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Shifting Baselines in the Fishing Industry of the Lummi Nation: A Study of Declining Expectations

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HONORS THESIS

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Abstract
Shifting environmental baselines are inter-generational changes in perception of the state of the environment. As one generation replaces another, people's perceptions of what is natural change even to the extent that they no longer believe historical anecdotes of past abundance or size of species. I present the first quantified evidence of shifting environmental baselines from a Pacific Northwest Native American fishery (Lummi Nation in Puget Sound, Washington). As depletion of commercial fish species spreads out from the coast, younger fishers share few of their elders' memories of former abundances. Of three generations, the oldest reported more fish species depleted, and they also recalled larger catches. Generations also differed in their perceptions of environmental change. Such rapid shifts in perception of what is natural help explain why society is tolerant of the creeping loss of biodiversity. They imply a large educational hurdle in efforts to reset expectations and targets for conservation.

3 Introduction

3.1 Shifting Baselines

Among scientists, a baseline is an important reference point because it measures the health of ecosystems, provides information against which to evaluate change and shows how things "used to be." Establishing a baseline for all natural resources is necessary to fully understand the extent various populations have been impacted throughout time, and is essential to their management and recovery. Without a reference point, managers and users may be unaware of drastic changes in the resource. This phenomenon of "shifting baselines" describes the tendency of people to perceive the condition of a natural resource as healthy, even though it has slowly degraded through time. The term was first used by fisheries scientist Daniel Pauly in his 1995 paper "Anecdotes and the Shifting Baseline Syndrome of Fisheries." Pauly developed the term in reference to fisheries management where fisheries scientists sometimes fail to identify the correct "baseline" population size (e.g. how abundant a fish species population was *before* human exploitation) and thus work with a shifted baseline. As one generation replaces another, people's perceptions of what is natural constantly shifts, sometimes even to the extent that they no longer believe historical anecdotes of past abundance or size of species. This phenomenon can be

applied to any natural resource, but the bulk of the research has been conducted in marine ecosystems.

The majority of these studies analyze historical catch records and how they have changed through time. Baum and Meyers (2004) tracked the change of the Gulf of Mexico's pelagic shark population from the 1950s to the 1990s. They documented a shifting baseline by analyzing past and present catch rate data. McClenachan (2008), Meyers and Worm (2003), and Roberts (2007) similarly used past catch rates and historical documentation to determine if shifting baselines existed. Most of these data are exclusively located in the hands of the natural resource managers. While managers may have a well established idea of what past conditions looked like, if this information is not transferred to members of the community or the harvesters of the resource, this valuable information will not be fully utilized. Fishers' insights and knowledge of fisheries could inform policy and management decisions, but fisheries management often excludes or discounts fishers' perceptions (Bunce 2008). Reflective of fisheries management, very few studies have gauged how the fishers' perceptions of these stocks have changed throughout time. Dulvy and Polunin (2004), Bunce (2008), and Sàenz-Arroyo (2005) attempt to quantify these intergenerational changes, but they all center on coral reef fisheries in Southern California, Indonesia, and the Indian Ocean. There are no studies documenting shifting baselines in any North Pacific Ocean fisheries, and moreover, within a Native American fishing industry.

My research focuses on the Lummi Nation fishers in Puget Sound, Washington State and attempts to gauge the effect "shifting baselines" has had on the local community and their perceptions of the state of fisheries in Puget Sound. In addition, my study seeks to track how

fishers obtain their knowledge of fisheries, and also to assess fishers' individual ideas of how best to address the management of the rapidly declining fish and shellfish stocks in the region. Due to the close-knit community, strong intergenerational communication, and a population closely integrated and dependent upon the fishing industry, I predicted that shifting baselines would not exist within the Lummi fishing community. I hypothesized that through storytelling and intergenerational connectivity, younger generations would have very similar recollections of historical fish stocks to older generations.

3.2 Site Description and Historical Context

I tested shifting baselines on the Lummi Reservation which is located seven miles northwest of Bellingham, Washington, in the western portion of Whatcom County, 95 miles north of Seattle (N 48.8165 and W -122.63462). The reservation is a five-mile long peninsula bordered by Lummi Bay on the west, and Bellingham Bay on the east. (Map 1). The majority of the reservation is comprised of deciduous forests and emergent wetlands (Grindell 2008), and major sources of water include the Nooksack River, Kwina Slough, Lummi/Red River, Jordan Creek, Bellingham Bay, Portage Bay, Hale Passage, Lummi Bay, Georgia Straits, Sandy Point Canal System, and Agate Lake (Miller 2007).

Map 1. Lummi Nation Reservation

The Lummi Nation signed the Treaty of Point Elliot in 1855, ceding much of their land in western Washington to the federal government. In return they received a reservation that originally covered 15,000 acres. Today approximately 12,000 acres of the initial 15,000 remain in Lummi control, and according to the 2000 census, approximately 4193 Lummi live on the reservation in 1749 housing units. Six hundred of the Lummi are licensed fishers, and fishing and shellfish gathering are the Tribe's primary means of subsistence (Boxberger 1988). Historically, main fishing sites included the Frasier River, the Nooksack River, Portage Bay, Bellingham Bay and Lummi Bay (Miller 2007; Muckleshoot Tribe v. Lummi Indian Tribe 1998; Boxberger 1988).

According to Boxberger, prior to the establishment of the reservation, the Lummi were a semi-sedentary people, traveling throughout the year in search of fishing, shellfish harvesting and plant gathering sites. They were primarily engaged in a traditional fishery, and harvested just enough each year to meet their subsistence needs. Their most vital sources of food, in order of importance, included: reef net fishing for salmon, weir site fishing for salmon, shellfish gathering, other forms of salmon fishing, fishing for other species, gathering plant foods, waterfowl hunting, sea mammal hunting, and land mammal hunting. Salmon were their most important food source. "One authority has estimated the pre-contact annual per capita intake of salmon for the Lummis at six hundred pounds, one of the highest in the Northwest coast culture area" (13). The fish consumed most by the Lummi during the 1700s included five species of salmon and one trout species, all collected through at least 12 different methods of harvest. These species included steelhead (*Salmo gairdnerii*), Chinook (*Oncorhynchus tshawytscha*), Coho (*Oncorhynchus kisutch*); pink (*Oncorhynchus gorbusche*); chum (*Oncorhynchus keta*); and sockeye (*Oncorhynchus nerka*) (193).

Sockeye salmon have historically been the most significant species for the Lummi, and to exploit the Frasier River runs of sockeye in the San Juan Islands and in Georgia Strait, they created a highly developed technology called reef netting (see Photo 1). Reef netting was used for taking large quantities of fish in salt water. Lummi had reef net sets on Orcas Island, San Juan Island, Lummi Island and Fidalgo Island, Portage Island and near Point Roberts, and Sandy Point.

"Reef netting is a centuries-old method of salmon fishing, and today there are only 11 licensed reef netters in the world, all located in north Puget Sound. To fish, a 'reef' is created, using lines and flags strung between two floating, stationary platforms. As the flood tide runs, salmon swim into this 'reef', which ultimately channels them between the two platforms and over the netting. When a Spotter, perched in their tower 20 feet above the water, sees fish over the net, a command of 'Pull!' is issued; the net is raised, and the fish slide gently onto the platform, then directly into a live holding pen below the gear. Once in the live holding pen the salmon swim freely in the current, and any unintended catch is returned to the sea, unharmed," ("Lummi Island Heritage" 2009).

