemented.

Once a particular trap's quota had been met, the trap itself would simply cease operation for the season. The opening to the first heart would be closed, the anchors pulled, and the trap dragged to its overwintering site. Given the limited number of fish traps and the real time data provided to managers, quota information would be immediately available. Managers could use the sonar counts to determine precisely the number of fish in the trap at any given time, the precise number of fish harvested, and, with additional sonar installed on the exit gate, the precise number of fish released.

Fish traps would not only offer great management benefits. Commercial fishermen would also benefit from the new system. Selective harvest would be a saving grace for participants of the salmon fishery during times of species-specific closures. In recent years, with Chinook salmon populations in the Yukon, Kuskokwim, and Cook Inlet dwindling, commercial harvest of other perfectly viable populations have been limited. A specific example is the closure of the Cook Inlet sockeye commercial fishery to prevent the by-catch of the threatened Chinook salmon. Commercial fishermen hoping to take advantage of the booming sockeye population could only watch as more than an estimated 1 million sockeye salmon made their way past commercial fishermen and up the river systems of Cook Inlet.[14] It was the inability of seiners to selectively harvest that prohibited participation in the perfectly healthy sockeye salmon fishery.

Fish traps would allow for such selective harvest, thus enable commercial fishermen to continue operation despite species-specific closures. Since the salmon are held alive in the fish traps, fishermen could realistically isolate the desired species and allow the threated species to swim free. Size-specific exclusion devices could be installed on each trap that would lead to different holding pens. During the early part of the salmon season, generally only four of the five species start heading to the rivers: sockeye, pink, chum, and Chinook. Chinook salmon are typically significantly larger than the other species and could thus easily be separated from the sockeye, chum, and pink salmon. Given the demand and the economic advantage of being able to quickly separate desirable and undesirable species, the technology would develop quickly.

Compared with the current commercial salmon fishery, enforcement of fish trap regulation would be remarkably straightforward. Instead of monitoring tens of thousands of commercial fishing vessels, policing heavily competitive salmon openings, and chasing down renegade fishermen, law enforcement would have to check in on a small number of stationary fishing sites. Even during site visits, law enforcement officials would only have to ensure that the gear was legal, all the monitor-

[14] Rashah McChesney, "King salmon restrictions affect Cook Inlet sockeye management," *Peninsula Clarion*, as reprinted in *Alaska Journal of Commerce* (18 July 2014).

ing equipment was operating properly, and the each trap had the appropriate documentation. The data regarding number of fish per trap, number of fish harvested, the trap's operational status, and other relevant data associated with the harvest of salmon would all be digitally monitored from a central location. With such vast advances in communication technology and digital sharing, all information essential to ensuring traps were harvesting according to established protocol would be available to managers and enforcement officers. If a trap's information was not reporting to the central location, it would be the responsibility of law enforcement officers in the area to check the site and ensure that the regulations – including relevant closures or openings – were being obeyed. The use of fish traps in Alaska's commercial salmon fishery would greatly reduce the number of law enforcement officers necessary to monitor participation in the industry.

In addition to law enforcement, each trap could have a resident state employee whose job is to monitor trap operations. Like Alaska Department of Fish and Game officials who accompany crab-fishing boats in the Bering Sea to ensure proper harvest, such employees could be stationed on some or all of the operational traps. The presence of these officials would not just alleviate the pressure of law enforcement officers, but could act as the liaison between commercial fishermen and managers. While managers monitoring the population data from a centralized location are effective and efficient, it is also important to have a representative on site. The Alaska Department of Fish and Game technicians stationed on the traps would also serve a scientific purpose. Age-sex-length data, as well as any other scientifically necessary samples, could easily be collected from the harvested salmon. Thus, in addition to the enforcement and management advantages to fish traps of having a technician stationed there, there are scientific advantages as well. The most exciting aspect of fish trap implementation, however, would be the possibility for scientific and technological innovation within the field of fisheries and in the commercial fishing industry.

The promise of a transition to fish traps in Alaska's commercial salmon fishery is the possibility of technological innovation spurred by the inherent economic nature of an ITQ or CFQ system. When compared to current open access or limited entry systems, both ITQs and CFQs create an economic incentive for efficiency. As discussed previously, Alaska's current system of limited entry does not address the problem of the zero-profit equilibrium. That is, instead of the number of vessels inevitably leading to a zero-profit industry, the investment of capital per vessel would result in the same economic phenomenon. By creating economic incentive to be as efficient and inexpensive as possible in an ITQ or CFQ system, there is little doubt that participants in the fish trap industry would develop new technology that would be economically beneficial, and in turn ecologically beneficial. To use an example from above, if DIDSON imaging sonar were implemented into each trap – a method of sonar currently used by fisheries managers to count the in-river escapement of salmon – extremely accurate population data would be available instantaneously. This would enable managers to create more realistic harvest quotas that would allow for the greatest economic gain while simultaneously ensuring the strength of salmon runs. Furthermore, the implementation of exclusion devises would allow commercial fishermen to participate in the fishery despite species-specific restrictions. The economic incentive for continued participation in the industry would certainly create a demand for technology that enabled them to do so. Technology that is available today would be a platform for a rush of technological innovation within the fisheries industry.

