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North Pacific salmon management: factors influencing interstate cooperation and conflict over management of a common pool resource

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ABSTRACT OF THESIS submitted by:
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North Pacific salmon species have faced centuries of overexploitation and habitat degradation. The ecological, economic and social effects of intensive artificial propagation of North Pacific salmon is the most recent focus of management authorities and fisheries scientists in North Pacific rim countries. Many studies have examined the ecological and genetic impacts of wild-hatchery interactions but the politics and international management incentives are still not understood. Through interviews and policy analysis, this study examined the underlying rationale for state behaviours and attempted to make predications about the future of salmon hatchery management in the North Pacific.

The interview and policy results highlighted many of the value systems and political motivations for current hatchery policies and revealed some of the potential roadblocks to implementing an international hatchery management regime in the future. The study took a more scientific focus, as most of the interviewees were fisheries scientist, biologists, or research scientists. Improving research methods to include politicians, policy makers, and government officials would improve knowledge of future possibility for international cooperation over salmon hatchery releases.

Keywords: North Pacific Ocean, salmon, hatcheries, artificial propagation, common-pool resources, management, international cooperation, environmental conflict

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Of course there is conflict in fisheries; when natural resources, humans, and institutions interact, there will always be debates over ownership, control and policy direction.

Source: (Charles, 2001)

1. Introduction

The first chapter of this thesis introduces the reader to the background and motivations for the researcher to carry out this research project. The rationale for studying North Pacific salmon is defended and explained, followed by a description of the research problem. Lastly, the aim, objectives, scope and limitations, and methodology of the research project are presented to put the research into context, to clarify the purpose of the research, and to explain how the research was executed.

1.1. Background and Rationale

1.1.1. Transboundary Management and Conservation

In the environmental field many issues are international and cannot be solved or managed by one country alone. Transnational environmental issues such as global warming, acid rain, and ozone depletion require cooperation and collaboration by multiple states. Similarly, since state borders do not contain ecosystems, cooperation among neighbouring states is necessary for good management and conservation of natural resources (Duffy, 2006). However, global conservation schemes can produce new forms of conflict as states determine who has access to and control of the natural resources at stake. Collaborating with neighbouring states on conservation issues can be unappealing, as issues of environmental security are brought to the forefront. Likewise, transboundary management of resources can make states fear exposure and disapproval from other states and agencies over current policies and practices (Duffy, 2006). While transboundary management may increase environmental security by increasing the resource, there will likely be new forms of competition and conflict that emerge when states vie for control and access to the new resources (Duffy, 2006).

The shift to thinking about transboundary environmental management has been justified by conservation biology, which suggests conservation should include entire ecosystems, rather than isolated regions or single species (Duffy 2006). The theory of transboundary natural resource management also allows for a greater geographical range of protection for migratory species that move within countries or regions (Abbott *et al* 2007). When species, especially those that have economic value, move between states, authorities must work together to manage, conserve, and protect the species. Classic examples of migratory species that require transboundary management are fish. Tuna, marlin, and others travel large distances and enter the waters of many states. Fisheries are more complicated, however, because much of the seas are international and are considered common property.

Fisheries are the classic environmental problem, clearly highlighting the impact and results of human impact and overexploitation of a resource. Excessive exploitation of the seas have demonstrated that ocean resources are finite and can be depleted by

overconsumption (Joyner, 1999). Countless studies have examined fisheries management, overexploitation of fisheries, and the management options for achieving a sustainable fishery. However, while at sea harvest of fish has been a major issue in the fisheries management discourse, the role of artificial propagation of fish and the effect of these programs is not well understood. This lack of information on the international politics behind artificial propagation of fish and the resulting impact on fisheries highlights the reason why more research is needed on this topic.

1.1.2. Salmon in the North Pacific Ocean

The North Pacific Ocean, an area stretching between northeast Asia and North America, encompasses the Bering Sea, the Gulf of Alaska, and the Sea of Okhotsk. Salmon in the North Pacific are an example of a migratory species that reproduce, live, and migrate through several states. The North Pacific salmon fishery is made up of salmon with a geographic distribution stretching from San Francisco Bay, California, northwards to the Arctic Ocean, and southward down the coast of Russia, Japan and Korea (Croot and Marcolis, 1991). There are seven salmon species that are included in this fishery: chum salmon *(Oncorhynchus keta),* coho salmon *(Oncorhynchus kisutch)*, pink salmon *(Oncorhynchus gorbuscha)*, sockeye salmon *(Oncorhynchus nerka)*, Chinook salmon *(Oncorhynchus tshawytscha)*, cherry salmon *(Oncorhynchus masou)*, and steelhead trout *(Oncorhynchus mykiss)* (Mahnken et al., 1998). Characterized by a lifecycle that starts in freshwater streams, includes a migration to the open ocean for growth and sexual maturation, and a strenuous journey back to the natal stream to spawn, salmon are a unique fish. Salmon are a key source of income for nations, and represent an important part of native peoples' culture and history. Salmon play a key role in the diet of many of these nations, are a key symbol of native people and the regions, and are a keystone species to many ecosystems, as they distribute the nutrients necessary for ecosystem health. Salmon have symbolic importance and represent a key species in the North Pacific. For these reasons, significant research has been done on these species and they continue to be a topic of research and political action.

1.1.3. Hatchery Policies and Trends

The most recent debates and concern over the North Pacific salmon populations have to do with hatchery raised salmon and their impact on the wild runs of salmon. Rearing salmon in hatcheries is a common procedure in all of the states and has been practiced in Canada since the early 1970s and in the United States since 1895 (Noakes et al., 2000). When salmon enhancement programs began, it was believed that the Pacific Ocean has an unlimited carrying capacity for salmon, so production figures were maximized (Noakes et al., 2000). Likewise, the success of hatchery programs was determined by the number of juvenile salmon produced and the increase in salmon catch (Noakes et al., 2000). Today, hatcheries, common in both North America and Asia, rear eggs and/or fry (juvenile salmon) in constructed environments before releasing them into the wild (Holt et al., 2008). Hatcheries have become a popular means of supplementing commercial harvest of wild salmon and boosting declining salmon runs in both quality and quantity (Holt et al., 2008). In 2004, Alaska released 1.6 billion juveniles and 2.0 billion were released from Japan (Holt et al., 2008).

The North Pacific salmon population is a transboundary environmental issue that demands cooperation from states in the region. Despite being a vast ocean, salmon generally congregate in the same feeding grounds and are dependent on the same resources whether they originate from Canada or Japan (Blumenthal 2010). Likewise, wild and hatchery salmon intermingle in the Pacific and can compete for similar resources and transmit diseases. While studies have noted that hatchery releases "may have done irreparable genetic damage to small stocks of wild Chinook and coho salmon," the amount of hatchery fish continues to grow, especially in Russia and Japan (Noakes et al., 2000). Because of this, the North Pacific salmon is a transboundary resource that must be managed cooperatively by the five states in order to be conserved. After declines in the fishery were observed in the 1970s, the five states implemented individual laws and policies, but also formed a commission to set up transboundary management of the species. Today, it is important to critically examine the impact these salmon enhancement projects are having on wild stocks and the total North Pacific salmon population.

1.1.4. Why Hatchery Policies Matter

The current hatchery policies are crucial as the Pacific Ocean currently has a salmon population twice what it was 50 years ago and may be reaching its salmon-carrying capacity (Barcott, 2010). Despite most salmon species being endangered or threatened, fishery biologists are now suggesting that the North Pacific will soon not be able to hold any more salmon. This increase in population had been caused by the production and release of hatchery fish. Unlike salmon populations from the past, more than one in five salmon in the current population originate in hatcheries (Barcott, 2010). This trend started in the 1970s when 500 million fry were released into the Pacific; by 2008 the figure has increased to 5 billion (Barcott, 2010).

While increasing salmon populations seems beneficial for the Pacific, there are many hidden problems. A majority of the hatchery fish (90%) are pink or chum salmon (Barcott 2010). This affects the salmon population in two ways: (1) pink salmon are a dominant competitor and out-compete other species and (2) hatchery fish are released sooner than wild stocks and thus consume a majority of food supplies in the North Pacific before the endangered wild runs reach the ocean (Barcott 2010). As a result, wild runs are facing further threats and declines, while the hatchery fish undergo population booms.

While these trends don't hamper the harvest of salmon by fisherman in the present moment, it is likely that the shift to hatchery fish will have long-term effects on salmon populations as a whole. As the number of salmon in the North Pacific increases, competition for food will increase and wild stocks could be crowed out (Blumenthal, 2011). Wild stocks, which are heartier and more resistant to disease, are necessary for the health of the population as well(Blumenthal, 2011). Furthermore, hatchery fish have less diverse DNA and are less genetically fit, which will lead to a less diverse population that will be less evolved and able to handle environmental change(Barcott, 2010). Moreover, further decline in wild runs will increase the need for hatchery releases, which are expensive and ecologically unsound.

1.1.5. **Current Management**

The five states that release salmon each have different salmon management plans and different objectives and goals. Russia and Japan, for example, are most interested in increasing catches; the United States and Canada have started to take more ecocentric approaches to salmon management. As a result, there is a large potential for conflict and disturbance of the salmon fishery when five states are running and implementing different fishery policies. However, management of North Pacific salmon stocks is not a new concept and countries of the North Pacific have already entered into agreements for management and regulation of harvesting and catch quotas. NPAFC (North Pacific Anadromous Fish Commission) and the Canada-United States Pacific Salmon Treaty are two examples of multilateral and bilateral agreements that are in place to address harvest of salmon populations (Holt *et al* 2008). The NPAFC's main tasks include "the collection and standardization of salmon catch data, communication of these data among nations, enforcement of high seas fishing regulations, and coordination of scientific research" (Holt *et al* 2008). As far as fishing is concerned, the NPAFC has been a fairly successful transnational resource conservation body. However, there is a lack of international governance structure to regulate and control the number of eggs or juvenile fish released by each country and little agreement or synchronization of farming methods and hatchery releases. Due to a lack of authority and enforcement mechanisms, there is little cooperation among the dominant contributors of salmon in the North Pacific (Canada, Japan, Russia, and the United States) (Holt et al., 2008).

1.1.6. **Cooperation and Conflict over the North Pacific Salmon Population**

Article 64 of the 1982 United Nationals Law of the Sea Convention states that all states that fish in a region are required to cooperate to ensure conservation and to promote optimum utilization of the species (Bergin, 1994). In the North Pacific, the North Pacific Anadromous Fish Commission was established. The NPAFC, set up in the early 1990s to promote conservation of salmon in the region, not only focuses primarily on fishing and harvest but also has very little authority or enforcement capacities. This lack of enforcement abilities is common to many international regimes. Similarly, there is no governance structure currently in place to regulate the number of juvenile salmon released from hatcheries. Such regulations would require the cooperation of the five member states, which is not likely considering the unequal power positions of these countries (Holt et al., 2008).

Hatchery policies offer the greatest possibility for salmon management conflict and cooperation. Aligning policies and focusing on restoring salmon diversity in the North Pacific would require international cooperation; business as usual and increased pink salmon hatchery production will likely lead to international tension, ill-will, and conflict. Attempts to alter the current commission or limit state's ability to release hatchery salmon could lead to conflict. Ruggerone (2010) points out that at a conference in Russia on salmon stocks, a guy stood up and asked if he was trying to start a war between Russia and the U.S. While this is obviously an overblown comment, it does highlight what an important issue salmon management is for the North Pacific states.

As with many conservation issues, there is the concern that nations will be "free riders" and benefit from one country's conservation efforts while continuing on with business as

usual. This is the case with salmon in the North Pacific. While the U.S. and Canada have been working to slow increases in hatchery releases, Russia and Japan have increased pink and chum salmon hatchery production and are planning on building more hatcheries (Barcott 2010). Thus, despite efforts to increase diversity of stocks in North America, the Russian and Japanese pink salmon releases will put more pressure on the common pool of North Pacific salmon and negate most of America's efforts (Barcott 2010).

However there is hope for cooperation and collaboration on increasing wild runs in the North Pacific. In Alaska the Department of Fish and Game denied a request from a hatchery operator to released 95 million pink salmon fry, a move that is seen as protecting wild salmon runs (Barcott 2010).

1.2. Importance

Pacific salmon are well-studied species and a large body of literature exists on the topic. A recently published article by Ruggerone *et al* (2010) found that the North Pacific is reaching its salmon-carrying capacity, and yet 17 strains of salmon are listed as threatened or endangered. This article, already considered controversial, is once again brining salmon management to the forefront of politics in the North Pacific. This thesis will constitute one piece of the ongoing research and debates on salmon management in the North Pacific. Research in this field is varied and includes research on native use and traditional rights to salmon runs, ecological implications of farmed salmon, international and domestic policy, etc. This thesis will address some of these issues, as they are important for background knowledge, but will attempt to keep its scope and aims focused on the international policy and management side of the issue. While many studies have looked at the problems affecting wild populations as a result of hatchery releases, there is still a need to analyze how differing salmon release polices and protocols can affect transboundary cooperation and conflict.

Common pool resources that are valued for the existence are relatively easy to manage due to shared interested between actors; those that are valued for their consumptive benefits face greater management challenges as actors' interests are varied and motivated by many outside factors (Joyner, 1999). Pacific salmon, thus, present a perfect opportunity to examine a common pool resource that is intensely valued for both the existence value, as well as the consumptive benefits. Given this research gap and the need for further study on this topic, this research project will focus on the factors that influence hatchery management decisions and actions and will examine how these factors influence international conflict and cooperation over the management of the common pool resource.

1.3. Research Statement

The suggestion that there is an overabundance of salmon in the sea was an absurd concept for this author, who grew up in the Pacific Northwest studying salmon issues from the perspectives of endangered species, declining stocks, and shortages rather than abundances. As a result of this author's upbringing and life-long interest in salmon issues, there was a slight initial bias in the research towards viewing the issue from an ecological and environmental viewpoint. It took further reading on the topic to

understand different perspectives on the issue and lots of dedication to keep this bias out of the research design.

This research is trying to determine if accepted views of common-pool resource management and state's behaviours in these situations can be applied to North Pacific salmon. It will do so by asking the following research question: can management of a common-pool resource (salmon food at sea) lead to international conflict between the involved states (United States, Canada, Japan and the Russian Federation)?

This study is of importance as, despite their status as cultural, economic, and environmental keystones, little research is being done on international policy relations with regards to North Pacific salmon hatchery issues. With recent publications showing an increase in competition between salmon at sea and contradictory policy measures between states, this study can contribute to the emerging body of knowledge on international common-pool resource management. Generally speaking, this thesis seeks to contribute to the understanding of North Pacific salmon hatchery policy, by looking at this issue for a international management perspective.

The idea of managing hatchery production at an international scale was first considered after studies showed that wild and hatchery populations of salmon were interacting at sea. These studies highlighted that salmon management actions in one region could have a direct impact on species abundance or health in distant regions—leading to economic costs, lost salmon fitness, and impediment of recovery efforts for wild salmon stocks (Ruggerone et al., 2003).

1.4. Scope and Limitations of Study

The scope of this research is limited to the identification of factors influencing Pacific salmon hatchery management in the North Pacific rim countries of the United States, Canada, Russia, and Japan. A map of salmon distribution in the North Pacific can be found in the section describing the current situation.

The North Pacific salmon management scene is made up of five regional systems: Japan, Russia Far East, Canada (specifically British Columbia) and the US (Alaska, and Washington-Oregon-California) (Augerot and Smith, 2010). Each region is defined by different salmon species and abundances, management plans and policy goals. However, each of these regional systems interact through shared salmon prey resources at sea, global fisheries trade, and politics over geography and resource extraction (Augerot and Smith, 2010). While both the Republic of Korea and the Democratic Peoples' Republic of Korea and the Peoples' Republic of China do release some hatchery fish and have active salmon fisheries, they are usually left out of negotiations and management structures (Augerot and Smith, 2010).

The scope of this study was refined several times throughout the process of designing the research, reading the relevant literature, and speaking with experts in the field. From the onset, this author hoped to narrow and refine the scope of the study to something much more concrete and defined; however, after speaking with many academics and experts in the field, it was revealed that very little research had been done on the policy

side of the issue and that there was one massive discipline-sized research gap, rather than specific research holes. This was beneficial, as the research project could be designed as freely and there wasn't any hesitation of duplicating work. On the flip side, this research project at times seems a little vague and haphazard because this author was working in a relatively new field with very little published work to build upon.

Similarly, this thesis is limited to political motivations, actions, and reactions. While the literature review will cover the basic science of the issue, this thesis does not try to present or analyze the hatchery, fisheries, or biological science. The science of this field is already well studied and understood; this thesis will address the political relationships between states managing a common-pool resource.