This type of fishing continued into the 1880s, despite the federal government's efforts to force the Lummi into agriculture. By the 1900s, the Lummi were producing not only enough for their people, but also a surplus that could be sold on the market. This, in addition to an increase in immigration from Europe, Japan and Russia and demand for salmon, resulted in the commercial salmon fishing industry quickly becoming Washington's primary source of revenue. The Lummis shifted from an exclusive subsistence

Photo 1. Two Lummi fishermen pull net full of salmon onto reef boat. Reef netting was once the Lummi's primary fishing technique. *Courtesy: Whatcom Museum of History & Art.*

harvesting lifestyle to one that centered on the commercial fishing industry (Boxberger 1988; Russo 2002; Lemoine 2009).

While they founded the salmon culture in the region, in the years that followed the Lummi suffered under a number of policies and practices directly excluding them from the commercial salmon fishery of Puget Sound. By the late 1960s, the combined take of the treaty tribes was down to about two percent of the overall salmon fishery (Boxberger 1988). However, in 1974, the U.S. Federal Circuit Court Boldt Decision defined Indian fishing rights and guaranteed the tribes of the Point Elliot Treaty of 1855 a legal right to half the annual allowable salmon harvest in Washington waters (Delagado 2007). In the 1990s this was additionally extended to shellfish and ground fish (Singleton 2009). The decision also created a co-management relationship between state agencies and treaty tribes. The State may not enforce a law on an Indian Reservation when doing so would interfere with the tribe's right to self government (Pevar 2000).

The Lummi are now allowed to fish freely on the reservation as well as on off-reservation territories as long as their activities are undertaken at all "usual and accustomed grounds and stations." These grounds include the marine areas of Northern Puget Sound from the Frasier River to the "present environs of Seattle," (*Muckleshoot Tribe v. Lummi Indian Tribe 1998*). However, under the Supreme Court case, *Puyallip, Tribe Inc. v. Department of Game* (1968), the State is able to regulate fishing on tribal lands when "absolutely essential for conservation purposes."

This critical economic and cultural resource, however, is presently severely threatened with extinction. During the past ten years the salmon stocks have drastically declined. Once so thick

you could "walk on their backs" as legends say, two of the four species of salmon are now being considered for protection under the federal Endangered Species Act. This decline is attributed to

> "accelerated logging in the headwater areas of the Nooksack Basin, the erection of small hydroelectric dams on salmon streams, ground and water pollution from industry and agriculture, the decline of wetland areas, and the rapid and irresponsible development of the lowland areas. As a result of such actions, the North Fork of the Nooksack River has dropped over eight feet in the past ten years, and over 60 percent of the original salmon-bearing streams have been destroyed due to logging practices. Some portions of the South Fork of the Nooksack River average over 70 degrees Fahrenheit which is a lethal temperature for salmon" (Russo 1996).

4 Methodology

4.1 Surveys and Interviews

I conducted interviews in April and May 2009 on the Lummi Indian Reservation using a questionnaire adapted from Sáenz-Arroyo, et al. (2005) to determine fishers' perceptions of the status of fish stocks in Puget Sound. A series of pre-study interviews were conducted to help guide the development of survey questions and to gauge general perception of fishers' view of the fisheries. Each fisher was asked to name species and places he or she considered to be depleted by fishing. Since the Lummi use both common and tribal names for species, the Gilbert (2002) and Lamb (1986) fish guides and photographs were used to clarify species identifications during the interviews. Any new species names encountered during interviews were recorded and added to the questionnaire. Two Department of Fish and Wildlife maps detailing Puget Sound commercial fishing and shellfish harvest zones were also used (Appendices A and B) to indicate primary harvesting zones. These maps are utilized by all Lummi fishing vessels, which ensured the fishers were familiar with the location of fishing areas. The study also followed the technical and ethical recommendations in Bunce et al. (2000) for conducting respectful interviews acknowledging local customs and culture, and minimizing disruption of interviewees' daily

routines. Guidelines on the determination of sample size that consider the trade-offs between available resources (time, personnel and money) and the goal of achieving a representative sample of adequate size also followed Bunce et al. (2000).

4.2 Data Collection

The population for this study included all Lummi Nation fishers, retired, full-time or part-time; male or female; young and old who have, or are presently, fishing in Puget Sound. Approximately eight percent (N=48) of the 600 Lummi fishers located on the reservation were interviewed for this study. Three generations of fishers were identified: young (15-30 years, N=14), middle-aged (31-50, N=22) and old (>50, N=12).

Photo 2. Site 1- Native American Shellfish Company, a fish processing plant.

Photo 3. Site 2- Gooseberry Point Boat Launch.

Photo 4. Site 3- Lummi Point Shipyard.

Lummi fishers work seven days a week, and all hours of the day. To account for this variability, 48 fishers were selected for interviews using two methods. Both of these methods are forms of stratified random sampling, where I preselected three locations, and randomly selected fishers within each of these locations. In the first method, fishers were randomly selected from three main gathering sites on the Lummi Reservation: Gooseberry Point, a boat landing, the

Lummi Point shipyard, and the *Native American Shellfish Company,* a fish processing plant (see photos 2, 3, and 4). Members of the Lummi Natural Resource Department and local Lummi fishers identified these as the primary places of congregation for fishers. The questionnaire was applied at random to fishers at each of these three sites. In the second method, I visited and interviewed fishers in their homes. Houses were selected systematically using a set of previously chosen criteria. They had to be located on the Lummi Reservation within one mile of the shoreline and to have at least one fishing boat in the front yard, suggesting a potential fishing-based income. Many of the old, retired fishers were visited in their homes after asking younger fishers where to locate them.

To categorize the extent the Lummi fishers felt the Puget Sound fisheries are in decline, and to identify signs of shifting baselines, I asked the fishers a series of 21 questions (Appendix C). Fishers were first asked to recall all fish and shellfish they had caught in their lifetime. This question was designed to aid fishers in recollecting all of the fish they have harvested before addressing these species later on in the questionnaire. Specifically, they were asked what they would consider a "good catch" for one day of fishing (in pounds) now, versus when they first began fishing. They were also asked if over the years the majority of the Lummi Tribe harvest had changed from fish to shellfish, and the year when they thought this occurred. Fishing effort and catch estimates were reported in a variety of units (e.g., totes, dollar value, number of fish). Where possible, these estimates were converted to the same units (e.g., pounds or hours). During interviews fishers also indicated their perceptions of the reasons for the decline of fish stocks. They discussed how this was linked to the environmental changes in the area, notably increased agricultural land use, deforestation and logging practices causing soil erosion and sedimentation in streams, and river dredging. I also asked each fisher to locate on two maps (Puget Sound

shellfish harvest zones and fishing harvest zones located in Appendix A and B) where their primary fishing areas are presently in contrast to where they were when they began fishing.