The potential for technological innovation that is both ecologically and economically beneficial is difficult to envision or quantify. There are no solid examples from when fish traps were previously employed. Because fish traps in the early- to mid-twentieth century did not operate under a quota system – the system was actually quite similar to the current limited entry system, where only the number of participants was limited, not the amount of fish they could catch –hardly any technological advances that would fall under the criteria of ecologically *and* economically beneficial were used. Nevertheless, a transition to an ITQ or CFQ commercial salmon fishery in combination with the current technological climate would result in vast technological improvements in the commercial salmon fishery that could be economically and ecologically beneficial.

Despite the countless advantages to implementing an ITQ system along with fish traps into the Alaska commercial salmon fishery, substantial legislative and cultural hurtles would have to be overcome. Specifically, Ordinance No. 3 – the ordinance preventing the operation of fish traps in Alaskan waters – would have to be repealed. This alone would be a daunting challenge given the climate surrounding Alaska's salmon fishery. By repealing Ordinance No. 3, legislators would be opening the floodgates of opposition. Commercial fishermen would fiercely oppose the privatization of what is promised as a common use resource in the Alaska Constitution.[15] As seen in the tumultuous history of the Alaska salmon industry, interest groups often dig deep trenches and create a political stalemate. Joe Sullivan, a partner at Mundt MacGregor, a Seattle-based law firm, articulated the dilemma: "the public…sometimes resists the privatization of a public resource and if government gets too involved in the details of the privatization (rather than leaving it to the fishermen to work out), it can end up politically messy."[16] These processes, according to Sullivan are often slow and could take from 5-15 years to come into effect. The fact that there are currently newly adopted ITQ systems in Alaska shows that a transition to a system based on fishery-privatization is not out of the question, however, partially because, as Sullivan notes, "evidence that ITQs work is a powerful new hook to capture the political will and public attention needed to spread an idea that could

[15] Article VIII, Section 3 of the Alaska Constitution reads: "Wherever occurring in their natural state, fish, wildlife, and waters are reserved to the people for common use."

[16] As quoted in "A Rising Tide: Scientists find proof that privatizing fishing stocks can avert disaster," *The Economist,* (2008). http://www.economist.com

avert an ecological disaster." [17]

While there are, in fact, quota systems currently in effect in Alaska – halibut and crab –Alaska does not actually have jurisdiction in the waters where the majority of these fisheries occur. Outside of three miles off Alaska's coast, the state is no longer allowed to declare a resource as "common use," because the fishermen are in international waters. Instead, United States territorial waters are managed according to the Magnuson-Stevens Fishery Conservation and Management Act – an act named in part for the late U.S. Senator from Alaska, Ted Stevens. This act gives the United States Department of Commerce sole control over exclusive economic zones. Thus, management authority for fisheries such as groundfish (cod, rockfish, etc.) and halibut is directly under federal control.[18] For example, the Western Alaska Community Development Quota "allocates a percentage of all Bering Sea and Aleutian Islands quotas for groundfish, prohibited species, halibut, and crab to eligible communities" in order to promote economic development and community participation in the fishery; a program implemented by the U.S. Department of Commerce.[19] However, the Magnuson-Stevens Act stipulates that salmon are explicitly exempt from federal management. Instead, the jurisdiction falls squarely on the state.[20] Therefore, fish traps and ITQs involving the commercial salmon fishery would *exclusively* take place in Alaskan waters, thus falling under the jurisdiction of the Alaska Constitution. Therefore,, to implement the quota system in the salmon fishery, the Alaska legislature would have to address Article VIII, Section 3.