- **Thematically**: This study focuses on fisheries management, common-pool resource management and the political incentives and disincentives for participating in international management regimes.
- **Temporally**: The history of North Pacific salmon management is vast and is the exclusive topic of many books, articles, and organizations. However, for this thesis some time boundaries were developed. This thesis is most interested with the factors influencing hatchery decisions today and into the future, providing background information and past history only to cement the background situation of the research.
- **Geographically:** This thesis focuses exclusively on North Pacific salmon and the countries of the North Pacific Rim. While there are also a multitude of issues and similar management struggles associated with Atlantic salmon, other anadromous fish, and highly migratory species around the globe, this thesis does not cover those areas. However, some of the conclusions and recommendations developed in this study may also be applicable for understanding and managing fisheries beyond North Pacific salmon.

A study of the political motivations and environmental management of four countries requires intense research methods, extensive resources and plenty of time in order to fully understand and grasp the whole picture. Due to restrictions on all of these aspects, this thesis does not claim to be exhaustive or to represent the whole picture; rather, efforts have been made to bring attention to this issue and to emphasize the emerging issues surrounding salmon hatcheries and management. As well, language barriers posed a challenge to conducting interviews in Russia and Japan, which lead to short and incomplete data collection. Likewise, the earthquake tragedy that struck Japan in March 2011 was the first priority of the country, which made data collection in this country difficult.

1.5. Research Project Aim

The present thesis seeks to describe the international politics of a new type of common-pool resource management. Specifically, it aims to describe possible political implications of the North Pacific Ocean reaching its carrying capacity for salmon. Unlike other environmental conflicts that are based around scarcity or access, the case of the North Pacific highlights emerging conflict on the basis of shifting resource populations and an overabundance of a resource, instead of a shortage. This thesis will also aim to highlight how conflict can emerge among friendly states, simply on the basis of common

pool resource management. This research will aim to show that conflict can arise between countries with no other significant disputes solely due to different management and conservation strategies for North Pacific salmon stocks. This research will build on the work of Holt *et al* (2008), who looked at the incentives and disincentives for international cooperation.

1.6. Research Objectives

- To identify and compare artificial salmon propagation policies and management strategies of the five North Pacific Ocean countries.

- To understand current conflicts and possible future points of contention between the five states regarding hatchery growth and releases.

- To determine and analyze the incentives and disincentives for cooperation among states in the North Pacific Ocean by conducting interviews with key stakeholders.

1.7. Supplementary research questions

Along with answering the sustentative research question proposed earlier, this thesis also aims to answer several supplementary research questions. The following are detailed research questions that helped guide the research process:

- Is the North Pacific salmon a common-pool resource?

- How do states respond to changes in common pool resources?

- What types of conflict may emerge when states utilizing a common pool resource have different management goals and contradictory political actions?

- How to salmon policies of the states differ? What effect does this have on the salmon populations in the Pacific?

- How will the shift in salmon species in the North Pacific impact political and economic relationships between Russia, Japan, Canada and the United States?

1.8. Outline of the Thesis

Chapter 1: Introduction to the research

- The section provides background information about North Pacific salmon, explains the research setting and research problem, and presents the aims, objectives, and goals of this research project.

Chapter 2: Literature Review

- This section provides a brief overview of relevant fisheries literature, covering main concepts, definitions, and theories that have shaped and influenced fisheries research over the years.

Chapter 3: Theoretical Framework

- This section describes the theoretical framework that is being used to examine this issue: common-pool resources. The main concepts of this framework are explained and presented.

Chapter 4: Research Methodology

- This section presents the methods used in the data collection for this thesis, discusses the limitations of these methods, and provides information about how the data was analyzed.

Chapter 5: Description of the Situation

- This section introduces North Pacific salmon, a history of the salmon fishery and background information about hatchery practices and problems.

Chapter 6: Current Management Structure

- This section briefly explains the current management structure for salmon in the North Pacific and discusses some of the overriding policies that influence salmon hatchery policies.

Chapter 7: Results

- This section provides a thematic analysis of data collected during interviews and describes what was found.

Chapter 8: Discussion

- This section discusses what was found in the data and what this means for management of hatchery resources in the North Pacific Rim region.

Chapter 9: Conclusions and Recommendations

- This section concludes the research project by presenting conclusions of the research project, providing some recommendations, and suggesting areas for future research.

2. Literature Review

The purpose of this literature review is to present relevant literature on the field of fisheries management and conservation. This section will explore how fisheries management and conservation have been studied, what issues have come up in these studies, and different ways the topic has been approached. This review focuses on topics that have been addressed in fisheries management research, and will attempt to show how this research project addressing fisheries management at the hatchery level fits into this context. Because there is very little literature on the politics of North Pacific salmon hatcheries, this literature view takes a step back and looks at approaches to fisheries management, with a focus on marine fisheries and migratory species management. This review highlights that there are many different approaches to looking at fisheries management and a plethora of issues facing fisheries and sustainable management of these resources.

2.1. Defining Goals for Fisheries Management

Despite the management approach that is adopted, there tends to be three general concern about fisheries that everyone can agree are important to fisheries management: sustainable use, economic efficiency and equal access to resources (Cochrane, 2000). Likewise, the reasons fisheries are struggling or collapsing around the world are for rather similar reasons: biological, ecological, economic and social (Cochrane, 2000).

2.2. Managing Highly Migratory Species

Highly migratory species have been the focus of many studies, as there movement through various ecosystems, political boundaries, and geographic regions make these species difficult to track, manage ad conserve. Sharks, for instance, require wide ranging and coordinated management plans because they migrate over such a large distance at sea (Barker and Schluessel, 2005). Due to this migratory nature, migratory fish species must be managed at the international level, though bilateral or multilateral agreements (Barker and Schluessel, 2005).

2.3. Fisheries as a Common-Pool Resource Problem

Fisheries produce yields that are rivalrous and their use is only partially excludable, making it difficult to conserve fisheries and to prevent countries from overexploiting the resource (Grafton et al., 1996). According to this view, fishers have incentive to overfish the stock because there are no property rights allocated over the resource.

2.4. Role of International Treaties in Managing Fisheries

The role, purpose, and necessity for international management structures are also a common thread in the literature on fisheries management. In most of the studies on this topic, international regimes are seen as one of the solutions to achieving sustainable fisheries around the world. Barker and Schluessel argued that international management of fisheries should be a prerequisite to improve management of fisheries (2005).

However, the problem with international treaties is that they are often not as effective as initially expected. Many management regimes face gaps, unwilling participants, and insufficient protection for species (Barker and Schluessel, 2005). In order for regimes to be successful, all stakeholders need to support the regime and participate in the project's goals and aims. Likewise, treaties have a higher track record of success when there are small number of member states, rather that those involving large complex institutions (Hilborn et al., 1995).

2.5. Role of Science in Fisheries Management

Another theme that runs deep throughout the literature is the role of science, scientific uncertainly, and scientific knowledge. With highly migratory species, species that inhabit the oceans, and fish, there is a large knowledge gap and a lack of complete understanding about species ecology and population biology. Compared to land animals that are fairly well understood, many marine species are difficult to conserve because scientists, managers and policy makers do not completely grasp all of the dynamics of the species. As an example, Barker and Schluessel argue that a more thorough understanding of the ecology and population biology of shark species would be key in creating more successful and effective management regimes that would lead to sustainable fisheries (2005).

It is also explained that sometimes with fisheries, managers and policy makers cannot wait for complete scientific knowledge, but should rather go ahead with the creation of management plans. If management of many fisheries were to be postponed until the species was fully understood, the species would be extinct before the management system would be set up. For example, it took the International Whaling Commission 10 years to develop a harvest system that met all of the objective for a sustainable harvest; but in the 10 years it took to solidify the science, it is likely that heavy exploitation of the whales continued (Hilborn et al., 1995). It is argued that changes, even if rudimentary and cautious, should be implemented now to address the most pressing problems and concerns before the fishery collapses (Barker and Schluessel, 2005). Likewise, it is more efficient to improve monitoring and management systems over time than to wait for traditional scientific research to explain every factor influencing species (Hilborn et al., 1995).

2.6. Role of Incentives, Pressure in Fisheries Management

It is also recognized in many studies that international fisheries regimes and management structures are not a given and that there are many political barriers to their implementation. It is likely that without major incentives, excessive external pressure, shame from international communities, or domestic support that countries will enter into management systems voluntarily or change their unsustainable behaviours (Barker and Schluessel, 2005).

2.7. Recognition of Limits in Marine Ecosystems

It used to be the belief that fish were so abundant that there was no way that fishing could affect the abundance of any particular stock (Hilborn et al., 1995).

2.8. Maximum Sustainable Yield (MSY)

The concept of MSY was first conceptualized in the 1950s and quickly became the objective of fisheries management (Hilborn et al., 1995). However, this term has changed and morphed throughout time as scientists have built a better understanding of social and environmental factors influencing the explotation of a resource (Hilborn et al., 1995).

2.9. Approaches to Managing Fisheries

The main goal when examining any fishery is how to restore depleted stocks and increase production of the resource in a sustainable way (Bell et al., 2008). How to manage and conserve fisheries and marine ecosystems is not cut and dry; rather, there are many approaches to managing fisheries. Different opinions about what restored fisheries should look like and how this stage should be reached often results in debates and disagreements (Bell et al., 2008). These different approaches to fisheries conservation are discussed in the literature extensively and often presented as opposing approaches, rather than complimentary approaches. Here, several of the main approaches to fisheries management are defined and explained.

2.9.1. Total Allowable Catch (TAC)

TAC is the classic approach to fisheries management that puts limits on the total harvest of fish. While this approach is effective in preventing biological overfishing, it is not an effective technique or approach to preventing economic overfishing (Grafton, 1996). In these systems there is usually excess competition among fishers and overcapitalization, leading to a more ecologically sustainable fishery but one that lacks social and economic sustainability (Grafton, 1996).

2.9.2. Individual Transferable Quotas (ITQs)

ITQs are an approach to fisheries management that was implemented to help control externalities that came up under TAC management systems. This is a management system that allocate total allowable catch among fishers in the form of ITQs, which is an incentive-based management system rather than a control-based (Grafton, 1996). In this management system, are allotted a quota based on past harvests and vessels and pay a price for harvesting fish over this quota (Grafton, 1996). Quotas can then be bought and sold depending on the fishers wants and needs. ITQs can be an effective fisheries management took when they are viewed as an exclusive property right and when there is adequate monitoring and enforcement. However, ITQs are not appropriate for stocks that are depleted, as they cannot remedy declines in stocks (Grafton, 1996). New Zealand was the first country to use ITQs to manage their fisheries (Grafton et al., 1996).

2.9.3. Integrated Ecosystem Conservation:

This type of conservation focused on bio-regionalization and marine protected areas as the key tools for achieving sustainable fisheries (Campagna et al., 2007). These approaches can guide conservation, even when there are gaps in scientific knowledge or there are many political roadblocks to international cooperation.

2.9.4. Landscape Species Concept (LSA):

Campagna et al (2007) state that “the Landscape Species Approach (LSA) is a wildlife-

focused, spatially explicit, landscape conservation planning tool developed originally in terrestrial ecosystems" (page S138). This approach to managing fisheries focuses on landscape-level conservation by focusing on habitat types, management units, and threats in these landscapes (Campagna et al., 2007). After identifying these key aspects for conservation, the goal is to identify the species that inhabits all of the habitats and is affected by all of the identified threats. By identifying one umbrella species and focusing conservation on that species, the LSA approach hopes to also conserve other species dependent on the same landscape (Campagna et al., 2007). For example, by conserving salmon in the North Pacific and letting salmon serve as the umbrella species of the North Pacific, conservation efforts will also effectively conserve species occupying lower trophic levels. The LSA approach maps biological landscape and human landscape on the same map; where these two landscapes intersect are identified as areas where conservation activities will be successful (Campagna et al., 2007).

The first time this approach was applied to an open ocean system was in 2008. The authors who first used the LSA approach on open ocean systems suggested that it would be a difficult approach to apply because oceans are different than terrestrial systems, as they have less discrete boundaries and have organisms that experience habitat at larger scales (Campagna et al., 2007).

2.9.5. Ecosystem-Based Management Approach

A fairly common approach to fisheries management is the ecosystem-based management approach. This approach was created as a way to move away from an emphasis on EEZs of individual nations and management of economically important species to a focus on whole ecosystems (Campagna et al., 2007). This approach focuses on long-term conservation goals across many spatial and temporal frames, instead of a single species or a single country (Campagna et al., 2007, Babcock and Pikitch, 2004).

2.9.6. Private Ownership, Allocation of Rights

It has been argued that private ownership is the most successful institution for promoting sustainable fisheries (Hilborn et al., 1995). However, private ownership can also result in owners who care little about genetic diversity, rather replacing native fish with more economically important species (Hilborn et al., 1995).

2.9.7. Using Genetic Data to Improve Fisheries Management

Another approach to improving fisheries management looks at genetic data. It has been suggested that fisheries should be managed in such a way that genetic diversity is maintained (Koljonen, 2001). Specifically, local adapted populations (stocks for salmon) are the focus of conservation efforts.

2.9.8. Fisheries Management and Habitat Loss

Another school of thought argues that fisheries management for too long has focused on overfishing, but instead should be focusing maintaining ecological integrity and ecosystem function to maintain healthy fish stocks (Turner et al., 1999). This approach is similar to an ecosystem-based approach, as the proponents argue that fisheries should be managed with the recognition that habitats and fish must be managed as one

entity (Turner et al., 1999). This approach has resulted in fisheries conservation involving marine protected areas and marine reserves.

2.9.9. Supplementing Wild Stocks with Artificial Stocks:

Another approach to achieving sustainable fisheries is through aquaculture practices. This practices goes beyond efforts to improve ecosystem viability and ecosystem health and looks to enhance stocks by manipulating populations (Lorenzen, 2005). These approaches use hatchery technologies to restore and augment fishers by releasing juvenile fish that are cultured and raised in hatcheries (Bell et al., 2008). Aquaculture-based fisheries enhancement includes organisms that are subject to husbandry and private ownership (Lorenzen, 2005). This approach started in the mid-19th century, was used extensively by Japan in the 197, and first gained national attention in 1997 when the First International Symposium on Stock Enhancement and Sea Ranging was held (Bell et al., 2008, Howell et al., 1999, Lorenzen, 2005). This method for achieving robust fisheries involves releasing juveniles into wild populations to either: (a) restore depleted spawning biomass (restocking), (b) augment natural supply and optimize harvests (stock enhancement), or (c) enhance size of fish at harvest (sea ranching) (Bell et al., 2008). This approach can be used to replenish fisheries and generate income, but in order to achieve a “win-win” situation, supplementation with artificial stocks must involve advisory groups and stakeholders, must be cost-effective, and must minimize externalities (Juinio-Mendez et al., 2008, Tringali et al., 2008, Aguilar et al., 2008).

Lorenzen (2005) created a list of criteria by which to evaluate fisheries enhancement programs. This list is shown in the table below. These criteria are helpful for analyzing a fisheries system, identifying outcomes, and seeing if objectives for the program were achieved.

Table 1: Criteria for Evaluating Fisheries Enhancement Programs

Outcome criteria	Specific indicators (examples)
Biological production	• Total yield of target species • Total yield from fishery • Size distribution of catch
Biological resource conservation	• Abundance of wild target population • Abundance of other wild fish populations • Natural productivity of target population • Genetic integrity of target population • Food web dynamics
Economic benefits and costs	• Economic rent from the enhanced fishery • Income flow • Costs of management (transaction costs) • Costs of benefits from wild fish harvesting foregone • Costs of enhancement research • Value of information gained from enhancement experiments
Contribution to livelihoods	In addition to the above: • Equity of benefits • Health benefits • Skills and knowledge developed • Networks and associations created • Trust • Access to wider institutions • Recreation
Institutional sustainability	• Persistence of management institutions • Rules are followed by stakeholders • Rules adapt to changing conditions
Broader sustainability	• Resilience of ecosystem maintained or increased

Source: (Lorenzen, 2005)

With these criteria, Lorenzen stated that enhancements to fisheries should start with an integrated, quantitative and participatory analysis process that starts at the beginning of

any enhancement process to ensure that the goals of the project are met(Lorenzen, 2005). Her approach varies from others before that emphasized scientific techniques before management issues.

2.10. Classic Challenges to Sustainable Fisheries Management

A classic challenge with fisheries is trying to schedule balance between conservation goals, genetic diversity goals, and catch goals. While a balance should be created between all of these aspects of the fishery, studies have shows that it is not always straight forward and is rather a very political process (Koljonen, 2001)

2.11. Research Gap

The above literature review highlighted some of the key concepts in fisheries management and introduced varying approaches to fisheries management. While there are articles on the science of artificial propagation of resources, it is clear that there are not enough articles on the politics of artificial propagation of marine resources and the political implications of these programs. As such, this research attempts to bridge the gap a bit by addressing the political issues surrounding artificial propagation of salmon and determining if management of a common-pool resource (salmon prey) is an appropriate lens by which to view fisheries issues.