All interviews were conducted in private and administered verbally to the interviewee. They were recorded both in handwritten form and by audio-recording. If any words throughout the interview were unrecognizable to the interviewee, a short definition or clarification was provided. To narrow the sample to Lummi fishers only, all interviewees were first asked if he or she was a fisher. I did not encounter any non-Lummi fishers during the study. To build trust and to accommodate the Native American verbal communication-based culture, the first one to ten minutes of each interview were spent discussing life in the fishing industry before beginning the questionnaire. This also provided time to explore the fishers' knowledge and allowed them to raise issues that they considered to be important (Light 1982). Prior to each interview, I informed the fisher he/she was participating in a Western Washington University study on the status of fish stocks in Puget Sound, and could decline to participate at any time. None of the fishers were informed of the intent behind the questionnaire until the completion of the interview, and I made the assumption that all interviewees answered the questions truthfully. Interview times ranged from ten minutes to one hour.

4.3 Data Analysis

Quantitative data were entered into *EXCEL* and one-way ANOVA statistical tests were used to test for significant differences. Qualitative interviews were recorded digitally and transcribed in full. Fishers' comments were arranged by key themes, with quotes selected if they appeared to be representative of the fisher's views.

5 Results

5.1 Fisher Profile

The fishing industry for the Lummi is integral to their livelihood. Lummis still believe they are the salmon people. According to the Lummi, the Great Salmon Woman has taught them if they take only the amount of salmon they need and protect their birthing areas, the salmon will continue to exist and thrive. They learn at a young age that it is their historic right and obligation to protect this resource and manage it in a way that it will last for generations to come (Johansen 1999). Fishing is not only a foundation for their spiritual, social and cultural lives, but 65% of the fishers also receive 100% of their annual income from the fishing industry. Like many other native communities, the Lummi struggle with a high rate of joblessness; 79% of the households are below the median income for a family of four in Whatcom County (Johansen 104), and 28 percent of the population is living in poverty (Buckles 2008). Only 61% of the adult population is employed, and the unemployment rate is presently at 15.9%. The median monthly income for employed Lummi tribal members is approximately $2000. For the enrolled adult population, 15.1% does not have a high school diploma or GED; 33.8% have either a high school or GED degree; 27.1 % have some college experience; 14.9% have either an AA/AS Degree; 7.5% have a Bachelors Degree; and 1.6% attained a Graduate or Professional degree (U.S. Census 2000).

Most of the Lummi fishers are born on the reservation and have spent their entire lives growing up in the fishing industry. Many began fishing on their parents' fishing boats as young as five years old, and continued into their teen years, when they began working as deck hands and loaders. At age 18 they can register as full time professional fishers. Many work on a boat for a few years, and eventually save up enough funding to purchase their own. There are three Lummi-owned processing plants on the reservation where most of the fishers bring their harvests

including a Lummi-owned seafood processing plant, *Fish Point Seafoods* (a privately owned seafood processing plant), and the Lummi-owned smoked fish processing plant (Tzo 2009).

The average fisher surveyed was 41 years of age, with 27 years of experience. Many fishers remain active well into old age and memories of the fishery among those interviewed start in 1937. When asked where the fishers received their information on the state of the fisheries in Puget Sound, 85 percent, said they said they gained it from family members and from personal experience growing up and living within the fishing industry. Additionally, only those who have been a member of the Fisheries Commission (11 percent of respondents), cited gaining their information from the Natural Resources Department (NRD) or any other state or federal agency. Only one fisher cited receiving his information from news articles. No other books, resources, biologists, or web resources were mentioned. This provides a social and cultural context for the remainder of the results, as most all of the fishers have learned about the state of the fisheries in Puget Sound almost exclusively through intergenerational communication and personal experience. No respondents from outside the fisheries committees gained their information from the NRD or other federal or state agencies.

Photo 5. Older Lummi fisher and his family of three generations.

Lummi fishers use a variety of equipment depending on the time of year and the species they are harvesting. The average fisher surveyed owned four fishing boats, and the majority owned seiners, skiffs and gillnetters used primarily for crabbing, halibut, and salmon. In total,

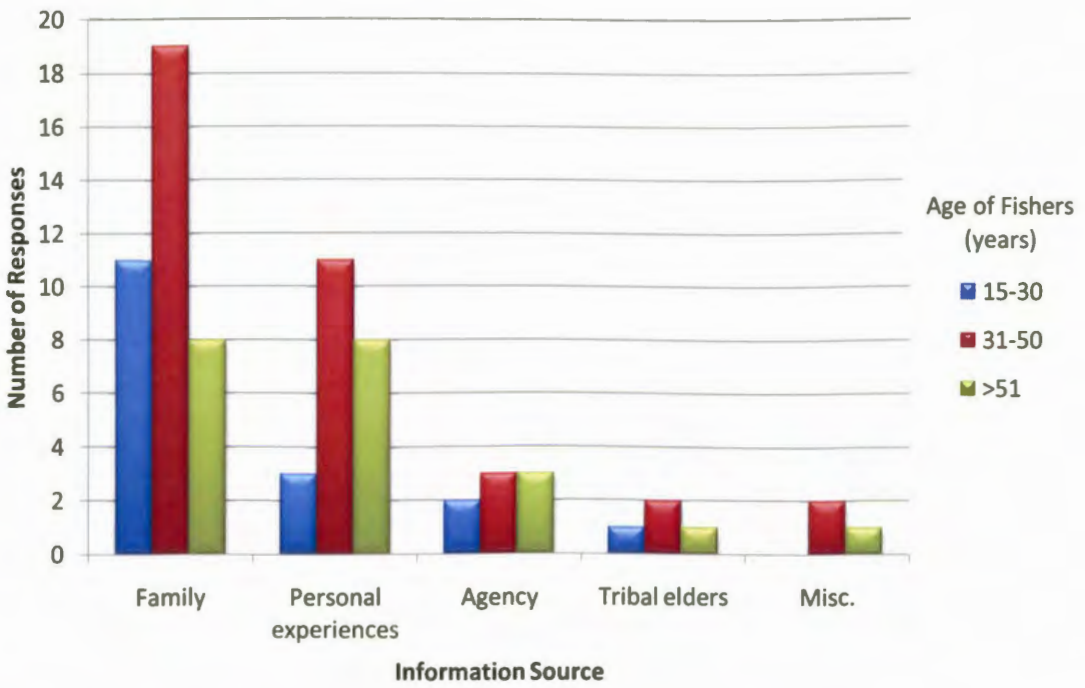
the Lummi own 302 skiffs, 105 gillnetters and 30 purse seiners (Johansen 156). Very few of the fishers mentioned ever using the traditional reef net fishing (three percent of respondents). Recently, some fishers have transferred to deep sea diving for sea cucumbers (*Cucumaria pallida*), geoducks (*Panopea abrupt*) and sea urchins (*Strongylocentrotus franciscanus*).

Approximately 25 of the fishers on the reservation applied for their commercial diver's license. To collect animals from the ocean floor and transport them to the surface, fishers must additionally invest in scuba equipment or surface-supplied air. Each diver is tethered to a support boat by a 300-foot air line and equipped with a high-pressure water jet. After less than an hour at 60 feet of depth, divers must surface for two hours to allow their bodies to recover from the pressure effects. This means that a diver can make no more than two or three dives in the course of a day (Stark 2008). Most of the harvested echinoderms are sent to overseas markets, such as China and Japan, where they are seen as a delicacy, used in a variety of dishes, and are especially popular for their aphrodisiac qualities. Very few are kept within the Tribe.