[17] *Ibid.*
[18] U.S. Department of Commerce, "Findings, Purposes, and Policies," *Magnuson-Stevens Fishery Conservation and Management Act* Section 2, (May 2007), 13. http://www.nmfs.noaa.gov/msa2005/docs/MSA_amended_msa%20_20070112_FINAL.pdf
[19] "Community Development Quota (CDQ) Program," National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office. http://www.alaskafisheries .noaa.gov
[20] U.S. Department of Commerce, "North Pacific Fisheries Conservation," *Magnuson-Stevens Fishery Conservation and Management Act* Section 313, 104-297, 109-479(a) (May 2007), 134. http://www.nmfs.noaa.gov/msa2005/docs/MSA_amended_msa%20_20070112_FINAL.pdf

4.5 Limitations to Quotas and Fish Traps

Transitioning to fish traps instead of continuing with the current boat-based commercial fishery would produce cultural ramifications as well. There is something to be said for what Ralph W. Johnson somewhat facetiously dubbed "the time-honored tradition of their forefathers . . ."[21] Commercial fishing in Alaska is embedded in coastal culture, and to suggest removing most, if not all of the commercial fishing vessels from the fishery, would create passionate pushback. Regardless of the validity and soundness of arguments regarding the economic, ecological, and biological benefits to the transition, suggesting that more than 30,000 people participating in the industry completely alter their way of life, is radical in terms of top-down economic reorganization in the United States. Thousands of fishermen would have to abandon their boats and reinvest in fish traps.

However, steps could be taken to smooth the transition. Local and state governments could explore options for transitional subsidies so that fishermen who have invested in a boat could affordably transition to fish traps. These funds could come directly from the state itself or through federal programs. For instance, when the federal government committed to sending disaster relief funds to mitigate the economic impact of poor Chinook salmon runs in the Yukon, Kuskokwim, and Cook Inlet drainages, there were no specific instructions as to *how* the $20.8M should be spent. NOAA Fisheries Alaska Regional Administrator Jim Balsiger stated that the only stipulation to the disbursement of funds was that they be used for activities that "restore the fishery or prevent a similar failure in the future, and to assist a fishing community affected by such failure."[22] The best way to fulfill this vague stipulation and develop a comprehensive economic, ecological, and biological program is to adopt an ITQ management system that uses fish traps as the harvesting

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[21] Ralph W. Johnson, 141.

[22] Julie Speegle, "Alaska Salmon Fisheries to Receive Nearly $21M in Fishery Disaster Relief Funds," *NOAA Fisheries News Release* (26 February 2014). http://alaskafisheries.noaa.gov

mechanism. Thus, a portion of the $20.8M could be used to subsidize individual fishermen and communities to ease the transition.

Still, boat fishing would be the preferred method of capture in some circumstances. For instance, in areas like Prince William Sound where pink salmon are returning to hundreds of small streams that feed into the sound, fish traps would not be as effective as commercial fishermen who can pinpoint pockets of pink salmon and harvest them. Fish traps are more suited for large estuarine environments where a large number of fish follow similar migration routes to a precise location, like the mouth of the Yukon, Kuskokwim, or other major river systems – precisely where a majority of the salmon crises occur. Therefore, a region-specific implementation of fish traps with ITQs or CFQs would be most effective. Regardless of the particular adaptation, the commercial fishery would still need to address the problem of subtractability and the zero-profit equilibrium while simultaneously encouraging local participation to promote the development of a sustainable local economy.

By empowering local participants and developing a commercial salmon industry that is not only economically sustainable, but ecologically and biologically, Alaska would be at the forefront of salmon fishery innovation. Demonstrating the effectiveness of such progressive policies would serve as a beacon for other nations that participate in the commercial salmon industry. Establishing the economic and ecological viability of such a program would encourage similar shifts in management ideologies and foster an international industry standard. Such a standard would open the doors to policies and scientific advancement unlike anything before.

Today, fish traps evoke significantly less emotional reactions from many Alaskans – certainly less than the nearly unanimous disdain for them in the 1950s. Unlike in the 1950s, adjectives like "murderous," "iniquitous," or "the very embodiment of evil in this world," resonate much less with current Alaska residents – many of whom have no knowledge of the historic debate. Today, terms prefixed with "eco" carry much more significant cultural connotations, and the fish trap's efficiency – both economic and ecological – might be seen as anything but brutal. Political aspirants would certainly not be able to "resort to taking a staunch stand against traps and count on the other issues being drowned out by ringing applause…" as George Rogers observed was effective in the 1960.[23] In the current climate fish traps do not carry the same negative connotations and have the potential to be seen for what they are: tools to achieve economic and ecological efficiency. The paradox of the fish trap and ITQ system is that its simplicity is perfectly suited for the complexities of the industry today. In an increasingly competitive and innovative world, fish traps offer the possibility of growth and profitability.

Nevertheless, the greatest hurdle to implementing a quota system and reintroducing fish traps to Alaska would be the huge cultural impact on the existing Alaska commercial salmon fishery. Cultural investment in the resource has come in the form of capital and also the fishing heritage. Not only have commercial fishermen in Alaska invested large amounts of capital into their fishing vessels and equipment, but those participating in the industry are often descendants of fishermen who likely fished the same waters. To ask commercial fishermen to give up the way of life they and their forefathers have practiced for centuries would not only be asking them to forfeit their investments as far as capital, but also their fishing heritage. For this reason, the implementation of such a system should not be taken lightly.