3. Theoretical Framework

Theories are necessary in order to explain and predict phenomena, relationships and behaviours. For this thesis, a lens was through which to view the issue and to utilize as a tool for making observation and generalizations about the situation. This framework can help explain why this problem exists and can help predict what future situations.

3.1. Introduction to Framework

North Pacific salmon have been the focus of many studies and have been examined through the lenses of many theoretical models of human and state behaviour. For this thesis, this researcher chose to look at the issue from a common-pool resource management perspective. The CPR approach is the chosen position for analyzing this problem and provides direction to the study. This theory has been used to examine many different environmental situations, including many fisheries, but has not to this researcher's knowledge been used to examine situations of prey resources at sea.

3.2. Description & Main Theories of the Common-Pool Resource Framework

Common-pool resources have become an important lens for analyzing environmental issues and conflicts over the last two decades (Agrawal, 2003).

3.2.1. Definition:

Common pool resources are goods that are non-excludable, but are rival (Barkin and Shambaugh, 1999). That is to say, that no one can be excluded from accessing the resource, but the level of consumption affects the amount that other parties can consume of the same resource (Barkin and Shambaugh, 1999). Fishing grounds and fish stocks are often used as a classic example of CPRs as no country can be excluded from fishing on the high seas, but overfishing by any country can reduce the amount of fish available for other countries to harvest or can lead to depleted stocks that cannot replenish themselves (Barkin and Shambaugh, 1999). With common pool resources, there is incentive for states to over consume and exploit the resource for personal gain (Barkin and Shambaugh, 1999). As a result, one actor is able to subtract the level of benefit available to other actors (Barkin and Shambaugh, 1999)

Another aspect of CPR management is the recognition of environmental limits. Barkin and Shambaugh (1999) explain that use and management of international environmental resources do not become political issues until the resource limits are recognized.

Barkin and Shambaugh (1999), argue that *all* international environmental issue that central political conflict have a root of common pool resources. By their hypothesis, the issue of salmon prey resources in the North Pacific Ocean would clearly be an issue of common pool resources. They predict that it is the characteristics of CPRs that generate the conflict.

Table 2: Types of Goods

		EXCLUDABLE YES	**EXCLUDABLE** NO
RIVAL	YES	Private Goods	Common-Pool Resources
	NO	Toll Goods	Public Goods

Source: (Barkin and Shambaugh, 1999)

Barkin and Shambaugh (1999) also present three key characteristics that differentiate CPR issues from other environmental issues: time horizons, free ridership, and market power. These three characteristics can help explain how international management of CPRs is constructed and how institutions are created.

- *Time Horizons and the Likelihood of Cooperation*: If a stakeholder values future benefits of an CPR almost as much as the present benefits, then there is a higher likelihood that the state will participate and cooperation with international agreements (Barkin and Shambaugh, 1999). With CPR management, stakeholders with a shorter shadow of the future can threaten to deplete the resource at a far faster rate that those with a longer shadow of the future, so negotiations quickly shift to securing an agreement as quickly as possible. As a result, the countries with the short shadows of the future have the most bargaining power in negotiations (Barkin and Shambaugh, 1999).
- *Free Riders*: In CPR situations, there is an incentive for countries to free ride, by either contributing un-proportionately to costs or by failing to participate in current agreements on management of the resource (Barkin and Shambaugh, 1999).
- *Market Power*: The third characteristic that defines CPR situations is through the use of market power. If countries have enough market power, they are able to modify the price of the good and its demand, leading to increases cooperation (Barkin and Shambaugh, 1999). For example, in 1991 the United States places restrictions on what type of shrimp could be imported into the country, which lowered the price on unsustainably caught shrimp and essentially forced the market to change (Barkin and Shambaugh, 1999). A similar situation could be in place in the North Pacific, but with salmon species and place of upbringing.

4. Research and Methodology

This section describes the way in which the research objectives and aims were achieved: the research tools and the methodology. The overall thesis design is organized into four parts, each step designed to address different aspects of the research project. The following section describes each of these methods in turn, elaborating on the methods and protocol that was carried out. There is also a discussion and acknowledgement of the limitations of this research.

4.1. Research Design

The research design was organized into four main phases: analysis of relevant literature, policy analysis, qualitative interviews, and results analysis. Each of these phases was guided by the research question, aims, and objectives that were developed from the onset of the research project. Research methods that complimented and answered the research goals were selected. As the main research question addresses resource management and environmental conflict, the literature review focused on these themes, the focus on international regimes and political cooperation contributed to the decision to conduct a policy analysis and because the majority of knowledge on this issue is held by stakeholders and not published materials, qualitative interviews were vital to understanding the situation. The review of literature was carried out throughout the research period, while the policy analysis, interviews, and results analysis were carried out in April-May 2011 at the University of Manchester and Central European University.

4.2. Archival Research

The initial stage of data collection involved archival research on topics defined in the conceptual framework of the thesis. This research was carried primarily using online databases and e-journals. The knowledge gained through reviewing relevant literature was used to formulate interview questions and prompts, to center this researcher in the core concepts of the field, and to highlight the main issues and areas of disagreement between states. The results of this research are presented in the literature review section of this thesis.

4.3. Qualitative Interviewing

In order to understand the situation at hand and to developed possible areas of conflict related to salmon hatcheries, it was determined that elite interviewing would be the most appropriate research method to answer my research questions. Elite interviewing is the appropriate form of interviewing when the respondents are experts about the topic and have more influence on the decision-making process than other individuals in the field (Burnham et al., 2004). However, elite interviewing only highlights one portion of an issue and should not be used exclusively; thus, this researcher also conducted a policy analysis to widen my methodological approach (Burnham et al., 2004).

The interviews were semi-structured, to allow the interviewees to elaborate on topics and investigate new material, without the restraints of a structured questionnaire or survey. The nature of the semi-structured interview also allowed the flexibility for

questions to be redesigned and new themes and ideas to be explored (Burnham et al., 2004)

Due to the geographical distance between interviewees and a limited budget for travel, all interviews were conducted on Skype. The advantages to using this program were the ability to interview key people in the topic area without having to leave Europe, the ease of audio recording, and the ability to interview with very low costs. However, conducting interviews on Skype is often unreliable, with time lags or Internet shortages that lead to interrupted and fragmented interviews. While in-person interviews would have been more appropriate for this research, limitations of time, geographical distance, and funding make Skype an appropriate and useful tool for conducting interviews.

The most time-consuming aspect of the research design was a series of semi-structured qualitative interviews carried out with experts in the field, including fisheries biologists, ecologists, policy analysts, and hatchery managers. The interviews followed the methodology of semi-structured interviewing where an interview protocol organized by thematic areas was structured, but interviewing was allowed to branch out into new topics and supplementary and follow-up questions were asked of the participants.

Semi-structured qualitative interviewing was selected as the appropriate method for this research project, as the interviewer and interviewee were on the seen as equal participants in the conversation (Mann and Stewart, 2000). Likewise, a semi-structured format allowed the interviewer to track issues that were most relevant to this research project without dominating the conversation, while simultaneously allowing the interviewee to structure the form and content of their responses (Mann and Stewart, 2000). By following this interview structure, a balance was struck between the needs and objectives of the researcher, and the ability of the interviewee to speak freely and openly.

4.3.1. **Email Interviewing**

The selected interview technique used for this research project was the email interview. This method was selected as it assisted in overcoming many research barriers. This method was appropriate to this research, as all of the participants used email in their day-to-day lives and were familiar with communicating on scientific topics by email.

Methodologically, email interviewing overcomes many of the barriers and roadblocks to carrying out effective and efficient qualitative interviews.

- *Geographical Distances*: Email interviews allow researchers to contact participants all around the world, without worrying about travelling costs or time differences. For this research, interviews were conducted with individuals in the western United States and Canada, Japan, and Russia; interviews that would not have been possible to conduct without the use of email interviewing. This methodology allowed an international study to be completed from a desk in the EU, a previously impractical research task.

- *Cost*: Conducting interviews can be an expensive process, but the email interview is free and can make interviewing possible when budgets are tight. Likewise, there is no need for recording equipment or transcription costs as the interviews are automatically recorded. As there was no funding for this research project, the ability to carry out email interviews meant that the researcher could afford to conduct interviews.

- Richness of Responses: The asynchronous nature of the email interview allows participants plenty of time to craft and review their response, which is helpful for non-native English speakers. One Japanese participant noted in his interview that his English skills were very poor but the quality of his responses led me to believe that email interviewing was a more comfortable method of interviewing given his English skills.

- *Flexibility*: an email interview allows the interviewees to respond to the questions on their own time schedule. One participant in this research noted that he would be answering the questions from home and asked that the interview questions be sent to his personal email address rather than the work address.

- *Privacy and Comfort*: Responding from a computer provides a degree of anonymity and a level of comfort for both the interviewer and the interviewee. All concerns about physical appearance, voice patterns, and nervousness are removed, leading to a comfortable conversation.

- *Snowballing*: asking respondents to referral potential interviewees is a cheap and quick way to locate additional participants without little time or energy commitment

Source: (Mann and Stewart, 2000)

While every step is taken to make the email interview as close to a FTF interview as possible, there are some downsides. While some studies have shown that rich research relationships can develop by email, others have found that the process fails to achieve fruitful interactions and connections (Mann and Stewart, 2000)

4.3.2. **Sample Recruitment**

Recruiting interviewees was a purposeful and focused task of finding individuals who were knowledgeable of the topic at hand. The selection of participants was not random, but rather involved individual solicitations for interviews and introduction to new participants through snowballing. The lack of random sampling is justified in this research, as the research needed the expert and informed opinions of a number of experts in the field. Selection of interview participants was based on a variety of criteria- including involvement in North Pacific salmon research and scientific teams, authors of scientific articles on hatchery-wild interactions, and membership in research, policy and management councils or non-profits associated with North Pacific salmon. However, since very few individuals are involved in this exact type of research, the selection of interviewees was widened to include experts in the fields of biology, ecology, and fisheries science.

To ensure sufficient participation and to account for non-response rates, interview invitations were emailed to increase participation rates (Meho 2006). This proved to be a successful move, as many individuals did not respond to the invitation or did not feel qualified to answer the question (problems that are discussed below). As well, interviews with experts in all of the states were desired, but it proved difficult to acquire interviews with Russian and Japanese individuals. This can be explained by a variety of factors: lack of English websites to find contact information, language-barriers, or cultural norms surrounding interviewing.

Snowball recruiting also proved to be quite successful in this study. Many of the interview participants were first located after a referral from an initial participant. This allowed the sample size to grow larger than originally hoped, leading to richer and more abundant data.

4.3.3. Interview Procedure

Participants were first contacted by email in May 2011 to gauge interest in the research topic and to request interview participation. The email interviews were solicited individually and personalized, as a means to show potential participants that their opinion was valued and hopefully as a way to increase participation (Meho, 2006). The initial email included information on the aims of the research project, brief information about this researcher's credentials, and information about how their contact information and email address was acquired. The participant was then asked to participate in the interview and to confirm participation by sending an email response and agreeing to the terms of the informed consent form, which was attached as a PDF to the email. Once the participant agreed to participate in the research, an email was sent that further described the nature of the research. Subsequent email between interviewer and interviewees included interview questions, instructions for completing the interview, and some guidelines for response deadlines and future expectations.

The initial email was very formal in nature, to show the solicited participant that the interview was legitimate and a worthwhile to participate in. Ensuing emails were more casual in nature and attempted to build some rapport and connection between the interviewer and interviewee. As well, there was great care taken to make the emails short and succinct, both to reduce confusion and misunderstanding and to make sure that the interactions didn't become over convoluted or long (Mann and Stewart, 2000).

4.3.4. Informed Consent and Ethical Considerations

The interview request email also included an informed consent form for the participants to review and agree to by written confirmation. With email interview, not unlike other interview techniques, establishing consent by telling the participant about the research in which they are asked to participate in crucial to the research design (Meho, 2006). The informed consent form provided the participant with information about the research project, agreements and expectations of participation, benefits and risks of participating, assurance of confidentiality, and information about the right to withdraw for the study at

any time. Without exception, the participants agreed to the terms of the informed consent form and did not have any questions about the terms of the agreement.
As some of the issues could be potentially sensitive or controversial in nature, interviewees were ensured confidentiality and anonymity before the interview process. Because hatchery management issues can be controversial, it was best to encourage participation by ensuring confidentiality for all participants. This confidentiality was achieved by removing all identifying information from the data collected and deleting the email records after the email correspondence was transcribed. Only one participant asked about how his statements would be cited in the research project, but this was more of an inquiry into the methods than concern over confidentiality.

4.3.5. Interview Design

Prior to interviewing participants, interview objectives were established in order to guide the interview questions, structure the conversation, and to facilitation analysis of the results. A rift in the email interviewing methodology exists on the topic of how questions should be sent: either in one clump or over multiple messages (Meho, 2006, Mann and Stewart, 2000). For this project, staggering messages over multiple messages was selected as the appropriate methodology. This allowed for the researcher to ask follow-up questions and to modify the interview technique if it did not work effectively on the first message. This proved to be a smart decision, as many participants struggled with the nature of the first set and the following questions were altered to make the questions more appropriate to the expertise levels of the interviewees.

4.3.6. Probes

Probes and follow-up questions were designed to ask for clarification and develop deeper and richer interview responses. Several responses by participants were ambiguous and not clearly defined and follow-up questions were asked to lead to greater understanding of the issue. In some cases, interviewees responded to these follow up questions and commented the comments and clarifications; however, in other cases these follow-up questions were glazed over and ignored.

4.3.7. Post-interview work

As the interviews were conducted by email, interviewees were thanked for their participation in the study and the interviews were transcribed. Transcription was done automatically, as the interviews were typed, and only involved some brief organizing and formatting to be complete. All implicit and explicit links between the interviewee names and the data collected was removed to ensure confidentiality and anonymity. Since the interviewee had access to the stored interview though their own email records, they were not provided with a transcript of their interview.

4.3.8. Interview Modification and Redesign

The interview design benefited from modifications and revisions throughout the process of conducting interviews. It was quickly discovered that the nature of the original research questions were far too based on international hatchery policy and protocol. As mentioned before, very few people are involved in this field so the questions were overly technical for most of the participants. Based on this revelation about the expertise and knowledge base of the interviewees, subsequent interview questions were modified to

focus more exclusively on the science and technical aspects of salmon hatcheries-topics that participants felt much more comfortable and skilled to answer.

4.4. Policy Analysis

The third aspect of the research design is a policy analysis of relevant salmon and hatchery policies in the four member states. However, as the ecological, social, and political implications of wild-hatchery interactions are still newly emerging problems, there is little relevant literature on the topic (Weimer and Vining 2005). As a result, the policy analysis was creative in its approach and attempted to identify related or correlated policies that could be analyzed.

4.4.1. Document Research

The documents used in the policy analysis were found through internet research, database searches, and official government websites. Some of the documents were found on federal government websites, while others were links on the websites of non-profits, policy advocacy group, or scientific commissions. Every effort was made to find the original policy document, while summations and opinion pieces on the policies were used to understand the intent, background, and motivation for the policy. As well, documents were also located through journal articles and recommendations from interviewees. Several documents were only located after an interviewee mentioned the agreement or policy in their interview response.

4.4.2. Document Analysis

Each policy was analyzed by asking the following question: Does this policy promote effective management of the fishery? This question was answered by assessing the policy, comparing it with possible alternatives and policies of the other states. Similarly, the policy was analyzed by asking if the policy provided an adequate basis for management or if alternative policies offered better management prospects. All policies were analyzed for their ability to meet the goals of an effectively managed North Pacific salmon fishery: scientific robustness, political feasibility, ease of enforcement, economic efficient use, etc.

Once each policy was analyzed on the basis of these factors, suggestions were made for improving current policy and developing policies that meet as many fishery management goals as possible.

4.5. Data and Results Analysis

The interview data collected in this interview was thematically analyzed. Thematic analyses are powerful ways to explore and explain, but it is also quite subjective (Attride-Stirling, 2001). A thematic analysis was selected as the means of analysis, as this research project was looking to identify common factors, motivations, concerns and roadblocks to international management of salmon hatchery releases. After the nine interviews were completed, this researcher went through the data, read it over several times, and started the analysis process. The process of analysis followed the three-step process described by Attride-Stirling (2001) for conducting a thematic analysis:

- *First*: The first step for the analysis was dissecting the text into management and meaningful segments. The coding framework was based on recurrent issues and

themes in the text. The codes were conceptual in many cases and any given segment of the interview could be classified under more than one code. At first, this researcher developed too many codes and quickly realized that many of the codes were overlapping and repetitive. After this realization, the codes were restructured to have more explicit boundaries. It is important to note that codes were not created if they did not exist in the data. While this researcher was hoping for some themes to emerge from the data, they were not mentioned by the interviewees and thus were not given a code. After these codes were developed, the text was separated section-by-section and categorized by code.