To help compensate for a steady decline in their fisheries, in 1968, the Lummi began an aquaculture program by constructing two salmon hatcheries: the Skookum Creek Fish Hatchery located near Acme, WA, on the South Fork Nooksack River and the Lummi Bay Hatchery located on the Lummi Reservation. They also have an on-reservation Natural Resource Department which includes scientists, specialists and technicians with expertise in fisheries, hydrology, geology, wildlife, and forestry. They work in close cooperation with private land owners, local government and state and federal agencies on programs designed to prevent further degradation of the watershed and to restore critical habitat areas (Russo 10). In fact, the Lummi Tribe's Fisheries Department, with an annual budget of over $3,000,0000, operates one of the most successful and productive salmon hatcheries in the United States, releasing over 17,000,000

salmon fingerlings each year (Ruby 2003). There is also an on-reservation 700-acre shellfish hatchery constructed in 1972, which can produce 400 million shellfish larvae per month (Delgado 2007). As another investment in future resource and cultural management, in 1982, the Tribe opened a two year, fully accredited institution, Lummi Community College, an affiliate of Northwest Indian College. It has over 800 full-time students, is open to both Indian and non-Indian students, and offers programs such as health, education, business, tribal administration, cultural arts, and natural resource management (Northwest Indian College 2009).

While ten percent of the fishers attributed the decline in fisheries to overfishing, the majority of the fishers named agriculture, logging, the dredging of rivers, and non-tribal sport fishers as the primary drivers behind the depletion. All of the fishers surveyed supported conservation efforts, and many thought that the most effective method to curtail the depletion of the fishery would be to halt all fishing for a number of years. However, most did not want other Lummi fishers to know they held this sentiment.



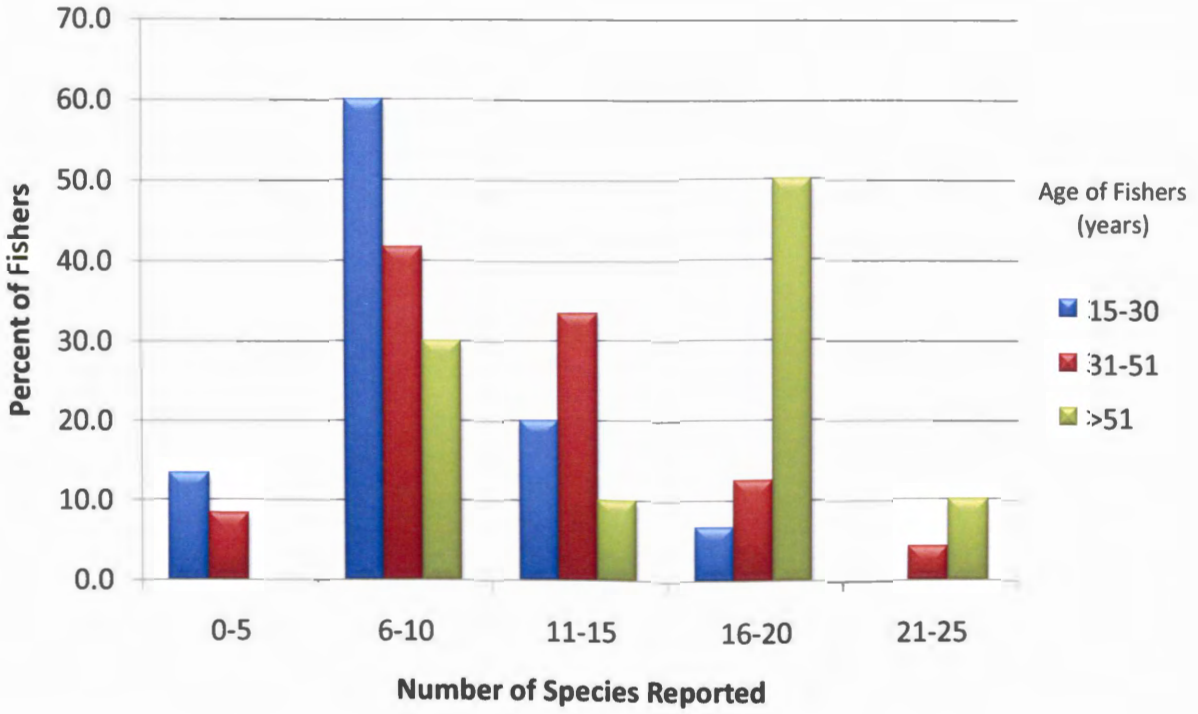
Graph 1. Where Lummi fishers obtain their information on the state of Puget Sound fisheries.

There is also a general distrust of state managers and biologists among the fishers. They would like to manage their fisheries in the way they have since time immemorial. They do not want the federal or state government overstepping its bounds. Many in the younger generation do not see much promise in the future of the fisheries. The majority of the older fishers said they have tried to teach the younger fishers the fishing ways, but most have resisted. Some recommended, however, "Get out (of the fishing business) while you still can." Still others have invested in other skills such as plumbing, carpentry and other forms of training to hone their skills and to diversify in anticipation of the fisheries' collapse. Many of the younger fishers specified that they plan to leave the business and obtain college degrees.

5.2 Fishers' Perceptions of Fish Species Depletion

Ninety-two percent of the fishers interviewed (N=48) cited the condition of the fishery stocks in Puget Sound as depleted or have seen a decrease in availability from past levels. Altogether the 48 fishers identified a total of 20 species depleted in their lifetime, citing three species on average. Further analysis reveals clear intergenerational shifts in the perceptions of species depletion within the Lummi population. When asked to name all of the species either caught or known in their lifetimes, younger fishers reported fewer than older fishers. Younger (15-30 years old) fishers cited only half as many species ($\bar{x}$ = 8.9 species) as those cited by the two older categories of fishers (middle-age $\bar{x}$ = 11.5 and oldest $\bar{x}$ = 14.7). Furthermore, only the middle-aged and the older fishers were able to report 21-25 species. No younger fishers could remember that many. There was a direct correlation between the increasing number of species recalled and the age of the fisher (see Graph 2). I also found a general trend of Lummi fishers moving away from high quality, desired and culturally significant species to those that were of lower quality, less desirable and less culturally significant for the Lummi Tribe. This

recognition, however, is mostly noted only by the mid-age and older fishers. The younger fishers were not able to distinguish these changes, view them as smaller or less significant, and as taking place later than older fishers.



Graph 2. Percent of Species Caught Over Lifetime - Distribution of Number of Species by Fisher Age. As the fishers increase in age, their ability to remember a greater abundance of species also increases.