However, this illustrates the theme presented throughout this thesis: the importance of considering political, economic, and cultural imperatives along with biological and ecological ones. Whereas the biological and ecological benefits of implementing such a system are clear, we cannot

[23] George Rogers, *Alaska in Transition: the Southeast Region* (Baltimore: Johns Hopkins Press, 1960).

impose a regime that discounts the complexity of a resource or those who participate in its extraction. Humans are as much a part of the ecosystem as salmon, and to ignore the cultural implications of management decisions would not be fulfilling the goals of a fishery manager.

4.6 Conclusion

Alaskans have reached a vital crossroads in the history of the salmon industry. They can choose to ignore the established record of current salmon fishery system, think of another palliative such as limited entry to delay the inevitable, and ultimately cripple the economic viability of the industry, Or, they can reinvent themselves. With a history of adaptability handed down from industries past, Alaskans have the power to redesign, reimagine, and ultimately reshape the future of the Alaska salmon industry. They have the power to address the underlying problems of subtractability and the zero-profit equilibrium, and, by fostering technological innovation and conservation practices, the development of an economically and environmentally sustainable industry is possible.

Conclusion

Alaska's fishery managers have the near impossible task of reconciling economic opportunity with ecological sustainability. Starting in the early twentieth century, economic demands placed on the resource often influenced policy decisions as much biological and ecological science. Political and cultural imperatives further complicated this balancing act.

The first era of federal management demonstrated how fishery managers, using hatcheries and predator control, operated according to the belief that producing salmon on an industrial scale would circumvent the need to manage wild stocks. Although escapement-based management had been implemented with an escapement goal of 50 percent of the total run, the lack of technological precision and the inability to accurately estimate population abundances meant early attempts at escape-based management were more of an art than a science. In many cases, as with the Rogue River in Oregon, attempts to manage salmon fisheries often resulted in the complete forfeiture of economic opportunity. Thus, the inability to accurately predict population abundances meant that management in the early twentieth century was often unable to reconcile economic demand with ecological realities. Despite their best efforts, managers did not have the tools to sustain both.

A shift in fisheries management began when E.S. Russell formulated the first biomass equation in 1931. Fishery scientists now had a way to abstractly quantify natural phenomena, and ecology and biology played a more substantial role in policy decisions. Still, political, economic, and cultural imperatives remained influential. For example, by the mid-twentieth century, the presence of fish traps in Alaska waters, the majority of which were owned by outside interests, came to symbolize all that was wrong with federal management. Because of the economic benefits fish traps provided their owners, many Alaskans felt left out. Fish traps not only represented exploitation by outside interests, but the exclusion of Alaskans from participating in the Alaska salmon industry. Regulations that prohibited commercial fishing operations within 300 feet of fish traps created exclusive economic zones, and Alaskans watched as brailers hauled hundreds of thousands of fish that would directly benefit their absentee owners.

Roadblocks to modern theories and practices further demonstrate how political, economic, and cultural imperatives remain present in fishery management decisions. Alaska defined open access and common use in the Constitution, which favored local participation in the resource. While the policies were based on what decision-makers saw as the best way to reconcile economic opportunity with ecological necessity, they were also reactionary. Anti-fish trap fervor had reached the point where open access and common use were a cultural requisite in Alaska. The main difference between state and federal management strategies was scope. Federal managers aimed to reconcile macro-economic opportunity with ecological realities, while state managers aimed to reconcile local- and regional-economic opportunity with ecological sustainability. It is clear that both management goals contained inherent contradictions that have yet to be reconciled.

This thesis has provided specific examples of various aspects of fishery management while simultaneously demonstrating how strategies changed over time. Hatcheries and predator fish eradication offered an analysis of economic imperatives. Escapement-based management demonstrated the struggle to incorporate ecological fragility into management decisions. Fish traps during the transition to Alaska statehood illustrated the power of political and cultural imperatives in fishery management decision-making. Analysis of each of those factors in the context of developing technology, advances in biological and ecological understanding, and fishery modeling techniques, highlights the complexity of fishery management decisions.

All these factors shed light on the Alaska salmon crisis today as managers continue to strike a balance between economic and environmental goals on the one hand, and political mandates and cultural expectations on the other. Reimagining the Alaska salmon industry as a quota-based fishery, or a return to fish traps, would be a fairly radical departure from current management strategies. But that would not be unique in the history of Alaska's salmon fisheries. Each era of management was a departure from the one before it as managers adjusted to new knowledge and changing demands. There is little doubt, however, that to implement a new management strategy, Alaskans would have to embrace an ideological shift that puts ecological sustainability on equal footing with economic needs.

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