- *Second*: After the text was separated and coded, the data was reviewed and common and significant themes were extracted. The process of identifying themes was challenging at first, as many of the themes did not seem specific enough to be point of analysis. However, further analysis revealed similar themes that could be merged and discrete themes that could be separated.
- *Third*: After being sorted by theme, the data was arranged thematically, grouped by similarities, and organized from specific and scientific to general and theoretical. This separation helped identify data that was factual and data that was speculative or opinion based.
- *Fourth*: The data was described and explored by theme. Every attempt was made to make transparent and plausible interpretations of the data and to include large segments of raw data in the analysis, so the interview participants' voices would resonate throughout the analysis. The interpretations of this data are provided in a later section.
- *Fifth*: Lastly, the data was interpreted and discussed. Significant themes, concepts and patterns were discussed and questioned and meanings were suggested and interpreted. This discussion is provided in a later section.

4.6. Research Limitations

The research design utilized for this project is not without a series of limitations, relating to both the data collection and data analysis methods. These limitations are described below, as they affect the validity and future applicability of this research.

4.6.1. Limitations with Interview and Data Analysis

Finding suitable participants for the research interview was the most challenging aspect of this research methodology. Because the topic is relatively new, there is not a well-establish body of knowledge or many experts in the field. As a result, it was difficult to identify appropriate participants for the research and some participants were contacted simply because they had presented at a hatchery-wild interactions conference or had published on a North Pacific salmon issue. While this selection method was successful at producing more interviewees though snowballing, it was frustrating to have so many participants state that they were not qualified to answer the research questions.

Another challenge with email interviews is that email addresses frequently change. Many interview requests sent to Japanese colleagues were returned for lack of acceptable email address. While this limitation was overcome by increasing the number of participations who were solicited, the inability to contact experts in the field due to the lack of proper contact information was a large research barrier.

Moreover, many individuals that were send invitations stated that they were not qualified to answer the research questions or were unable to answer the questions due to a lack of time or being out of the office during the interview period. If the research period was much longer, these obstacles could have been easily overcome; however, due to the short nature of the research period, it was not possible to interview these individuals.

While conducing email interviews did address many of the challenges of conducting interviews with large geographical distances between interviewer and interviewee, it is not without downfalls. Similar to every research method, there are some areas of weakness to this method. One limitation with the interview method was that if questions were misinterpreted or misunderstood, this researcher could not immediately explain the question or ask for clarifications on their response. While every effort was made to construct clear and easy to understand questions, there was some confusion with the questions. As a result, not all of the responses were as applicable to the research at hand. Another limitation with the interviews was the brevity of some responses. Due to the informal nature of the email interview, many respondents didn't feel compelled to give detailed answers, as they would have in face-to-face interview.

Data analysis also was not without limitations. Due to the nature of email interviews, there were nicely transcribed interviews, but the data was rather bland and dry. The interview questions did not create rich, personal data, but was rather information that could have been found in a textbook or journal article. As a result, data analysis was very difficult and a lot of time had to be spent reading the interviews over and over to glean the most important information and to get a sense of what the interviewee was truly trying to say in their responses. However, after analyzing the data for a long period of time, several themes started to jump out of the interview data and analysis became easier.

5. Description of Situation

This thesis aims to examine common-pool resource management of salmon prey resources in the North Pacific. In order to fully understand the issue, it is first important to understand the history and importance of North Pacific salmon, the history of hatcheries and salmon propagation, and the current management structure and policies influencing Pacific salmon today. The history of human interactions with Pacific salmon stretches centuries, with extensive fishing occurring for more than a century. This section attempts to explain the basic trends and issues in salmon management, but is in no way an exhaustive overview of the history of North Pacific salmon. This section will begin with a brief overview of salmon characteristics and biology, continues with information about the history of North Pacific salmon and will cover the threats to salmon fisheries around the North Pacific Rim. Lastly, the section will conclude by introducing salmon hatcheries, explaining their history, and delving into the many problems and challenges associated with their construction and use.

5.1. Salmon Characteristics and Biology

Salmon are unique species with unique life cycle characteristics that influence management, conservation and policy decisions. Because of the ecological complexity of salmon, conservation is extremely difficult to achieve, especially in an industrialized age (Buhle et al., 2009). This difficultly stems directly from a complex lifestyle and a migratory pathway that includes many different habitats, ecosystems and regions, making conservation plans a challenge to prioritize and implement (Budy and Schaller, 2007). Therefore, before any attempt can be made to understand the politics of salmon management, it is first necessary to understand the physical and ecological characteristics of salmon that make them such a difficult species to conserve and manage.

Salmon are also umbrella species, meaning that their habitat requirements encompass multiple political and management boundaries and that they interact with many other species and cross though many different habitats (Budy and Schaller, 2007). Salmon spend time in freshwater lakes, rivers and streams, estuary and coastal waters, and deep ocean. As they pass through each of these ecosystems, they influence the life and diversity of species. As well, Pacific salmon occupy higher trophic levels in food webs (with chinook salmon and steelhead trout occupying higher levels than those of sockeye, chum, pink and coho) and are important for maintaining ecosystem health in the Subarctic Pacific Ocean (Kaeriyama, 2004). Likewise, salmon are also extremely heritable, meaning that they evolve dramatically in response to even minor changes in the environment (Johnsen, 2009)

Moreover, salmon have three unique traits that are key to their position in ecosystems and the effective conservation of the species—they are anadromous, they return to their natal streams to spawn and they die after spawning (Naiman et al., 2002). This unique life cycle presents three key time frames that salmon are influenced by human activities and interventions.

The life cycle of a salmon starts when salmon spawn in gravel beds in inland streams or lakes. Once hatched from their egg, fry, as they are known at that time, inhabit their natal stream for 6 months to three years, before entering the smolt stage, which prepares them for entering marine habitats. Salmon grow quickly during this time, but also suffer high mortality (Johnsen, 2009). After inhabiting costal estuaries for several weeks, salmon migrate to the open ocean and oceanic feeding areas (Cooney and Brodeur, 1998). Depending on the species, the time spent in both freshwater and marine ecosystems varies. The journey to the ocean occurs as a fry (pink and chum salmon) or as older smolts after several years in fresh water (chinook, coho and sockeye) (Cooney and Brodeur, 1998). Likewise, pink and coho salmon spend one year feeding at sea before returning to spawning grounds, while other species return after 2 to 6 years at sea (Cooney and Brodeur, 1998). While at sea, acquiring proper food resources and nutrients is crucial as salmon stop feeding when they approach freshwater and rely on body mass gained while at sea alone to provide the energy needed throughout the migration and spawning process (Ruggerone et al., 2007).

One of the most unique aspects of salmon is that after maturing at sea, nearly all salmon return to the stream where they were born to spawn and die. This feature, known as homing, is a biological feature of salmon that was likely developed to reduce levels of gene flow between populations, so that the genes adapted for specific habitats stayed within a population (ENRI, 2001). However, salmon also stray, which is the process where a small portion of salmon return to streams different than their natal stream. Biologists guess that this is an evolutionary way to increase genetic diversity and remain genetically connected with local populations (ENRI, 2001). Balance between homing and straying has allowed wild salmon populations to improve the fitness of their populations over time, but also to remain distinct genetic stocks around the North Pacific Rim. Salmon are also unique species in that they only procreate once in their lifetime, and this event hinges on their ability to migrate from the open ocean back to their natal stream (Farrell et al., 2008). If salmon fail to reach their spawning grounds, the result is zero lifetimes fitness for that individual (Farrell et al., 2008).

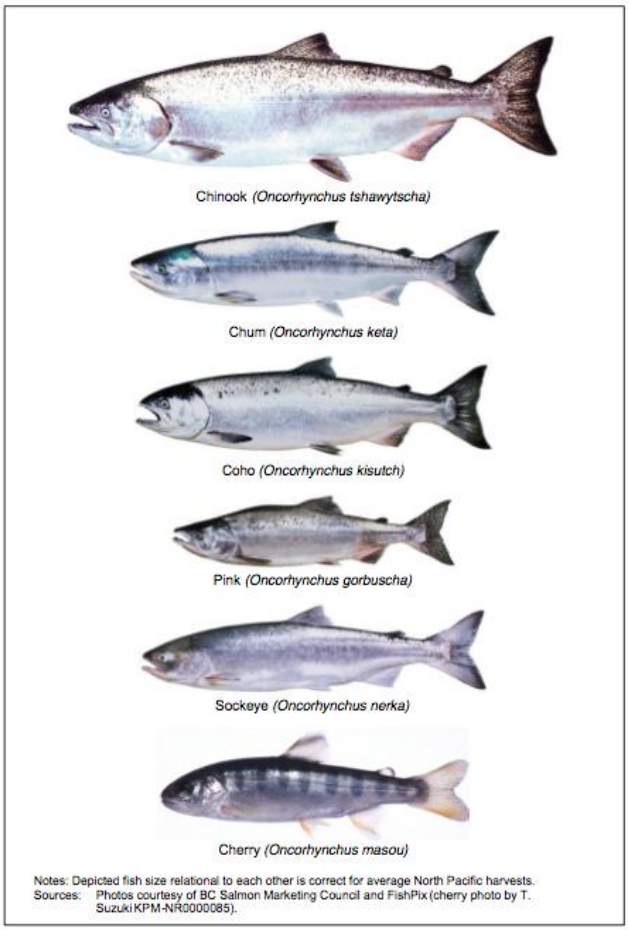
The most ecologically significant step in the lifecycle is death after spawning. Upon death, all of the nutrients accumulated at sea are deposited in the freshwater ecosystem and utilized by all levels of the food chain(Budy and Schaller, 2007, Kaeriyama et al., 2009, Seo et al., 2011). Due to the amount of nutrients that are brought to inland ecosystems, salmon are a keystone species in all of the regions that they occupy. In sockeye salmon, for example, 99% of the biomass of an adult fish is accumulated at sea (Finney et al., 2000). When the salmon dies these nutrients are transferred and distributed through their carcasses, and end up supporting whole ecosystems. In one lake on Kodiak Island, Alaska, for example, nutrients from salmon carcasses contribute more than half of the lake-water phosphorus and nitrogen annually (Finney et al., 2000). These nutrients are then passed though to higher trophic levels, building an ecosystem that is depending on the salmon species.

5.2. Species of Salmon in the North Pacific Ocean

Pacific salmon are in the family Salmonidae and the genus *Oncorhynchus*, which is Russian for ‘hooknose,’ which described the hooked upper jaw that male salmon

develop during mating (Lichatowich, 1999). There are seven anadromous species that migrate into the North Pacific Ocean. These seven species each represent different management and conservation challenges, as they each have unique lifecycles with varied times in freshwater and saltwater, different body sizes, and different values. Likewise, these species are not universally distributed throughout the North Pacific Rim countries, but rather are region specific. However, it is important to note that while the species have the same scientific name and may occupy many regions, salmon species are recognized, identified, and often managed at the stock level. Stocks are the fish that spawn in a particular lake or stream during a particular time of the year, but that do not interbreed with any salmon spawning in different locations or at different times of the year. This distinction makes salmon conservation an extremely local management concern, while also being a matter of international concern.

Figure 1: Pictures of Six Species of Salmon, by body size and scientific name



Source: (TRG 2009)

The table below explains the main salmon species and some of the key and identifying characteristics. This is a brief overview and much more detailed information can be found in specific studies of the species, of which there are many. Of the salmon species, sockeye, chum and pink make up around 90% of the total catch of Pacific salmon

(Kaeriyama et al., 2009). However, each species and the local stocks have value and are the subject of conservation efforts, despite their portion of total catch at sea.

Table 3: Salmon Species and Key Characteristics

Coho *Oncorhynchus kisutsch*	• Most successful hatchery-cultivated species in North America • unique in their appearance (silver scales) and in their life cycle (spending very little time at sea) • Before 1940, output never exceeded 25 million fish • 1950s and 1960s: improved post-release survival of coho fish • Released as either fry or yearling smolts • In 1981, 198 million fish released from North America • Beginning in 1989, coho salmon production started to decline
Chinook *Oncorhynchus tschawytscha*	• Largest, reaching up to 147 cm in length and 61 kg in weight • Released as either fry or yearling smolts • First species to be artificially propagated in North America • Hatcheries release fall, spring, and summer chinook salmon • First produced in WA state in 1895 • In 1988, 420 million fish released from North America
Chum *Oncorhynchus keta*	• Second most abundant salmon in the Far-East • Released since the late 1800s in Japan • 1950-1970: hatchery product rose from 260 to 580 million fish • In 1981, Japanese produced 2 billion chum fry • In 1970s, North America released 850 million chum fry
Pink *Oncorhynchus gorbucha*	• Most abundant of Pacific salmon species (58%) • Shortest life cycle (2 years), spending 1+ year at sea • Feed at lower trophic level • Dominant salmonid involved in competitive interspecies interactions • Alaska released 800 million juveniles in 1992 • Russia released 584 million juveniles in 1992 • Alaska releases of pink increased tenfold from 1980s to 1992 • Most recent of the Pacific salmon species to be industrially produced
Sockeye *Oncorhynchus nerka*	• incredibly important from an economic standpoint • stay in freshwater for a year (much longer than other species) • spend 2 to 3 years feeing in the North Pacific • Reach densities of 30,000 adults/ km^2 of lake surface area during spawning • Eggs were produced in late 1800s to send to Atlantic coast • No consistent benefits, most hatcheries closed by early 20^{th} century • Smallest artificial propagation for any species in Pacific NW • Canada produces the most sockeye of any Pacific Rim country
Steelhead	• Steelhead only produced in North America

Oncorhynchus mykiss	• Programs started in late 1800s • Production declined sharply in 1977 following establishment of tribal treaty fishing rights
Masu/Cherry *Oncorhynchus masou*	• Smallest of the species • Native only to Asia • Only Japan produces significant numbers • Highly dependent on riverine environment

Source: (Mahnken et al., 1998, Dronova and Spiridonov, 2008, Cooney and Brodeur, 1998, Ruggerone and Goetz, 2004, Ruggerone and Nielsen, 2004)

5.3. Value

How did a fish become the iconic species of the North Pacific? Salmon are by no means a charismatic megafauna, lack any cute or cuddly characteristics, and enter everyday lives very little except for on the dinner plate. And yet, the fact that salmon are the focus of so much attention speaks to their importance in the North Pacific Rim region. Salmon are unlike many other species and hold a special place in the culture and history of many nations. Salmon conservation has gained so much attention and focus due to the tremendous value of salmon.

Salmon not only play a keystone role in ecosystems, but also play a keystone role for cultures in the North Pacific Rim countries. As a result, the Pacific salmon fisheries cannot be viewed from a single perspective, but rather should be viewed as relationships between people, fish and the environment (Augerot and Smith, 2010). In contemporary times, value was placed solely on the subsistence value of salmon; however, in recent years the ecological services and cultural significance were one again included in management considerations (Augerot and Smith, 2010).

- *Economic Value:* Salmon are an extremely valuable economic resource and expansive harvest networks have been constructed to fish for these fish. Salmon are of key economic importance to Pacific Rim countries. In 2007, approximately 511 million fish were caught, with a wholesale value of $USD 2.2 billion (TRG 2009). Some of the highest economic value is placed on salmon by Japan and Alaska.
- *Cultural Value*: Salmon are also the cornerstone and iconic symbol of many cultures in the Pacific region. According to archaeologists, the history of interactions between people and salmon in the Pacific NW of North America started around 9,000 years ago (Lichatowich, 1999). First Nations (aboriginal people of Canada) and Native American tribes traditionally harvested Pacific salmon for numerous purposes, playing a significant role for cultural, social, and economic development of their communities (Noakes et al., 2006).
- *Environmental Value*: Salmon are a keystone species- supporting many species and ecosystems throughout the course of their life (Peery et al., 2003).
- *Recreational Value*: While the economic, cultural and environmental values tend to be the most important values driving salmon policy and decision-making, the recreational value associated with salmon is also highly valued. Salmon fishing is a big business and a hobby of many people.

5.4. Threats to North Pacific Salmon

The story of North Pacific salmon is a classic case of tragedy of the commons, where exploitation and overuse by multiple users has lead to resource decline. While native people effectively managed salmon for thousands of year, the advent of modern technologies and new settlers in North America led to a quick a steady depletion of the resource. The story of salmon decline really started between 1860-1880, when the race to harvest salmon for cannery operation began all along the Northwest Coast of North America (Johnsen, 2009). And by 1997, over 300 native stocks of Pacific salmon were at risk of extinction in the Pacific Northwest of the United States alone (Allendorf, 1997). In 2009, 28 Evolutionarily Significant Units (ESUs) of salmon in the Pacific NW of the United States were listed on the U.S. Endangered Species Act (Buhle et al., 2009). In this situation, globalization and industrialization put pressure on regions to maximize yield and overexploit the resource in order to meet market demands (Augerot and Smith, 2010, Noakes et al., 2000).