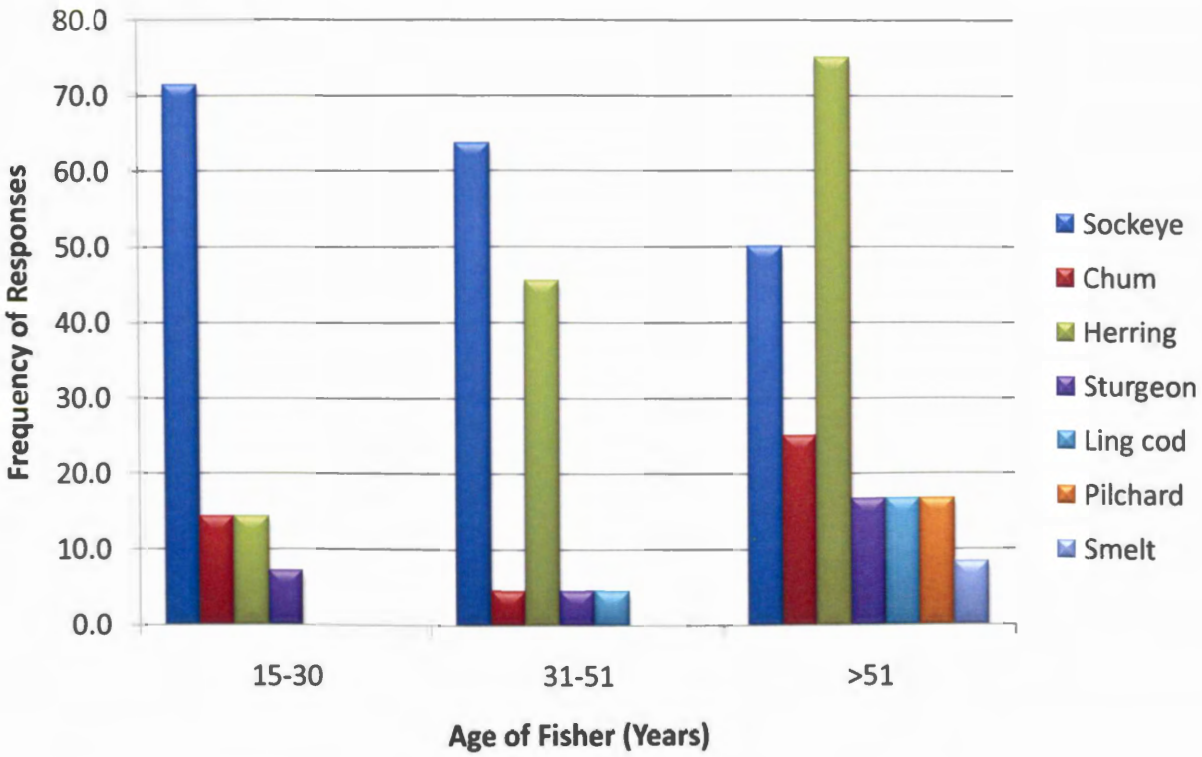
In general, salmon have declined in importance over time in this fishery. According to Boxberger and confirmed through my study, the steelhead, Chinook, pink, chum, and sockeye salmon were all once the primary sources of both revenue and subsistence for the Lummi Tribe. While 73 percent of all fishers reported some species of salmon as the number one source of income for the Tribe when they began fishing, when asked to name the top five species today, just 27 percent of the fishers reported salmon in their top five species.

There are also many species-specific intergenerational differences. For example, younger fishers have never known a time when halibut were not a key species in Lummi fisheries. The halibut has not been a key fish for the Lummi fishing industry until recent years, and is additionally considered a lesser quality fish in comparison to many of the salmon species previously caught. Conversely, the younger generations had little or no knowledge of the former presence of herring, one of the largest sources of revenue for the Lummi in the mid 1900s. Across all generations, there is an increasing importance of halibut and decreasing importance of herring. However, younger fishers show a greater dependence on halibut now than in the past, while the older fishers show a greater dependence on herring in the past, and halibut presently. Only 14.3 percent of younger fishers indicated knowledge of the decline in herring, compared to 45 percent of the middle aged fishers and 75 percent of the older fishers. Furthermore, no younger fishers indicated herring as ever being an important stock, in comparison to 66.7 percent of the older fishers.

Many species were caught only by older fishers, and not by younger fishers including steelhead (*Oncorhynchus mykiss)*, pilchard (*Clupeidae)*, Pacific herring *(Clupea pallasii)*, black cod (*Notothenia microlepidota)*, long fin smelt (*Spirinchus thaleichthys)*, sculpin (Irish Lord) (*Hemilepidotus hemilepidotus*), cabazon (*Scorpaenichthys marmoratus)*, skate (*Raja binoculata)*, rock cod (*Lotella rhacina*), perch (*Sebastes alutus)*, abalone (*Haliotis fulgens philippi*), littleneck clams (*Protothaca staminea*), mussels (*Mytilus eddies*) and ling cod (*Ophiodon elongates*). Older fishers were also the only group to remember times when large sea mammals such as whales and seals were once a mainstay of their harvests.

Overall, older fishers with more fishing years of experience remembered the ecosystem as being in a better condition. Younger fishers very rarely reported more species depletion than

their elders. Only younger fishers could recognize the decline or disappearance of some species, but could not recall the species names (14.3 percent of respondents). Significant species caught only, or at least primarily, by older fishers include herring, steelhead, rockfish, smelt, and flounder (see Graph 3).



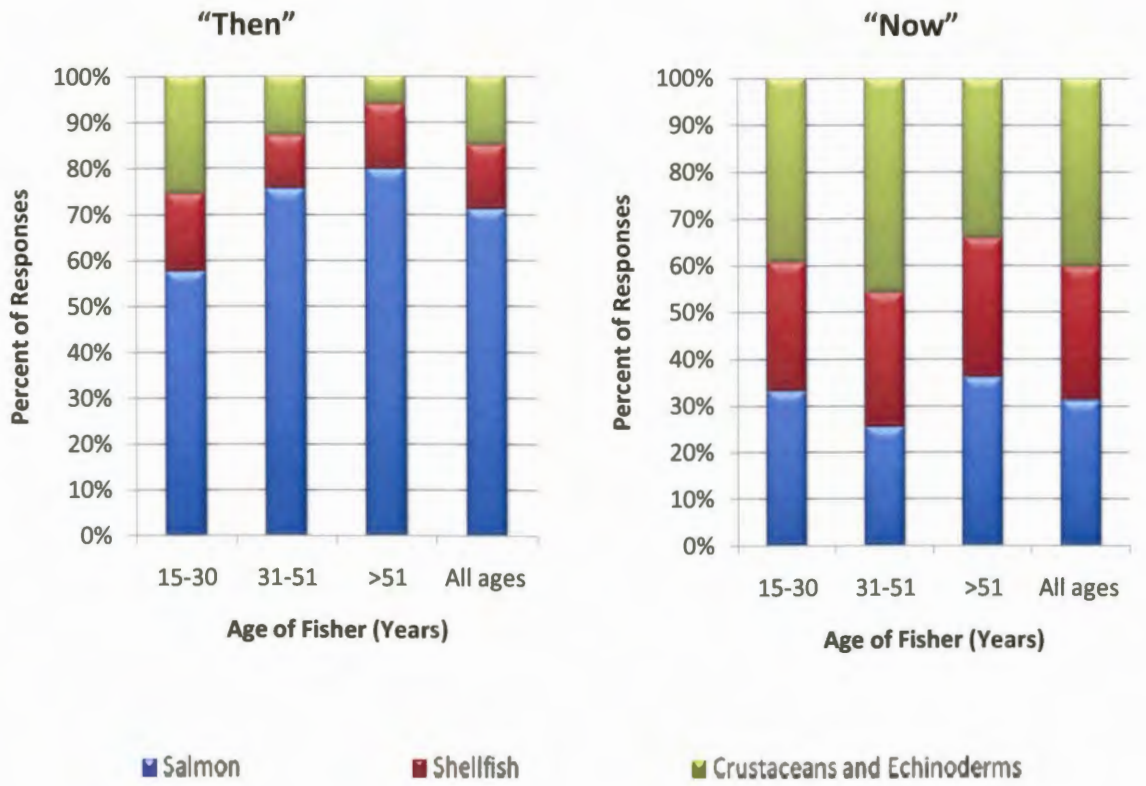
Graph 3. Frequency of Mention of Selected Rare or No Longer Caught Species by Fisher Age. Many culturally significant species caught only by older fishers are no longer recognized by the younger generations.