There are effectively four main factors that are responsible for salmon decline, known as the 'four H's': habitat degradation, hydroelectric dams, harvest practices, and hatcheries (Ruckelshaus et al., 2002, Sharma et al., 2005).

- **Hydroelectric Dams:** Dams have had a clear effect on salmon species, especially in the Pacific NW of the United States. Here, dams have resulted in the loss of 90% of salmon spawning habitat in some area, as they prevent salmon from effectively migrating to their natal streams or to the sea (Ruckelshaus et al., 2002). While dams have undergone renovations to become passable for salmon, they still result in many ecological consequences by flooding native habitat, changing stream depth and flow, and making it physically impossible to pass upstream (Ruckelshaus et al., 2002).
- **Harvest Practices:** Commercial and recreational harvests have also had a significant impact on Pacific salmon populations (Ruckelshaus et al., 2002). Because it is easy to see the salmon caught at sea do not survive to spawn, commercial fishing regulations have often been one of the first management actions taken to sustain populations (Sharma et al., 2005). Catches of Pacific salmon have varied throughout time, but there have been periods of high catches and low catches, usually as a result of climate regimes shifts at sea (Beamish, 2004). Catches were average from 1930s to the early 1950s, declines though to the late 1970s, increased tremendously in the early 1990s, and experiences a sharp decline in the mid 1990s (Beamish, 2004). Between 1985 and 1997, 43% of salmon were caught by the United States, 28% by Japan, 20% by Russia, and 9% by Canada (Beamish et al., 1997). Within that time period, pink, chum, and sockeye made up 93% of the catch (Beamish et al., 1997). Over time, these figures have shifted. For example, the Canadian catches have ranged from 2% to 24% of the total catch since 1922 (Beamish, 2004).
- **Poaching**: One of the largest threats to salmon species in the Russian Far East is illegal poaching and harvesting of salmon. In this region, it is estimated that the illegal catch exceeds the legal catch by 1.5 to 3 times, amounting to approximately 200-400 salmon harvested illegally (WSC 2009).

- **Habitat Degradation:** One of the most detrimental threats to salmon is the loss of spawning, rearing, and migratory habitat. For example, in the Central Valley of California, only 5-18 percent of the historic spawning habitat is still accessible (California Department of Fish and Game, 2001). In many parts of Japan, 20% of watershed area is inaccessible to salmon due to damming, channelling, and invasive species (Morita et al., 2006). In North America, salmon no longer occupy 40% of their historic ranges, and in some regions they only occupy 16% of the original area (Naiman et al., 2002). As a result of land use changes and degraded habitat, salmon survival rates have dropped. Magnusson and Hilborn (2003) found that salmon residing in severely altered estuaries in the Pacific Northwest had significantly lower survival rates that salmon residing in more pristine or natural habitats. The salmon habitat in these regions has declines due to forestry practices, agriculture and urbanization (Sharma et al., 2005).

5.5. Hatcheries

One of the largest and most direct impacts to salmon populations has been the advent of artificial propagation of salmon though hatcheries. Hatcheries have been used for decades to increase at sea commercial harvests, to raise farmed fish, to enhance recreational fishing, to compensate for degraded habitat, and to conserve depleted or endangered stocks (Hayes et al., 2004, Leider et al., 1990, Morita et al., 2006, Reisenbichler and Rubin, 1999). As the North Pacific salmon fishery has transformed over the past century, hatcheries have become an evermore-important part of the puzzle. Today, hatcheries contribute greatly to ocean harvests, contributing around 10 percent in Russia, 55 percent in southeast Alaska, and nearly 100 percent in Japan (TRG 2009). Hatcheries are common in all regions of the North Pacific, but very in intensity and purpose. In the Pacific NW United States, hatcheries are part of a program to make-up for loss in salmon habitat by dams and other habitat alterations; in Alaska hatcheries are designed to increased natural production; in the Russian Far east, hatcheries are primarily designed to increase overall sea harvest of salmonids (TRG 2009). And with each different hatchery structure come a different set of complaints, worries, and fears about the purpose of the hatchery. Some see hatcheries as assisting declining wild stocks, while others see hatchery fish as yet another negative human influence on salmon stocks. While these issues will be discussed in length later, it is helpful to acknowledge some of the leading mindsets for hatchery production.

It is important to point out that hatcheries-raised salmon and farmed salmon are not the same. Hatchery salmon are raised from egg to fry in hatcheries and then released into inland waters. Farmed salmon, on the other hand, are the product of captivity breeding and aquaculture, usually in the form of salmon cages. While salmon aquaculture also contributes to increased mortality of wild salmon, this aspect of salmon fisheries is left out of the scope of this thesis (Ford and Myers, 2008).

At first, fisheries managers believed that hatcheries could account for all human impacts on salmon habitat and allow for business as usual with development (Mahnken et al., 1998). However, now as a result of large-scale hatcheries, habitat loss, and overfishing, hatchery salmon have replaced wild salmon in many areas (Noakes et al., 2000, Zaporozhets and Zaporozhets, 2004, Kostow, 2008). Salmon hatcheries have been

seen as the solution to declining salmon abundance since the 20th century, but have recently come under criticism with suggestions that hatchery programs may actually further contribute to wild salmon population declines (Buhle et al., 2009, Naish et al., 2008, Chittenden et al., 2010).

In some areas, hatchery fish were actually determined to be a factor contributing to poor status of populations that were eventually listed on the ESA (Kostow, 2008) In the last 100 years, approximately 27 species of salmon have become extinct due to the impacts of introduced species, hybridization, and overharvesting, all of which can be linked to hatchery releases (ENRI, 2001). The main concern is that hatchery fish can lead to genetic change and decreases in fitness when two genetically isolated populations interbreed (ENRI, 2001). Local adaptations mostly include a salmon's intuition about when it is time to head to the sea, when it is time to return to homing grounds, and how the salmon finds the original stream where it was birthed (ENRI, 2001). Also, hatchery fish usually have lower survival rates and lower reproductive success, which can lead to genetic changes throughout the whole population when hatchery fish spawn in the wild (ENRI, 2001). One issue with an increasing dependence on hatchery-raised fish to boost salmon populations, is that the more hatchery fish that are in the wild, the higher the chances are that the two origin salmon will have genetic interactions (ENRI, 2001), Hatcheries impost costs on the environment, by impacting the genetics of the salmon population, causing harvest changes, and increasing competition with wild fish for food resources at sea (Eagle et al., 2004, Reisenbichler and Rubin, 1999).

Hatcheries have been used to compensate for lost habitat, to protect early life stages from natural predators, and to increase marine survival (Cooney and Brodeur, 1998)Hatcheries can be referred to as "constructed capital," where hatcheries are built to augment the stock of natural capital (Augerot and Smith, 2010). Successful hatchery programs should meet four criteria laid out by Hilborn and Eggers (2011): "(1) the successful production of fish that survive to be captured, (2) adequate survival, sustained for a long period, (3) hatchery production that can be harvested without affecting the production of wild fish, and (4) production of enhanced fish that does not significantly reduce the survival and production of wild fish (so that there are true net benefits of the enhancement)" (p. 340).

5.6. Histories of Hatcheries and Artificial Propagation, by Region

The development of salmon hatcheries in the Pacific Rim began in the late 19th century and has played a large part in salmon enhancement and conservation plans since the 1950s (Beamish et al., 1997). Beamish *et al* (1997) describes four many stages in Pacific Rim hatchery production: (1) Late 1800s to 1970: rudimentary hatchery husbandry developed; (2) 1970 to 1980: technical period characterized by significant improvements in feed and disease control and new hatchery designs; (3) 1980 to 1990: industrialization of hatcheries to deal with fishing pressure and loss of salmon habitat; and (4) after 1990: characterized by a concern about total number of releases (Beamish et al., 1997). While hatcheries were constructed around the same time in many regions of the North Pacific, the motives and success rates of each region vary. These differences are discussed below.

British Columbia, Canada:
The Salmonid Enhancement Program of Canada was put into place in 1977, with the objective of doubling salmon catches at sea by protecting and enhancing fish stocks in Canada (ENRI, 2001). Hatcheries built under this program supply 10% of total coho and Chinook catch, and it has been suggested that 80% of juvenile coho in British Columbia originated in hatcheries (ENRI, 2001, Noakes et al., 2000). In 2001, Canada ha a total of 38 federal hatcheries and 150 public involvement project, which produced around 650 million fish at the peak of production (ENRI, 2001).

Japan:
Japan has the largest and most extensive hatchery program of the Pacific Rim nations, with 150 hatcheries on Hokkaido and 165 on Honshu (ENRI, 2001, Morita et al., 2006). Most of the salmon released from these hatcheries are chum, pink and masu salmon, and on the scale of billions of fish per year (ENRI, 2001). The hatcheries were developed beginning in 1878 (Morita et al., 2006). All of Japan's fish stocks are maintained by artificial propagation and species exists solely as a result of hatchery releases that aim to increase catches at sea (ENRI, 2001, Morita et al., 2006). When adult migrate upstream, they are captured in weirs at the botommo of the river to be used for broodstock for hatchery production (Morita et al., 2006)In the 1980s and 1990s, Japan had a self-imposed cap on the number of hatcheries releases and regularly released around 2 billion fry each year (Heard, 1998). It has been shown that Asian pink salmon releases have a negative effect on the growth of Russian sockeye salmon (Ruggerone and Nielsen, 2004).

In Japan, transitions between high seas fishery and intensive coastal hatchery-based fishery have occurred as a result of political gains and losses. After the Russo-Japanese War, Japan gained extensive fishing concessions from Russia and was able to build a successful high seas fishery to account for loss of natural capital (Augerot and Smith, 2010). After World War II, however, Japan lost access to Russian fishing grounds and adapted by expanding hatchery production and transition to a fishery based upon hatchery releases (Augerot and Smith, 2010).

US Pacific Northwest:
In the Pacific Northwest of the United States, hatcheries were seen as the solution to conflicts between development and salmon declines; a way to develop agriculture, power technologies, and development while still maintaining strong salmon runs (Beamish et al., 1997). Development of hatcheries began in this region in the late 19th century and were built to account for loss of natural habitat due to urbanization, industrial development, dam creation, and increased agricultural impact on the river (ENRI, 2001). Hatcheries in California, for example, were established in 1872 to obtain Pacific salmon eggs to help replace depleted Atlantic salmon stocks (California Department of Fish and Game, 2001). And while hatchery production started in the late 1800s, it was not until the 1960s and 1970s that hatchery production increase dramatically (Magnusson and Hilborn, 2003). The trust in hatcheries and the promise of the best of both worlds lead to an expansion of hatcheries throughout this region in the 1970s (Beamish et al., 1997). It was also a common belief at this time that the ocean

had an underutilized capacity with respect to salmon (Noakes et al., 2000). Starting in the late 1990s, however, scientists began recommending that hatchery programs start taking a more conservative approach, focusing on conservation of salmon alongside production for at-sea fisheries (Beamish et al., 1997). Today, many scientists and policy makers recognize that salmon hatcheries must be managed according to their impact on the ecosystem, not only on net output of juveniles (Noakes et al., 2000).

In 2000, there were nearly 100 hatcheries in the Columbia River Basin alone, that produced around 200 million fish each year (ENRI, 2001). Most of the salmon produced in the Pacific Northwest are chinook, which first were produced in 1895 (ENRI, 2001). The primary purpose of the hatcheries in the Northwest are to support recreational and commercial fisheries (Kostow, 2008). In 1995, 470 million fish were released from the Pacific Northwest, mainly from Washington State, where salmon have been produced since the early 1900s (ENRI, 2001). In the Columbia River Basin, hatchery fish make up "95% of coho, 70% of spring-run chinook, 80% of summer-run chinook, 50% of fall-run chinook, and 70% of steelhead adults" (Levin and Williams, 2002). While hatcheries releases have increased in recent years, other areas have scaled back production with the intention of protection wild salmon runs. In Oregon, for example, releases of coho salmon dropped from 34 million juveniles in 1981 to an average of 1.6 million each year between 1998 to 2002 (Buhle et al., 2009).

In California, dams were constructed in many important spawning streams in the late 19th century and as a result in some years hatchery fish provided more than half of the salmon harvest (California Department of Fish and Game, 2001). In some areas of California, salmon only exist is those streams today due to the presence and operations of hatcheries (California Department of Fish and Game, 2001).

Alaska:
Salmon hatcheries in Alaska were started in the 1960s and 1970s in response to low salmon abundance (Hilborn and Eggers, 2011). At this same time, the Hatchery Act and the Fisheries Enhancement Loan Program was passes, which provide low-interest loans to aquaculture organizations (Hilborn and Eggers, 2011). A boom in Alaska hatcheries were the result of a 1900 amendment to the Alaska Salmon Fisheries Act which required anyone taking salmon for commercial purposes to also establish a hatchery (ENRI, 2001). As a result, many hatcheries were built but many were of very poor quality or ineffective. Again in 1988, the Alaska Department of Fish and Game increased hatchery programs to counteract declining salmon harvests and were operating 2 state, 27 private and 3 federal hatcheries (ENRI, 2001). Alaskan hatcheries predominately release pink and chum salmon and these releases account for roughly 34% of harvest of salmon in 2000, and between 16-30% in the 1990s (ENRI, 2001, Heard, 1998). In 1985, 2% of all commercial landings in Alaska were hatchery fish; in 2002, this figure grew to more than 20% (Eagle et al., 2004). Eagle *et al* (2004) predicted that this figure would continue to grow as fishing becomes less and less economically viable.

Russia:
The first hatcheries were built in Russia in 1920s both in mainland Russia and in the then Japanese controlled Sakhalin Island and Kurile Islands (ENRI, 2001). There were

also many hatcheries that developed in the 1990s in the Sakhalin and Iturup Islands, with the purpose of increasing pink salmon returns (Radchenko, 1998). Russia releases around 500 to 550 million Pacific salmon each year, of which approximately half are pink and half are chum (ENRI, 2001). In the Sakhalin-Kurile Islands region, hatcheries are major contributors to salmon production (Heard, 1998). In Russia, hatcheries are concentrated in the Sakhalin Territory, where hatcheries are working to increase pink salmon populations (Augerot and Smith, 2010).

5.7. Problems and Concerns Associated with Salmon Hatcheries

Throughout their history, salmon hatcheries have been a controversial strategy with perceived benefits that have changed and transformed throughout the years. However, despite some of the disputes, there are some key biological issues associated with hatcheries that will be discussed below. For many years, salmon hatcheries were seen as the modern and technical answer to rebuilding declining runs of wild salmon. It was thought that advancements in technology would be the solution to centuries of habitat degradation and environmental impact. However, little thought was give to how hatchery fish would interact with wild fish in the streams and rivers of the area (Bakke, 2010). In short, hatchery-raised salmon pose management, ecological, and genetic hazards to wild salmon populations, even if the intention of the hatchery was to boost or recover native populations (California Department of Fish and Game, 2001, Hayes et al., 2004).

Interactions between Wild and Hatchery Fish:

One of the biggest concerns with hatchery fish is that they interact with wild fish in inland streams and in the open ocean, at the detriment of wild fish. Because hatchery fish are released in river reaches were wild populations are still present, it is inevitable that the two populations will interact, mainly at the cost of reduced fitness and vitality for wild populations (Kostow, 2008). Chilcote (2003) found that when 50% of more of spawning adult fish were hatchery fish, the productivity of wild fish declined by 63%.

Another major concern with wild-hatchery interactions during spawning is that genetic introgression can lead to reduced fitness and reproductive success, because wild fish are no longer properly adapted to their spawning and rearing streams (Bakke, 2010). Simply put, wild fish are adapted to surviving in natural streams better than hatchery fish and hatchery fish have been show to have higher mortality rates at all stages of the salmon life cycle (Leider et al., 1990). When wild fish and hatchery fish interact in the wild, the fitness and productivity of wild fish are reduced (Bakke, 2010, Kostow, 2008). Hatchery-origin fish that spawn in the wild will have lower reproductive success, which may diminish the fitness of wild populations (Buhle et al., 2009, Hayes et al., 2004, Reisenbichler and Rubin, 1999).

Competition for Resources:

Another problem is that hatchery fish compete with wild fish for food resources and spawning and rearing space, sometimes even preying on wild fish or introducing diseases (Bakke, 2010). As juveniles, hatchery fish are significantly larger and can out-compete wild fish for resources or prey directly on the wild fish themselves (Hayes et al., 2004)During spawning, hatchery fish can increases competition for redd sites, reduce offspring fitness, and increase disease transmission (California Department of Fish and

Game, 2001). Similar situations occur at sea, when competition occurs over migratory corridors, food, and estuarine environments (California Department of Fish and Game, 2001, Ruggerone and Nielsen, 2009). Hilborn and Eggers (2011), argue that hatchery production will replace wild production whenever the two types of fish interact and there is mixed-stock fishing.