5.3 Fishers' Perception of Harvesting Lower Into the Food Web

A clear correlation seen throughout the interviews is the diversification of the Lummi fishing industry. This is shown by the transition of species harvest in the present and historically, the percentage of fishers changing their fishing equipment to harvest new species, and a recent shift to harvesting species lower in the food web.

Over the last 15-20 years the Lummi have shifted from salmon and fish to shellfish harvesting. All generations are aware that there has been a general shift in the Lummi fishing

industry from a primarily salmon and fish-based industry to one based on crustaceans (especially Dungeness crab) and echinoderms (Graph 4).

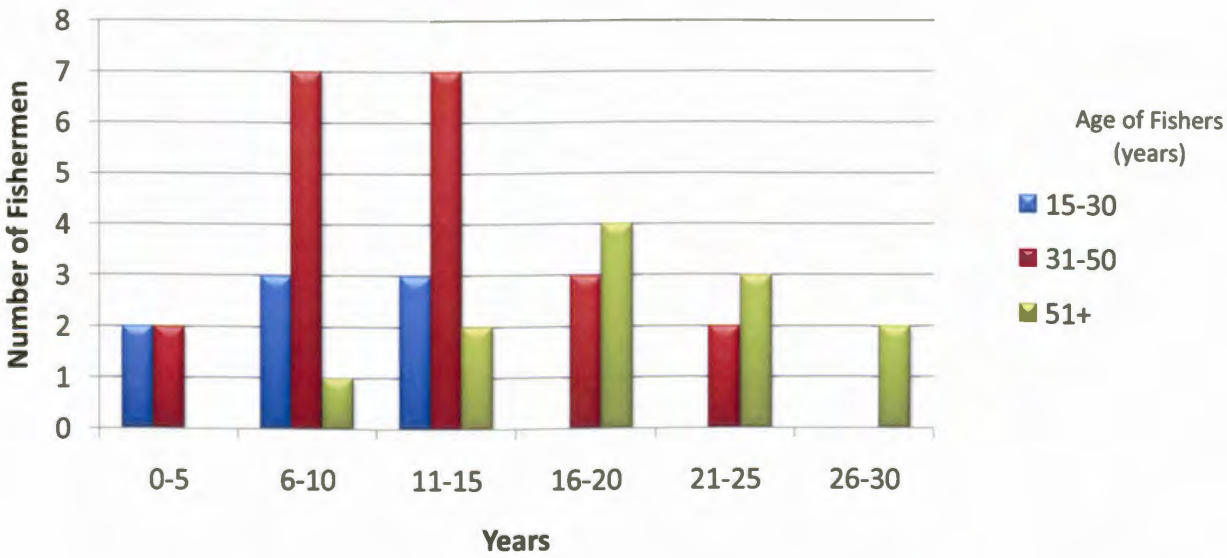


Graph 4. Percent of Fishers Reporting Three Major Categories Of Fish Harvested When They Began Fishing ("Then") vs. Currently ("Now"). There is an awareness among all generations of a shift from a primarily salmon and fish-based industry to crustaceans and echinoderms.

All generations indicate this transition, however, there is a difference in how the younger Lummi fishers perceive this change in contrast to the older. A higher proportion of the young fishers (43 percent) did not report the change from fish to shellfish, which is clearly reported by both the mid-aged (95 percent) and the older fishers (100 percent). Older fishers also report the time of this transition an average of ten years earlier than younger fishers (younger fishers = 9.6 years ago; middle-aged fishers = 13 years ago; older fishers = 19.6 years ago). Younger fishers have also experienced more dependence on non-salmon species, such as crabs, shellfish, and

echinoderms than have older fishers. These non-salmon species were not a part of older Lummi fishers' past fishing histories (see Graph 5). Further, older fishers report catching crab, shrimp, and sea cucumbers less often than both the young and mid-age fishers [crab: 66.7% (old) vs. 96% (young and mid-age); shrimp: 16.7% (old) vs. 54% (young and mid-age); sea cucumber: 8.3% (old) vs. 28% (young and mid-age)].

Photo 6. Lummi fishers collect Manila Clams. Crustaceans and echinoderms are now one of the primary sources of income for the Lummi fishing industry. *Courtesy of Lummi Nation Natural Resource Department.*



Graph 5. Fishers Indicate How Many Years It Has Been Since Shift In Industry From Fish To Shellfish Took Place. Younger generations indicate the transition from a primarily fish-based industry to a shellfish-based one much sooner than older generations do.

During the interviews, many fishers indicated diversifying their occupations in response to fish scarcity in their usual and accustomed grounds. Fishing is no longer profitable for many

tribal members. They have made the decision to invest in faster more effective fishing equipment, crabbing gear, to expand their scope to clams, or invest in scuba and diving equipment and certification to collect sea cucumbers, urchins, geoducks, and other echinoderms. Many of the older fishers indicated a gradual transition in fishing gear through time. The gear used by each generation has reflected the abundance of various species in the sea, and the depletion of others. As one older fisher stated, "The gear is becoming more high tech to catch more fish in less time. This makes the fishermen more competitive, and is quickly depleting our fish."

5.4 Fishers' Perception of Fishing Grounds Depletion

Fishers also identified their main fishing sites when they began fishing in contrast to the Tribe's main fishing sites currently (see Appendix D and E). Although these graphs do not show the amount of fish caught in each area, older fishers showed a distinct change from near-shore fisheries when they began as fishermen, to an expansion to off-shore fisheries presently. As the maps show, fishers have seen a general shift over time from near-shore and inland fisheries to sites farther out at sea with longer travel times that require more sophisticated equipment to obtain daily quotas.