Reduced Fitness:
Wild-hatchery interactions, mainly in inland waters, can lead to reduced fitness of wild salmon populations, which can lead to an overall reduction in the health and success of the fishery (Bakke, 2010). Much of the concern over wild-hatchery interbreeding arose after the collapse of many Columbia River basis populations that was suspected to have been accelerated due to staying and interbreeding (California Department of Fish and Game, 2001). Wild-born offspring of hatchery fish have a low reproductive fitness and average only 37 percent the reproductive fitness of a fish with two wild parents (Bakke, 2010). This is important, because hatchery programs will have impact on salmon populations for generations to come, as wild and hatchery continue to interact, leading to gradual reduction of the fitness of the whole fishery (Bakke, 2010). For example, wild salmon are more productive when hatchery fish were below 12%, compared to when they were above 30% (Kostow, 2008).

Genetic Changes:
Similarly, there is concern that hatchery fish will effect the genetic pool of wild salmon. Because salmon adapt and change extremely easily, these changes can be seen in a population after just a few generations. There is also concern that hatchery fish will dilute the gene pool in populations of wild fish when they enter streams that are not their natal stream (ENRI, 2001). Because hatchery fish are transplanted to a stream, they may not experience the correct stimuli necessary to successful return to that stream to spawn; this can affect the amount of straying and increase gene dilution (ENRI, 2001).

Further genetic problems occur because selection that occurs in hatcheries favours salmon traits that are advantageous in captive environments but may not be equally as advantageous in the wild (Ford, 2002). Fish that are raised in hatchery do not display the same traits as a wild salmon. Also, hatchery fish can influence salmon behaviours such as levels of aggression, feeding habits, habitat uses, and predation behaviours (ENRI, 2001). As a result, salmon populations are more attractive to predators (Kostow, 2008). Hatchery fish are also at a higher risk of predation, as their predator-avoidance abilities are not as developed (Chittenden et al., 2010) As well, hatchery fish accustomed to received feed pellets in the hatchery may not be able to recognize optimal prey and have reduced foraging skills (Chittenden et al., 2010). As a result, several generations of captive breeding may result in a wild population that has evolved for hatchery conditions and far away from its wild optimum (Ford, 2002). With Pacific salmon, it has been shown that generations of hatchery releases have behavioural and morphological traits that are better suited for a hatchery than natural habitat (Ford, 2002).

Doesn't Address the Real Problem:

The other complaint with hatcheries is that they don't address the real causes of salmon declines. In some regions, hatcheries have been built to mitigate for habitat loss, human impacts, and mortality at dams, instead of working to restore habitat and natural populations (Bakke, 2010). Likewise, hatcheries give the fishing industry false hope about the abundance of salmon runs and can lead to an unsustainable harvest that only encourages more hatchery fish releases (Buhle et al., 2009, Naish et al., 2008). Or, hatchery production may mask declines in productivity of natural stocks (California Department of Fish and Game, 2001). Similarly, the presence of hatchery fish intermixed with wild fish can make evaluating the status of wild fish extremely difficult because the exact proportion of hatchery fish is not known (California Department of Fish and Game, 2001, Ruckelshaus et al., 2002).

5.8. Wild-Hatchery Interactions at Sea

One of the key themes in this research project is wild-hatchery interaction at sea and the ecological and political implications of these interactions. Density-dependent growth and survival occurs when salmon populations belonging to the same or different species compete for a common pool of prey resources in shared feeding grounds in the open ocean (Holt, 2010). Density-dependent growth is crucial to understand as salmon originating from different regions and continents intermingle in the North Pacific Ocean and compete for prey resources, which can lead to a reduction in growth for all species, but especially more vulnerable wild species (Ruggerone and Goetz, 2004, Ruggerone et al., 2003) (Ruggerone et al., 2003). High salmon abundances in the ocean can reduce growth and survival among salmon of the same species and among other salmon species (Ruggerone et al., 2010, Ruggerone and Goetz, 2004).

Density-dependent growth is an important concept, as it is directly related to the fitness or salmon species. Normally salmon only produce an average of one adult offspring, but when densities are low more offspring survive so that the population is able to recover from shocks to the system (Kostow, 2008). When hatchery fish skew the natural abundance of salmon, the natural density-dependent mechanisms are interfered with and the number of offspring stays low (Kostow, 2008).

While population size of Pacific salmon doubled between the early 1970s and 2000, the average body size of salmon returning to natal streams had decreased (Morita, 2001, Ruggerone et al., 2005). The concept of density-dependent growth became a large issue after several studies showed declining trends in salmon size, decreased weight, scale radius and width, and increased age of maturity (Cooney and Brodeur, 1998). The relationships highlighted in these studies implied that competition at sea could result in measurable growth reductions and that competition was due to an increase in production of hatchery fish (Cooney and Brodeur, 1998).

Density-dependent growth has the strongest impact in freshwater shortly after emergence, when increased density leads to decreased growth, increased emigration, increased competition for food, and increased mortalities (Kostow, 2008, Zaporozhets and Zaporozhets, 2004). In short, hatchery adults and their offspring occupy spawning and rearing habitats that could be used to support larger wild populations, that are instead being outcompeted (Kostow, 2008). Reduce growth can also be extremely

detrimental during the later stages of life, when it can affect reproductive potential and success (Ruggerone et al., 2007).

This type of competition, however, was not always recognized as plausible. In the 80s and 90s, it was assumed that salmon were consuming less than 0.5% of the available zooplankton biomass and that the ocean could easily sustain a population ten times greater than what was present (Heard, 1998, Ruggerone and Nielsen, 2009). It was not until the mid 1990s that scientists began to link high abundances of salmon and reduced salmon size with limited resources in the ocean (Heard, 1998). At this time, scientists started to suggest that density-dependent effects resulting in smaller salmon was a result of competition for food and space in ocean migration pathways (Heard, 1998). However, even in 1998, it was argued that there was a lack of evidence that hatchery salmon had any direct affect on wild salmon in the North Pacific (Heard, 1998)

Helle *et al* (2007) found that some salmon populations may compete for resources in the ocean but concluded that carrying capacity is not a constant value and varies with changes in environmental and biological factors. Instead, carrying capacity for salmon is highly dynamic and fluctuates over time (Heard, 1998)

Also, since salmon migrate across large distances at sea, hatchery fish from one region can affect the wild populations produced from a different region (Kostow, 2008). This suggests that density-dependent effects in the ocean are the result of combined releases of hatchery fish around the North Pacific, making this an international problem (Kostow, 2008).

As early as 1998, there were talks about regulating hatchery releases. Heard (1998), suggested “NPAFC member countries should consider a concept of cooperative quotas or a partitioning system to limit production of Pacific Rim salmon. Such a system could allow each country to decide what portion of its quota would be derived from wild and hatchery fish” (p.409). Furthermore, the idea of treating the seas as cropland and issuing quotas or grazing rights for salmon production was originally mentioned as an idea in 1975 (Joyner, 1975). When these ideas were being proposed, however, it was stated that more knowledge of ocean ecology and salmon interactions at sea would be necessary before a quota program could be implemented or considered (Heard, 1998).

5.9. Role of Climate Regimes on Salmon Populations

What makes this situation even more complicated is that all of the factors that influence salmon abundance and success at sea are not fully understood. Fluctuations in air and ocean temperature and atmospheric pressure appear to have a large impact on salmon populations, even when corrected for effects of fishing, but it is difficult to draw definite conclusions when so many factors influence salmon populations (Finney et al., 2000, Gargett, 1997). However, it is agreed upon that there is a link between salmon stocks and the Aleutian Low pressure area over the winter/spring seasons and that most of the ocean influence occurs in the costal waters during the early stages of development, rather than in the open ocean (Gargett, 1997). For example, salmon abundance in the mid 1990s can be attributed to favourable oceanographic and climatic factors that lead to high survivals (Heard, 1998). Likewise, Hollowed *et al* (2001) found that Pacific

salmon stocks showed production patters that shifted consistently with oscillations of the PDO. Phytoplankton and zooplankton production shifts according to climate conditions and regulate salmon populations, which leads to an ocean mortality rate for salmon ranging from 90 to 99% (Levin et al., 2001). And it times where hatchery releases are high and ocean productivity is low, increased competition for food resources will occur (Levin et al., 2001).

The most studied climate shift was the 1976-1977 climate shift that lead to an increase in the size and intensity of winter storms, and an increase in winter sea-surface temperature (Ruggerone et al., 2007). After this regime shift, Pacific salmon increased from approximately 300 million to 700 million adult salmon (Ruggerone et al., 2007). While all of the factors that caused this change in abundance aren't clearly understood, it is thought to be due to greater biomass of zooplankton (Ruggerone et al., 2007). Another regime shift occurred in the winter if 1988-1989, and in 1997 there was a warm and calm summer that had an impact on biota in the North Pacific (Ruggerone et al., 2007).

6. Current Management Structure

6.1. Japan

In Japan, fisheries are managed under the Fishery Law of 1901, which regulates that only cooperative members are allowed to fish (Augerot and Smith, 2010). Fishery Cooperative Associations (FCAs) are were traditionally financed by government subsidies, but are not becoming increasingly self-financing and independent organizations (Augerot and Smith, 2010). As a result of this structure, most hatchery and salmon fishery decisions are made at the local or regional scale. In Japan, the management plans developed by the FCAs are monitored by the prefecture but there is little regulation over commercial fisheries (Augerot and Smith, 2010).

The market is also highly influential in the management decisions of Japan. The country depends on salmon resources for internal consumption as well as export. While historically most salmon was consumed internally, today most of the salmon caught by Japanese vessels is exported to the People's Republic of China to be processed and sold (Augerot and Smith, 2010).

Japan's fisheries are also heavily dependent on salmon hatcheries and aquaculture. Japan is producing far more salmon that was naturally occurring. However, even with the increase in salmon propagation, only 2% of chum and 40% of pink even considered naturally spawning fish (Augerot and Smith, 2010).

6.2. Russia

The Russian salmon fishery is less developed, mostly focused in shore-based and terminal fisheries (Augerot and Smith, 2010). Most of the salmon harvest is carried out

by large private fishing companies, while recreational, native, and tourist fishing is hardly present (Augerot and Smith, 2010).

Russian fisheries are managed by a 2005 federal fisheries law that was updated and revised in both 2007 and 2008, giving 20-year commercial fishing concessions, and providing authority to provincial authorities (Augerot and Smith, 2010). Likewise, Russia has a strong set of policies called Forest and Water Codes that include clauses on salmon habitat protection. Unfortunately, these policies are weakening, enforcement capabilities are low, and new trends are effecting the strength of these codes (Augerot and Smith, 2010).

The Russian salmon fisheries were also highly impacted by the fall of the USSR. Historically, salmon were a property of the state and were managed using a top-down approach (Augerot and Smith, 2010). After the fall, more authority and management decision-making was allotted to regional authorities and regional salmon councils (Augerot and Smith, 2010). However, salmon is still a national resource and is managed by national agencies with regional offices (Augerot and Smith, 2010). There is also a system of provincially based salmon councils that help with salmon management activities (Augerot and Smith, 2010).

6.3. North America

Both Canada and the United States are managed by the Pacific Salmon Commission and the U.S.-Canada Salmon Treaty (Augerot and Smith, 2010). There are also regional policies that provide direction: the Alaska Department of Fish and Game, Canada's 2005 Wild Salmon Policy, the Canada Department of Fisheries and Oceans, and in the U.S., the Pacific Fisheries Management Council, tribal governments, state fish and wildlife agencies and sub-regional commissions (Augerot and Smith, 2010).

6.4. Washington-Oregon-California

WOC has the most complex set of management regulations- state, federal, and tribal authorities all have a say in the management (Augerot and Smith, 2010).

6.5. Alaska

In Alaska, salmon management is in the lands of the state; federal authority is only necessary with issues regarding federal lands (Augerot and Smith, 2010). However, Alaska participated in the NPAFC, the U.S.-Canada Salmon Commission and the Pacific States Marine Fisheries Commission (Augerot and Smith, 2010). In Alaska, it is estimated that Alaskan salmon runs are at 110% of historical abundance and biomass is near record highs (Augerot and Smith, 2010). However, in WOC the opposite is true; current runs are estimated to be only 5% of historical runs (Augerot and Smith, 2010). British Colombia is doing slightly better, with 40% of the historic levels and moderate environmental impacts (Augerot and Smith, 2010).

6.6. Canada

In British Columbia and Canada, management is shared by the Department of Fisheries and Oceans and First Nations tribes (Augerot and Smith, 2010). An overarching Wild Salmon Policy also aims to strengthen local fishery-based community organizations(Augerot and Smith, 2010). Regulations that state that there is to be no net loss of salmon habitat has protected habitat protection in British Columbia (Augerot and Smith, 2010).

Canada's salmon fisheries are also regulated by the county's Wild Salmon policy, and the Species at Risk Act (SARA) that was a response to the UN Convention on Biodiversity. There is also a committee on the Status of Endangered Wildlife in Canada.

6.7. Market Connectedness:

It is clear that economics are one of the most important factors in salmon management decisions across the Pacific Rim. This is due to the fact that salmon markets are well developed and there is a lucrative market for salmon products. While historically Japan consumed most of their salmon production internally, today salmon are exported for reprocessing in China (Augerot and Smith, 2010). The same was true with Russian salmon fisheries during the Soviet era, when most fish was sold to Western Russian markets (Augerot and Smith, 2010). Today, most of the fish caught in Russian waters is exported to Japan, Korea, and China (Augerot and Smith, 2010).

In North America, most salmon catches are exported. In the past, canned salmon was a global export, while today high-quality fresh-frozen fish is mainly sold to restaurants across the United States (Augerot and Smith, 2010).

6.8. Key Policies that have influenced salmon

- *The US Endangered Species Act (ESA):* Over time, more and more salmon species have been added to the ESA, which has resulted in increased spending for recovery of populations, totalling approximately $1 USD billion in 2009 (Augerot and Smith, 2010). The ESA recognizes that hatchery fish can be part of recovery efforts for certain species of salmon, as long as they don't impede progress or negatively affect natural populations (California Department of Fish and Game, 2001). Under the ESA, effects of hatchery operations on listed species must be evaluated and authorized (California Department of Fish and Game, 2001).
- *The Magnuson-Stevens Conservation and Management Act and the Canadian Wild Salmon policy:*Both encouraged more focus on ecosystem-based management and valuation of ecosystem services (Augerot and Smith, 2010).
- Fish and Game Code and the policies of the Fish and Game Commission regulate hatcheries in CA. These codes result from legislation and are reviewed every 5 years (California Department of Fish and Game, 2001).

6.8.1. 1982 United Nations Convention on the Law of the Sea:

This convention is significant, as it deals with subjects of marine fisheries that were previously outside the realm of international law, including EEZ's, rights and jurisdictions of coastal states, conservation, maximum sustainable yield, and management bodies for

higly migratory species (Alder and Lugten, 2002). However, by the time the convention came into force in 1994, however, many agreed that the convention was outdated and no longer addressed the issues at hand (Alder and Lugten, 2002).

6.8.2. UN Fish Stocks Agreement

This agreement implemented provisions in the 1982 convention dealing with straddling stocks and highly migratory species (Alder and Lugten, 2002). This agreement was significant as it took a precautionary approach to high seas fisheries, increased the role of regional fishery bodies and granted power to states to regulate other states' fishing practices (Alder and Lugten, 2002).

7. Results

The process of analyzing interviews and policy documents produced several emergent themes regarding how salmon management and hatchery policies are constructed. In the following section, the findings are presented and discussed by themes that emerged from the research analysis.

7.1. Doubts about Level of Expertise

One of the first themes to emerge from the research occurred before the interviews even commenced. Countless subjects of interview requests replied saying that they did not feel qualified to answer the questions, that the topic area was outside their area of expertise, or that they didn't think they could provide meaningful responses. Participants were helpful, engaged, and interested in the topic, but felt unable to respond to the research questions due to personal beliefs about their expertise levels. Some of the responses received are listed here:

- *Unfortunately, hatcheries are not my expertise.*
- *I know very little about salmon and therefore feel I should not participate.*
- *I must say that I'm not actually all that involved in hatcheries issues.*
- *I would not characterize myself as an expert on hatcheries in general. Also, I am not directly involved with management in any capacity.*
- *I feel that I am not a very qualified person on North Pacific hatchery resources.*
- *I am not an expert on North Pacific Salmon issues.*
- *Yes, I'm involved in marine resource management, but I'm not so familiar with salmon management.*
- *I am not an expert on North Pacific salmon issues and have only peripheral knowledge of salmon hatchery issues.*
- *These questions are far beyond my scope of knowledge.*

These responses went beyond issues of non-response for interviews and did not include the many people who said they didn't have the time or energy to have an interview. These respondents quickly responded to interview requests and were helpful in referring this researcher to new respondents. However, despite their background in salmon hatcheries issues, many people contacted for this research did not feel qualified to answer the on the theme of this project.