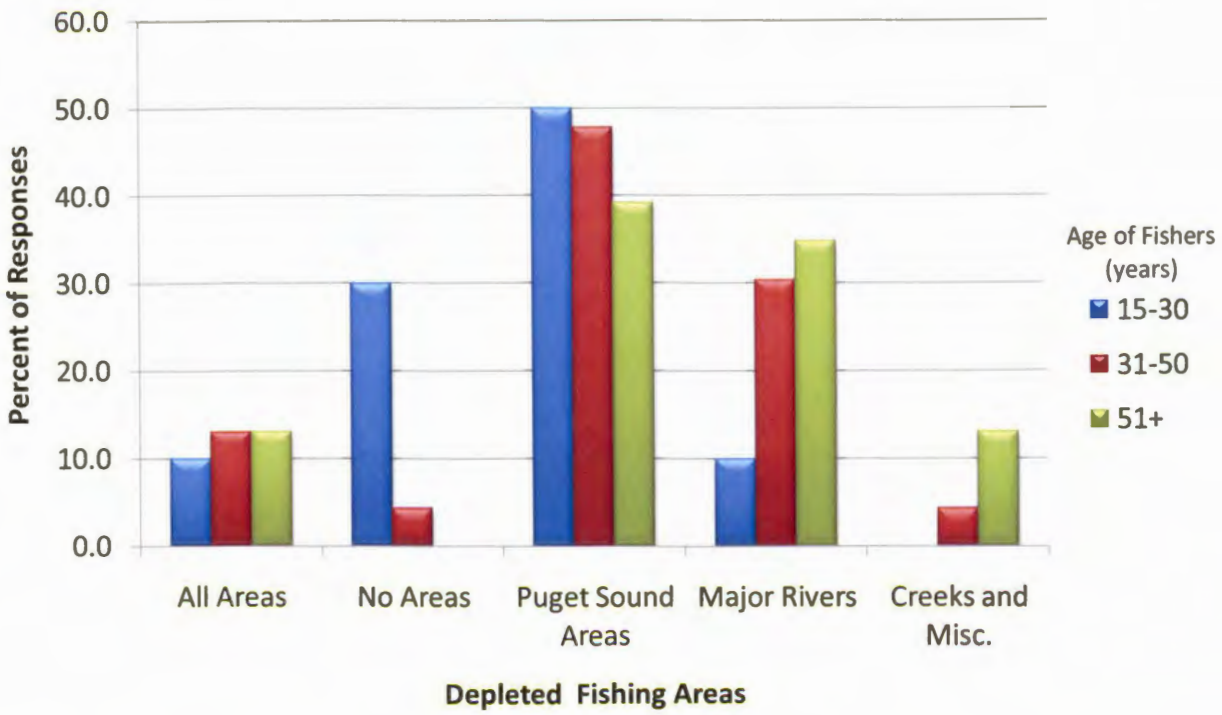
This shift is demonstrated by a number of indicators including overall improvements in searching for and targeting various fish species, an intensified fishing effort in recent times, an expansion to new fishing areas, investment in newer and more efficient fishing equipment to capture new species, and an overall perception among older fishers that the younger fishers are more "aggressive" than previous fishers.

The original fishing grounds indicated by the Lummi fishers include the Nooksack River and its tributaries, Lummi Bay, Bellingham Bay, Portage Bay, and the Frasier River. Many of

the older fishers recalled days when salmon and shellfish could be harvested just feet from the shoreline and closer to their homes. One older fisher stated: "I remember when all I had to do was go out in that bay over there (points to bay next to his house) and I could get my entire day's quota. I can't do that anymore." No younger fishers reported these same recollections, and 30 percent indicated that no areas in Puget Sound are depleted (the most common response among young fishers), in comparison to zero percent of the older fishers (see Graph 6).

This trend is confirmed by comparing the oldest and youngest fishers' current vs. historical fishing zones maps. (Appendix E). There is very little change from "Then" vs. "Now" for the younger fishers. Harvest sites when they began fishing are essentially the same as they are today. Older fishers, however, indicated a general shift to off-shore fisheries in comparison to when they began fishing (Appendix D). As fishers were unable to obtain their harvest quotas from previous historical fishing grounds, they moved farther and farther into Puget Sound.

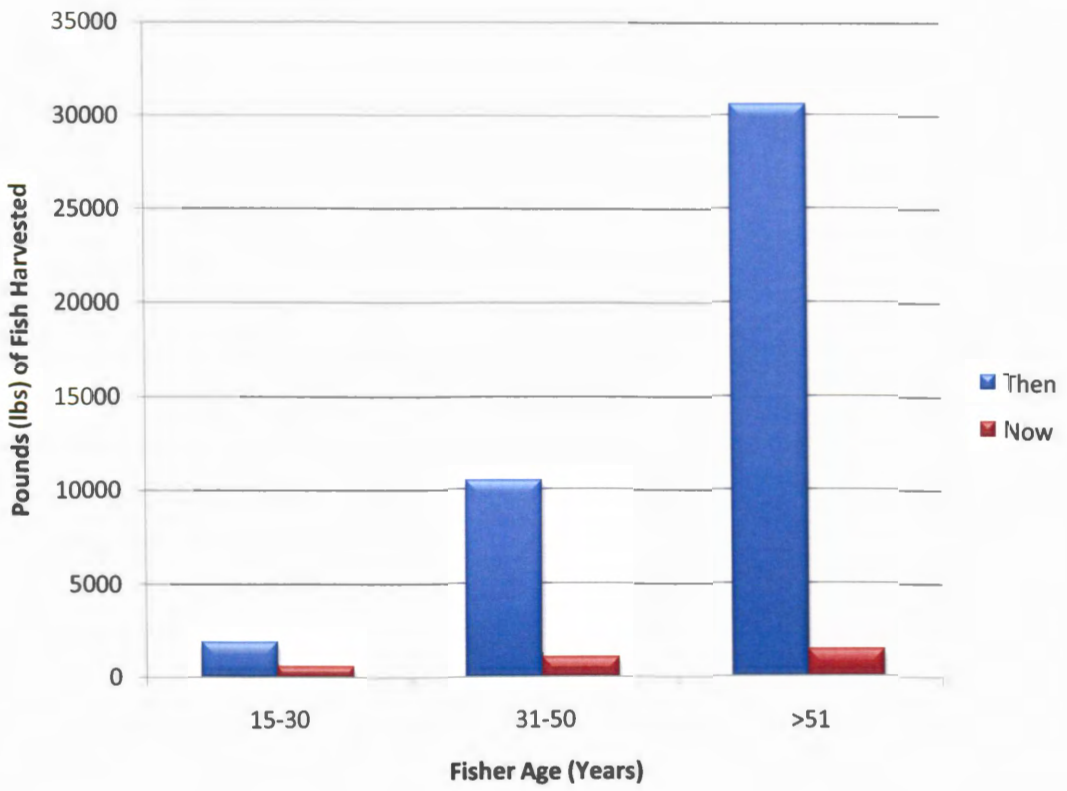
While not captured on the maps, I also found an overall shift from rivers and creeks as the main harvest sites, to sites farther out into Puget Sound. Younger fishers are far less aware than mid-aged and older fishers that rivers and creeks were once productive. Among rivers and creeks, younger fishers identified only the Nooksack River as depleted. When asked what former fishing grounds were depleted, 49 percent of the older fishers identified the primary depleted fishing grounds as rivers, while only ten percent of the younger fishers cited them.



Graph 6. Comparison of Generational Perceptions Of Major Depleted Fishing Sites. Few young fishers remember a time when rivers and creeks were the primary fishing grounds.