With some participants who provided this statement, this researcher followed-up with questions modified to their particular field and background. In some cases this got the individual to participate, but others read this second set of questions and still decided that they were not qualified enough to respond to the questions. It appears that the initial request to discuss an international issue was too intimidating for many recipients.

7.2. Differing Goals and Objectives

One of the key themes that emerged from the data was that countries have different goals and objectives for hatchery programs and that these goals influence how hatchery programs are run. The different goals and objectives for hatchery programs were clearly revealed in the research. Most participants were able to provide clear, factual statements about their region or countries hatchery plans, but most statements about other countries were based on speculation and assumptions. One respondent from Alaska was clearly able to state the goals of hatcheries in his region, but made speculations about other regions:

- *Alaska's hatcheries are geared towards augmenting harvest. The NW hatcheries now seem mostly aimed at conservation/supplementation and maintaining catches for Native American obligations. Canadian hatcheries I think follow the Alaska model. Japanese and Russian hatcheries are purely for producing catch* (fisheries professor, Alaska).

Other respondents commented about levels of government control and how this effects how hatcheries are managed:

- *I think different countries (and states within countries in the US) have different levels of govt. control and objectives (e.g., economic and species recovery) that influences policies* (fisheries biologist, Pacific NW 1).

The policies vary by country, leading to different policies:

- *Hatchery goals and objectives differ within a country, within a drainage system, as well as between countries* (fisheries scientist, Alaska 2).

Sometimes the appropriate issues can attention, while sometime the most pressing issues take a back burner for reasons like lack of interest, lack of knowledge, or lack of funding:

- *Competition in the fresh water environment has been an issue, but competition at sea has not* (fisheries scientist, Alaska 2).
- *Japan essentially wrote off their wild stocks, so they weren't considered in developing their hatchery programs* (fisheries professor, Alaska).
- *In Oregon we have reduced or eliminated a number of hatchery programs over the last 20 years or so. Many were in response to interactions with wild salmon in the same basins and some were due to budget cuts* (wildlife biologist, Pacific NW).

7.3. Politics of Hatchery Management

Another theme that emerged from the data was the political nature of hatchery releases and who would support international hatchery management.

One respondent commented that:

- *Japanese hatcheries policies are strongly affected by external pressures* (fisheries biologist, Japan 1).

This statement tends to suggest that the hatcheries policies of Japan are not only worried about domestic ecology or domestic fisheries, but rather about performing and meeting international standards for external sources. This respondent carried on my explaining that export is very important to Japan, and the pressure outside clients influences a lot of salmon policies that are created:

- *Scientists will be OK, but politicians and managers would probably not OK. However, external pressure would play an important role. For example, studies on wild salmon are now required to obtain MSC. Because export is very important for Japanese salmon fishery, MSC is necessary* (fisheries biologist, Japan 1).

- *The concept of international management of hatchery releases has not been discussed widely here and I don't think our stakeholders are even aware of the idea* (fisheries scientist, Alaska 2).

Two respondents echoed each other when talking about the reasons hatcheries were built in the Pacific Northwest:

- *Most of the hatchery programs were developed to replace or mitigate for salmon populations that were impacted by man. In most cases this was due to the building of dams which altered the rivers and/or blocked access to historical spawning and rearing reaches in the areas above the projects* (wildlife biologist, Pacific NW).
- *Many hatcheries in the US and Canada were built to mitigate for loss of habitat due to dam construction. The federal governments have legal obligations to provide salmon to native Indian tribes upriver to harvest* (salmon management specialist, Pacific NW).

Here, it appears that in the Pacific Northwest hatcheries have been set up to make up for loss of salmon habitat and to maintain historical spawning. When you compare the goals of these hatcheries to the goals of the Japanese hatcheries listed above, it is clear that the objectives and goals of the two are quite different.

7.4. Cultural Values and Norms

The role of culture, values and norms also emerged as a factor influencing hatchery policies of countries. Specifically, the hatchery policies of Japan were explained by cultural influences by two participants who pointed to Japan's large population, history of salmon consumption, and norms surrounding salmon. The first respondent addressed the fact that large populations depend on salmon resources and seems to suggest that salmon practices must continue on as usual, so that the citizens are pleased:

- *Culture plays a large part in hatchery policies: Japan has a large population with few natural resources so their hatchery program has been designed to maximize the number of salmon returning* (salmon management specialist, Pacific NW).

Another interviewee from Japan explained hatcheries is a completely unique way and compared them to public works:

- *It might be a different of the culture. Hatchery release is the one in Japan like public works. And, there is a superstition that only the hatchery fish is making fishing resources. Therefore, there is a tacit rule that the person who doesn't release it must not do the fishery* (fisheries biologist, Japan 1).

In this response, the interviewee compares hatcheries to public works like water, sewage and garbage, services that the state provides for the benefits of its citizens. This is the first time hatcheries had been described in this way in the literature, and it is very telling that the Japanese system that pumped out extraordinarily high amounts of hatchery views their releases as a public works that is making public resources for its citizens.

7.5. Conflicting Values and Stakeholder Perspectives

It is also clear from the data that stakeholders' viewpoints and perspectives are often at conflict at that this influences how hatchery and salmon management decisions are made.

For example, one respondent in Alaska talked about how finger pointing often occurs with salmon conservation because it always seems that someone has to lose in order to achieve salmon conservation"

- *We have a wide range of stakeholders from fishers, wild salmon advocates and water users (hydropower, irrigation, etc.). If a wild species declines in abundance such that they are listed under an endangered species act, then restrictions in harvest and water use ensue. Next comes the finger pointing as no stakeholder want to bear the burden of conservation (i.e. reduced harvest or reduced water consumption or reduced habitat development)* (fisheries scientist, Alaska 2).

Similarly, in North America, the dynamics between tribal groups and other stakeholders are often strained, especially with tribal groups have to go up against business or water uses on the rivers:

- *Competition between hatchery and wild salmon at sea has not been an issue in the debate on restoring endangered salmon stocks. Instead, water users want more hatchery production to mitigate loss of fish habitat. Meanwhile, tribal (Indian) and wild fish advocates argue that more hatchery fish only hides the problem of diminishing wild abundances and lost habitat (e.g., there is plenty of salmon being harvested and sold in the markets and cheap too, and therefore how can there be a problem?)* (fisheries scientist, Alaska 2).
- *The value the country places on wild salmon populations. Canada recently adopted a wild salmon policy, Alaska has politics that protect wild salmon over hatchery produced salmon, other countries provide protection only when salmon populations are depressed or in danger of being extirpated* (salmon management specialist, Pacific NW).

The media can also influence how the issues are viewed and how stakeholders are represented. In Japan, hatchery issues do not seem to be an issue of concern to most people:

- *In Japan, wild-hatchery issues have not yet gained lots of media attention. There are gaps between Japanese and foreign media, as well as fishery persons and scientist* (fisheries biologist, Japan 1).

But in other cases, the media can shape how a situation is viewed and lead to more conflict between stakeholders:

- *The classic case occurred at the Alsea River hatchery on the Oregon coast nearly a decade ago, when some fisherman filmed hatchery workers clubbing adult coho salmon to death because the State (who runs the hatchery) had determined that the run needed to be terminated because of negative impacts to listed coho salmon. It was definitely very bad publicity for the State, but was good policy from a conservation standpoint* (fisheries biologist, Pacific NW 1)

But like most issues, stakeholders lose interest, the conflict waxes and wanes and sometimes something that seems important has actually already been covered:

- I actually think wild-hatchery interactions were a bigger issue to the public 20 years ago in both Canada and the Pacific Northwest. Major changes to hatchery programs were instituted as a result (fisheries biologist, Alaska 2).

7.6. 'Healthy' and 'well-managed' fisheries

Participants provided reflections on what they viewed as a healthy fishery. Many participants shared some ideas of what this entailed, while other participants mentioned specific traits of a healthy fishery that was not mentioned elsewhere in the interview data or in the literature review.

Many participants talked about how a healthy fishery would have healthy interactions between wild and hatchery salmon:

- *To achieve long-term sustainable use of Pacific salmon risk of hatchery (i.e., disease, genetic diversity) should be considered. Wild fish and the fishery (hatchery release) are not things doing binary opposition. The fishery cannot exist without the healthy nature population* (fisheries biologist, Japan 1).

However, it is unclear if the concept of wild-hatchery interactions was brought up in this statement because the participant felt it was key to a healthy fishery, or if it was brought up because the participant thought that was the correct answer to give during an interview about hatchery salmon. Likewise, another participant brought up the need for managing both hatchery and wild salmon, but argued that hatchery salmon may be better to manage:

- *Healthy fisheries can target either hatchery or wild populations, although hatchery stocks obviously are much more productive since the egg to smolt mortality is much lower therefore more adults can be harvested* (fisheries biologist, Pacific NW 1).

- *A "healthy" or well-managed fishery as one that meets its economic objectives while having a minimum impact on wild populations. A "minimum" impact means that the fishery would not decrease or otherwise impact the viability of wild populations* (researcher, Pacific NW).

- *Healthy salmon fisheries are those that only cause mortality to specific stocks (not mixed either by stock or species) with high certainty, at sustainable levels (enough fish survive to produce future generations)* (fisheries biologist, Pacific NW 1).
- *Wild fish should be considered not only as a target of conservation but also making fisheries resources (fisheries biologist, Japan 1).*
- *I cannot still define a healthy salmon fishery. It is very difficult* (fisheries biologist, Japan 1).

7.7. Money Makes the World Go Round

As is true with other environmental issues, economic power and money are often some of the biggest drivers for making hatchery decisions. The role of economics appears to vary across region,

In the Western North Pacific ocean, it appears that economic play a larger role in the development of salmon hatchery policies and programs. Several researchers pointed out that Russian and Japan have both been increasing hatchery releases to increase economic opportunities:

- *My sense is growth in hatchery production in Russia is largely driven by economic opportunity, with little intervention by the government or concern for wild fish. This is also true to some extent in Alaska* (fisheries biologist, Pacific NW 1).
- *In Japan, they made a decision years ago to ignore wild fish in favour of hatchery fish* (fisheries biologist, Pacific NW 1).

One respondent noted that the economic incentives were too high and that they had little hope that any conservation efforts would occur, as long as there were high economic incentives:

- *I think economic incentives in places like Alaska and Russia are too high and government intervention too weak to ever make rationale policy around the Pacific Rim as a whole. Unfortunately, if someone can make a buck on hatchery fish, there are incentives to continue with business as usual* (fisheries biologist, Pacific NW 1).
- *I believe that in general most nations are trying to maximize economic activity from their hatchery activities in terms of numbers released, species released, and current world market conditions* (fisheries scientist, Alaska 1).

The global demand for salmon also influences hatchery decisions and because the economic incentives are so high, there is little incentive to change practices:

- *Currently the world-wide demand for salmon is very high and several countries are planning to increase hatchery production to be able to compete for market shares. The only way this will change is through international agreement to limit production. At the present time, there is no international body that can play such a role. I fear that things will have to get much worse before countries will come together to establish international agreement that limit hatchery production* (salmon management specialist, Pacific NW).

And beyond direct economic activity, there is also a desire to keep hatchery production up and running because it supplies the fish for sport and recreational fishers, which are a lucrative business in many areas. Such disagreements can lead to conflict, as one respondent notes:

- *There is a similar battle going on in the Columbia River because the federal govt. (who runs many hatcheries under the Mitchell Act) wants to decrease hatchery production while the counties are screaming about lost revenue because of lost fishing opportunity* (fisheries biologist, Pacific Northwest 1).

7.8. Distributed Power and Management Structures

Another aspect affecting hatchery releases is the body of government that regulates the hatchery releases and what agency gets to make decisions about hatchery releases. In the United States, hatcheries tend to be based on government mandates and controlled from the federal level:

- *The United States—that is federal government—hatchery policies are very specific to either Endangered Species Act listings, or to the operation of several federal operated hatcheries* (researcher, Pacific NW).
- *Most hatchery policy in the United States occurs at the level of state government. Individual states in the Western United States have widely varying hatchery policies* (researcher, Pacific NW).
- *I am not an expert on the hatchery policies of other countries. However, I believe they tend to be more centralized at the federal level* (researcher, Pacific NW)

And with ownership at the federal level, many people think this is as high up as the decision-making should go:

- *I think hatcheries are viewed as domestic responsibilities* (fisheries biologist, Pacific NW 2).

This is in contrast to other areas around the Pacific where ownership is in different hands:

- *Policies among countries will differ because of the types and levels of government control exerted on the hatchery, who owns the hatcheries (government vs. private), governmental subsidies for hatchery operation, and the state of each country's wild stocks of salmon* (fisheries scientist, Alaska 1).

This difference in jurisdictions and who holds the power to handle hatchery releases impacts what can get done:

- *The huge variation in jurisdiction around the Pacific Rim contributes significantly to our inability to establish uniform policies for hatchery operations that influence North Pacific salmon. We do not have any regional hatchery policies. Such policies would have to take the form of international treaties. I would say that there is no interest in forming such treaties at this time. We do have international treaties to govern ocean fisheries. These are managed by joint, international management councils* (researcher, Pacific NW).
- *I would guess that in the eastern Pacific international cooperation and coordination would strengthen the effects of hatchery form, but lack of cooperation would not "negate" benefits. In the western Pacific, where release*

numbers may be even larger than in the east and there are more nations feeding a common body of water the story may be different. This is pure speculation! (fisheries biologist, Pacific NW 2).

- *Many hatchery stocks in the eastern Pacific migrate across international boundaries and are caught in a variety of fisheries. If one of these hatcheries reduces production and fisheries are not adjusted then other stocks will be disproportionately harvested. This is treated as an allocation issue but could also be considered an interaction between hatcheries at the international level* (fisheries biologist, Pacific NW 2).

7.9. Changing perspectives of role of hatcheries

A positive theme that emerged in the data was that the role of hatcheries have been changing over time, so that it feasible that hatchery goals could change again once the science of wild-hatchery interactions is solidified.

For example, in the Pacific NW salmon hatcheries have started to look at Endangered Species and preserving genetic stock:

- *The newer hatchery programs focus on restoring a species to its former abundance or to a former drainage. These programs are motivated by the Endangered Species legislation in the United States and Canada. In turn, both follow through on the UN Convention on Biological Diversity. Thus newer hatchery programs are much more concerned about preserving the genetics of the endangered stock. Therefore the broodstock is always from the endangered WILD or NATURAL stock with very little mixing with other stocks. There is more emphasis on mimicking the natural rearing environment (within the rearing ponds), mimicking the natural out-migration timing, and the natural age of out-migration,* ***even if it means a lower rate of adult returns*** (fisheries scientist, Alaska 2).
- *US hatchery policy is increasingly moving away from production (fish for harvest) there are a number of "Mitchell Act" hatcheries on the Columbia River whose purpose is to "mitigate" for the habitat lost above dams. There is also a move toward "conservation" hatcheries that are intended to produce fish that are more compatible with natural runs. This is an experimental field, implementation varies widely, and effectiveness is really unknown* (fisheries biologist, Pacific NW 2).

However, even though the shift has been made, some stakeholders still see hatcheries as the problem:

- *On the West Coast of the US (California, Oregon, Washington, Idaho, British Columbia to some extent), there has been a major shift in policy towards hatcheries in response to ESA listings of many salmon populations: instead of being the solution to declining wild salmon runs, they are now viewed (in some circles) as part of the problem, but a necessary component of salmon management if fisheries are to continue at high levels. There is a major effort to reform hatchery policy in places like the Columbia River and it ain't over yet* (fisheries biologist, Pacific NW 1)

As a result of disagreements about what purpose hatcheries should hold, it is really just left up to individuals to suggest what hatchery release policies should be based upon:

- *Hatchery release policies should take in a wide variety of considerations. There are economic, social, and biological tradeoffs that should be considered when developing hatchery release practices…in my opinion, hatcheries should not be operated strictly as production (i.e., aquaculture) operations, but should be considered, in the broadest ecosystem context, to include needs of society as well as sustainable ocean and freshwater systems* (fisheries biologist, Pacific NW 2).

7.10. Role of Scientific Uncertainty in Management Decisions

The role of scientific uncertainty is absolutely key to hatchery management decisions and was a crucial theme in this research.

- *It has led to some major battles between folks who are concerned about the detrimental impacts of hatchery fish on wild populations, and those who want to fish catch, regardless of their origins or impacts to wild populations* (fisheries biologist, Pacific NW).

But even when discussing scientific ambiguity, there is controversy about whether or no there is a consensus. One person argues that there is no confusion about the science, while the other argues that there is no indications carrying capacity is understood:

- *I do not agree that the science is ambiguous on this issue. The lack of consensus about hatchery programs is political, not scientific* (researcher, Pacific NW).
- *In the US, scientific consensus about effects of hatcheries on natural runs is quite strong—in almost every study hatchery releases have negative effects on natural runs. However, the mechanisms governing this effect are not clear. The three main candidates are genetic changes in hatchery fish, behavioral changes in hatchery fish, and ecological interactions between hatchery and natural fish. As in most biological systems, all three probably play a role* (fisheries biologist, Pacific NW 2).
- *In the Eastern Pacific Ocean I do not see indications that ocean carrying capacity will become an issue in the near future* (fisheries biologist, Pacific NW 2).
- *Ocean carrying capacity issues have not been demonstrated yet, but it's a hard thing to show…until these show something, I think regulating releases on consideration of local wild salmon populations is most appropriate* (fisheries professor, Alaska).
- *To my knowledge there is not much evidence of wild-hatchery interactions at sea, at least in the Eastern Pacific. A few statistical studies in the mid 1990s found weak evidence for density-dependent interactions, but they were far from convincing. Environmental factors were the main driving force for variability in survival* (fisheries biologist, Pacific NW 2).

It is this ambiguity and confusion that has led to scientific debates that can't often be solved:

- *The lack of scientific consensus regarding the above observations and its effect on self-sustaining wild populations, has led to considerable debate on hatchery*

programs and its role in restoring endangered stocks (fisheries scientist, Alaska 2).

- *Because a chinook salmon may take as many as 6 years to return as an adult, it will be many more years before the data becomes available regarding this particular hatchery program. In the meantime, it is considered an experiment* (fisheries scientist, Alaska 2).
- *The mounting evidence for these effects has led to changes in goals for NW hatcheries. Alaska hatcheries ramped up later, as these effects began to become evidence, so the programs were set up to minimize interactions with wild stocks. However, AK is finding evidence that the interactions may be too large in some regions* (fisheries professor, Alaska).
- *The majority of fishers (commercial, sport, tribal, etc) still view hatcheries production as the only way to maintain or increase the harvest of salmon. Fishing groups are effective at lobbying resource agencies and policy makers to continue funding for hatchery releases. Lack of scientific consensus makes it difficult to change this paradigm or counteract demand for increasing production* (salmon management specialist, Pacific NW).
- *There is a large scientific debate over the carrying capacity of North Pacific (NP) and I have seen that hatchery releases in Japan have stabilized, but I do not know if this was due to the influence of the scientific debate over the issue of some other overriding factor* (fisheries scientist, Alaska 1).
- *Our knowledge of wild-hatchery interactions in the ocean will remain largely speculative and fraught with process and measurement error, but our knowledge of wild-hatchery interactions in freshwater (via straying and deliberate stocking in wild systems) will continue to be refined through better genetic techniques* (fisheries scientist, Alaska 1).
- *This is an experiment that needs to be done to evaluate whether hatchery releases can exceed local carrying capacity* (fisheries biologist, Pacific NW 1).
- *Just like climate change, there is a huge signal to noise ratio because of the multitude of factors influencing survival, so the decline may be difficult to detect* (fisheries biologist, Pacific NW 1).
- *I don't think it's black and white—in some years other factors will be more important, but there definitely will be years when the overall impact of too many fish in the ocean will be felt around the N Pacific* (fisheries biologist, Pacific NW 1).

7.11. Lack of Consensus

Another theme is the lack of consensus among stakeholders on all issue. It seems that some specialists are in the know and understand the scientific issue, while others don't have a clue or are ignored. As a result, the issues don't get talked about and people don't know what is going on:

- *I believe that outside of some scientific literature this issue is largely ignored, rather than argued over* (researcher, Pacific NW).
- *There is no international management of hatcheries now, nor have I heard of any proposals* (researcher, Pacific NW).

- *I haven't heard of any discussion about international management of hatchery releases* (fisheries biologist, Pacific NW 1).
- *Concerns about North Pacific carrying capacity and the effects of climate change is largely restricted to the research community, not other stakeholders (e.g., mangers, fishers, enviros). The information is just beginning to permeate the research community so it will be a while until it is general knowledge to other communities. Its also difficult to take a "precautionary approach" until some major event occurs that really gets people's attention. If business as usual is working reasonably well, why change it?* (fisheries biologist, Pacific NW 1).
- *While scientists agree on the direction of the effect, if not the mechanism, there is less acceptance among the non-scientific stakeholders. It is these non-scientific stakeholders who influence policy* (fisheries biologist, Pacific NW 2).

The other concern is the number of factors influencing salmon abundance at sea. Because all of the science is not well understood, it makes it a challenge to make any decisions on the topics:

- *Although competition and climate change are/will affect salmon productivity, so do a whole suit of other things (e.g., local conditions, ENSO events, Humboldt squid explosions, etc.) so its hard to make major policy changes when its just one of many factors affecting salmon survival* (fisheries biologist, Pacific NW 1).
- *Hatchery supplementation is one tool for maintaining these runs. There is controversy about how long such supplementation can be sustained, and whether it leads to continuing degradation of wild stocks* (fisheries biologist, Pacific NW 2).
- *I, myself, maintain that in the fisheries I work with these issues are minor compared with the effects of varying marine environmental conditions on interannual and decadal time scales. More of an issue, related to short-term (weekly) fluctuation in marine environment, is timing hatchery releases to coincide with favorable ocean conditions* (fisheries biologist, Pacific NW 2).

7.12. Incorrect Information

One theme that resonated throughout the data was the incorrect information that is portrayed, an incorrect perception of the issues, and some uncertainty about what effect this will have on management decisions:

- *One problem with the media is that they may not be particularly well informed. Also the public tend to believe what they want to believe* (researcher, Pacific NW).

Even if this study had reached out to citizen stakeholders, it is likely that most of the public would not be well informed and would know very little about the issue, since it isn't portray in the media often and often isn't portrayed correctly.

- *I hope so, especially if it is based on science, not some skewed view of the issues. The US Govt. is spending millions of $ on salmon recovery, and hatchery production is a huge part of the problem for many populations, but people want to fish so there is a tendency to paint hatchery fish in a more positive light than they often deserve* (fisheries biologist, Pacific NW 1).

And because of this uncertainty and lack of understanding:

- *It is not clear whether it will have an effect across international level of management* (researcher, Pacific NW).

7.13. Risk

Risk also plays a role in this debate. Some stakeholders choose to take the precautionary approach and try to minimize all interactions, while others don't believe anything will be done until there is a huge ecological disaster:

- *…if the fish are going to be released and fisheries are going to occur in mixed-stock areas, risk management will be highly complex* (researcher, Pacific NW).
- *In the Columbia River, salmon from California is being raised and released in Oregon. The release of non-local stocks has to be regulated such that the adult returns do not interfere with the spawning of the local wild salmon* (fisheries scientist, Alaska 2).
- *In this day and age when the emphasis is on protecting endangered species in both the U.S. and Canada, the mutual and primary concerns are non-local hatchery returns straying into the local wild spawning areas* (fisheries scientist, Alaska 2).
- I *think it would take a collapse of some wild or hatchery stock to raise international competition to a major issue* (fisheries scientist, Alaska 2).

7.14. Perspectives on how hatcheries should be managed

Lastly, how to properly manage hatcheries is not an agreed upon concept. Rather many factors can be used to describe a perfect hatchery.

- *I believe that artificial production of salmon can be used in risk-adverse fisheries (or food production) provided that the risks of both the hatchery program and of the mixed-stock fisheries are properly managed* (researcher, Pacific NW).
- *There will be limitations to fishery and hatchery production levels if they are to be compatible with wild population conservation* (researcher, Pacific NW).

Another researcher sees that hatchery releases should be based on risk/benefit analysis or on historical run size:

- *Hatchery release numbers should be based on case-specific expected benefits and the results of a sound, scientific risk/benefit analysis. The risk/benefit analysis should consider cumulative effects of multiple hatchery programs* (researcher, Pacific NW).
- *Hatchery releases should be related to historical natural run sizes at some agreed upon point in time. Each country could product a combination of hatchery and wild salmon up to their historical run size. In reality, these numbers will have to be negotiation between all countries involved* (salmon management specialist, Pacific NW).
- *A set of international principle or policies for salmon releases could and should be developed that would guide each country in deciding the costs and benefits of their hatchery operations. These policies would not control the numbers released, but would define the best practices (e.g., topics would be genetics, suitable release sites, avoiding wild salmon fishery interactions, reduced straying) that*

need to be adhered to in developing hatchery releases. These policies could indirectly change the number of salmon released (fisheries scientist, Alaska 1).

- *Hatchery release levels and locations should be determined by a variety of factors. First should be local effects on wild populations, so that fish aren't impacted by stray hatchery fish or subject to fisheries that have significant mortality on wild populations. In many cases, both of these issues aren't strictly a matter of numbers of fish but also location of hatcheries and the behaviour of fish* (fisheries biologist, Pacific NW 1).
- *There should be the ability to release more (or less) fish in a given year depending on ocean conditions in local waters. If ocean conditions are expected to be poor, then fewer hatchery fish should be released* (fisheries biologist, Pacific NW 1).
- *Hatchery production should not increase beyond the current level and if anything should decline. If projections are correct that suitable habitat for salmon will rapidly shrink with climate change, then taking a conservative approach is our best bet* (fisheries biologist, Pacific NW 1).
- *I would hope that better understanding of ocean carrying capacity and hatchery-wild interactions would lead to rational hatchery management. It is happening in some pleaces at the regional level due to ESA concerns (e.g., Pacific Northwest) and the ability to structure fisheries to catch hatchery fish without impacting wild populations, such as required under the Pacific Salmon Treaty (between US & Canada over salmon harvest)* (fisheries biologist, Pacific Northwest 1).

7.15. Wrap-Up of Thematic Analysis

This section attempted to describe the many themes that emerged from the qualitative interviews that were conducted for this study. Several key themes emerged, most of which had to do with the role of scientific knowledge in managing hatcheries and the role of uncertainty and the precautionary principle. In the following section, some of these results will be discussed and countries policies will be used to see where there may be potential for conflict or debate between countries.

7.16. Discussion

7.17. Japan

Japan's overarching perspective to salmon management appears to be that hatchery and wild fish can coexist and should be managed together (Morita et al., 2006). Because most of their historic runs have been depleted and their current hatchery releases far surpass historical outputs, Japan is in a unique place in hatchery negotiations and has unique sets of drivers.

Japan's current salmon policies and structure are governed by several factors. However, it seems unfeasible that Japan would early join any time of international management of hatchery release, due to the importance of salmon in their economic situation.

However, for all indications that Japan will be unwilling to participate in hatchery management or hatchery regimes, there are the reports that Japan has cut back their hatchery releases because of fear of negative results. Perhaps the tide are turning and Japan is willing to take a more ecosystem approach to these issues, or perhaps the downturn in hatchery releases was simply for economic reasons.

It also seems likely that the recent nuclear disaster in Japan might change some mindsets in the country about environmental limits, precautionary approach, and surviving on resources that are not naturally present in the country. Maybe in the rebuilding of the nation and the restructuring of policies, Japan will decide on more conservative environmental policies that reduce salmon hatchery releases.

7.18. Russia

Russia is a bit of a wildcard in the negotiations over hatchery salmon. They are the least studied country in the region and their motivations and goals for their salmon hatcheries are not as well understood as other regions.

Russia also seems to have the most potential for conservation, as they still have huge expanses of untouched and pristine salmon habitat. As some conservationists suggest, maybe more attention and efforts should be directed at Russia so that you can save the best habitat, rather than saving little patches of shoddy habitat is other regions of the North Pacific Rim.

7.19. Canada

Canada has a strong wild salmon policy in place and is working to achieve sustainability between hatchery and wild salmon. Canada would likely join an international treaty on hatchery management from the get-go, as they are already concerned with wild-hatchery interactions and are interested in working to sustainable fisheries. For the most part, the federal government and First Nations people have goals of increasing wild salmon yields and maintaining ecosystem health and complete habitats.

7.20. United States

7.20.1. Alaska

Alaska is one of the most interesting cases, as they seem to have the most diverse stakeholders and the most opinions about what should be done. For decades, Alaska has been releasing hatchery fish, leading to bigger salmon stocks. While total abundance has gone up, diversity and body size have dropped. Alaska also faces stakeholders representing all sides of the story. Negotiating and finding common ground will be difficult when so many stakeholders have a point of view on the topic.

7.20.2. Washington-Oregon- California

The WOC region seems to have the most at stake with regards to the negative implications of wild-hatchery interactions. Because this region's shadow of the future is the longest and they have the most to gain from long term conservation and immediate action, it is likely that this region will lead the charge for implementing hatchery policies that promote healthy wild runs.

7.21. Management Options for the Pacific Rim Region

After analyzing the literature in the field, speaking with experts, and reviewing policy documents, it makes sense to present the various management options that could be adopted or considered in the North Pacific Ocean rim.

Kostow (2008) argues that there are only two possible strategies for completely eliminating the negative effects of hatcheries- either to shut down all the hatchery programs or to never release hatchery fish in to the wild. However, both of these situations are rather unrealistic when you look across the North Pacific rim and the scale of the hatchery releases. At this stage in the game when there is still scientific ambiguity and political disinterest it seems unlikely that such radical changes would even be considered, let along implemented or acted upon. It would take scientific proof and a collapse of the Pacific salmon for any drastic measures like shutting down all hatchery programs to take place.

Rather, management options should focus on lessening ecological risks, instead of total elimination (Kostow, 2008). One such management option to consider is ecosystem-based management that considers and incorporates aspects of climatic and oceanic monitoring, biological monitoring, and sustainable management of salmon production (Kaeriyama, 2004). Such a comprehensive management plan would help determine how salmon were affected by ocean climate versus hatchery fish, would help identify all of the factors that are influencing salmon, and would take a holistic approach to restoring salmon by looking at ecosystem health, as well as catch at sea and other direct effects.

Another approach for managing salmon hatchery releases is to take it on a case by case basis and treat wild-hatchery interactions on a local scale. While this management option then ignores any at sea interactions, it is possible that managing local populations will also address the challenges at sea.

With any management option that is selected, the resulting conservation structure should be based on restoring and increasing natural runs, protecting and restoring natural habitat, making sure wild fish are not being depressed by hatchery fish, and that adults can reach natural spawning areas.

Other approaches include releasing smaller fish from the hatcheries so that competition is reduced, decreasing the total number of species that are reduced, timing hatchery releases so that they don't affect wild runs, and marking all hatchery fish so that their movement, interactions, and lifecycle are more fully understood.

8. Recommendations and Conclusion

The previous chapters presented the research results and discussion from the research project on North Pacific Ocean salmon hatcheries management. The aim of this research was

8.1. Meeting the Research Aims and Objectives

This study was rather haphazard in its approach and left many open questions and gap about the current situation of hatchery salmon in the North Pacific Rim. That being said, this study did address the main research questions and achieved most of the set out aims and objectives.

The aim of this research was to show that conflict could arise between countries with no other significant disputes solely due to different management and conservation strategies for North Pacific salmon stocks. While this thesis didn't end up showing that conflict has occurred or will occur in the future, it did identify areas of disagreement and differences in value that could lead to conflict in the future.

- *To identify and compare artificial salmon propagation policies and management strategies of the five North Pacific Ocean countries.*

By comparing the policies and management strategies of the various countries, it became clear that there are differences in artificial propagation approaches and that these difference can be explained by several factors including loss of native stocks, desire to boost output, and a desire to build a more economically sound fishery.

- *To understand current conflicts and possible future points of contention between the states regarding hatchery growth and releases.*

The factors influencing a state's wiliness to participate in hatchery regimes has a lot to do with the current level of ecosystem stress, the economics of salmon runs in the region, and the level of scientific ambiguity surrounding wild-hatchery interactions at sea. This thesis identified several factors that may influence future points of contention and disagreement between the states.

- *To determine and analyze the incentives and disincentives for cooperation among states in the North Pacific Ocean by conducting interviews with key stakeholders.*

The interviews were very revealing, but unfortunately the audience was not diverse enough

8.2. Recommendations for Further Research

While the conclusions drawn in this study highlight some of the main factors influencing a country's likelihood to cooperation in international hatchery management regimes, it is quite clear that more research need to be done on this topic. The sheer fact that very few people are working in this field and that there is very little literature on the politics side of the issue highlights that this issue is under studied and under valued.

8.3. Last Words

This thesis project was by no means exhaustive and still lacks analysis and discussion about the conclusions that were drawn. However, the data that was collected is revealing about the nature of salmon hatchery policies in countries in the North Pacific Rim. At the moment, it appears that wild-hatchery interactions are understood by scientists and conservationist, but are not a big concern for many other stakeholders. To remedy this, more people will need to be educated about the interactions and negative consequences of competition at sea. Another problem that must be addressed is the lack of scientific understanding about wild-hatchery interactions at sea. This field must be studied and carrying capacity must be full understood so that managers and politicians can make the best possible salmon management decisions and promote healthy, sustainable fisheries.

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