5.5 Fishers' Changing Perception of Success

Lummi fishers have changed their perception of "success", both in terms of hours needed to obtain a day's harvest and in its size from when they began fishing until now. All generations of fishers indicated a lower harvest rate presently compared to when they began fishing. Fishers of all age groups identified the present harvest poundage to be approximately the same. However, there is a distinct variation among age groups for recollections of past harvest levels. Younger fishers' recollection of their best past harvest levels for a day of fishing is over 30,000 pounds lower than older fishers (see Graph 7).



Graph 7. Averages Of A Good Catch (pounds) For One Day of Fishing in Current Time ("Now") Versus When Fishers First Began Fishing ("Then"). There is a clear generational distinction between average catch.

All fishers, regardless of age, also thought that it now takes more time to catch a day's quota of fish. The magnitude of this change differed from one generation to the next. Older fishers recalled that the quotas can no longer be met in one day. The time to catch the same amount they caught 20 or 30 years ago is no longer possible today. Younger fishers, while also indicating an increased amount of time, never cited that they were unable to obtain the quotas, but rather it took more hours to harvest them. Two groups that diverged from this trend were the divers and those who recently invested in more effective fishing equipment. Both of these groups thought it took less time now to obtain their quotas in comparison to when they began fishing.

5.6 Fishers' Ideas for the Future

When asked how to solve the loss of fish stocks, there was a discrepancy among the older and younger generations. Most of the older fishers thought the only way to stop the depletion was by implementing no-catch zones and greater restrictions on quotas. Younger generations thought the answer to the steadily depleting stocks was to increase the number of hatcheries. The Tribe already owns three hatcheries, and while these have been very profitable, they also pose a number of other issues. Hatcheries are not a sustainable option as it can take three pounds of fish meal to yield one pound of salmon, and they are also shown to produce fish with higher levels of PCBs and PBDEs in their tissue (Mobrand 2005), a potential health hazard and an environmental justice issue for the Tribe.

All generations said that one of the keys to sustainable fisheries is to create a better relationship between the Lummi and the state managers, and to increase efforts for community education on the state of fisheries within Puget Sound. "I have tried to educate my sons on how to fish these waters, but they just aren't interested anymore. They know there is nothing left here for them," one elder Lummi fisher stated. When a population does not have the correct educational tools at their disposal they lose the ability or the know-how to adequately manage the resource.

5.7 Limitations of Results

There were very few confounding factors that impeded this study. There was very little reluctance from the interviewees and most seemed to be telling the truth. Retrospective study bias, a usual limiting factor when dealing with human subjects, did not deter from my study, because my study was outwardly testing the retrospective bias of the fishers. If this study were to be performed again, however, there are three areas needing change.

One area the study did not adequately take into account was the quotas and regulations regulating the fishery. Many of the responses about harvest yields, fishing zones, and harvest times provided by the interviewees were most likely affected by regulations implemented to manage various species and populations. My study did not recognize these regulations within my questionnaire or analysis. The various management laws should reflect species depletion, but I had no set mechanism in my study to gauge this.

In the pre-survey process, I refined and reworded questions to better capture the data I needed. However, during the interview process many of the questions created a few problems and confusion, and if I perform this study again, I would rewrite a few of them. Some of the questions were difficult for the fishers to provide the type of quantitative responses I needed. For example, one question asked fishers to specify their biggest catch in the past in comparison to current catches. Instead of leaving it so broad, I should have asked about a specific species and unit of measurement to keep all of the responses more consistent and easier to process.

Lastly, this study could have benefited from a larger sample size and more time and resources. The collection of data took place during a two month time interval and only 48 surveys were completed. In order to gather more accurate results, a larger, more representative sample size (at least ten percent of the Lummi population) should be obtained.

6 Discussion

6.1 Evidence of Shifting Baselines in Fishers' Perception of Puget Sound Fishery

It became increasingly apparent throughout the course of this research that despite the close-knit community, strong family atmosphere, strong cultural significance, and a population closely integrated and dependent upon the fishing industry, the shifting baselines phenomenon

still exists within the Lummi fishing industry. As one generation has replaced another, the fishers' perception of natural change has evolved to the extent that many of the younger fishers are no longer able to remember or believe historical anecdotes of past abundance or size. Older fishers were more likely to remember fish and species higher in the food chain, while younger fishers remembered species lower in the food chain and of less historical and cultural significance to the Tribe. Older generations remembered fishing zones closer to the shore, and in places younger generations failed to ever mention. Younger generations are harvesting species lower in the food web, and do not remember many of the larger, more culturally significant species caught at one point in time.

As entire generations of fishers die, they take with them a crucial piece of ecological and cultural knowledge of past fishery stocks, and how the environment once looked. If this information is not passed onto younger generations or resource managers, it will be lost forever.

While there are a number of contributing factors to fishery depletion such as agricultural run-off, climate change effects and logging, I found through this study that Lummi fishers are not fully aware of the impact that their cumulative actions have had on the exploitation of local fish stocks. Bunce, et al. (2008) emphasized the importance that the fishers' perceptions of fishery declines or in some cases, increases, do not need to be "objectively true" to be useful in policy formulation. If there is a difference between how biologists and fishers view the same population this is a problem in the system, whether or not these perceptions are scientifically "true." The harvesters of the resource need to play an integral role in not only the collection of the science, but also in the formulation of policy to protect these resources. If fishers have a different perception from the resource managers of that baseline, then the resource will be very difficult to manage effectively or equitably. Establishing a baseline for all natural resources is

necessary to fully understand the extent various populations have been impacted throughout time, and is essential to their management and recovery. In addition, in order to fully manage these natural resources, all managers must have a complete knowledge of their unexploited state (Pauly 1998).

6.2 "Fishing Down the Food Web"

Ward (2005), Pauly and Watson (2003), Roberts (2003), and Meyers and Worm (2003) have all found clear evidence of fisheries delving deeper and deeper into the food web. On average, marine biomass is only about ten percent of former levels and communities are composed of smaller fish and fewer large predators. These authors also found that fishers must work farther offshore and at greater depths in an effort to maintain historical catch rates, and to meet the escalating demand for fish. Meyers and Worm (2003) reported that the world's oceans have lost 90 percent of large predatory fish. Pauly dubbed this phenomenon as "fishing down the food web." This describes what occurs when fishers "deplete large predator fish at the top of the food chain, until they become rare, and then begin to target smaller species that would usually be eaten by large fish" (3). He goes further to state that many people are under the mistaken impression that pollution is responsible for declines in marine species, whereas in reality the drastic increase in commercial fishing rates are principally to blame. Myers and Worm (2003) used data from a wide range of fisheries throughout the world to demonstrate that industrial fleets generally only take a few decades to reduce the biomass of a previously un-fished stock by a factor of ten. By the time it takes a regulatory regime to be established to manage the fishery, the baselines have already shifted. Any law put into place will reflect present population and environmental declines, not historic levels.

This phenomenon of "fishing down the food web" was clearly found to exist in the Lummi fishing industry. As salmon stocks were depleted, Lummi fishers steadily transferred their harvests to other, less desirable or quality fish such as halibut and pink salmon, the smallest of the salmonids (Boxberger 193).

As upper level species were overfished, the Lummi have moved even farther down the food web to species with larger biomass such as crustaceans and echinoderms. Rosenberg (2009), McClenachan (2008) and Sàenz-Arroyo, A., et al (2005) have all found that technological improvements in fishing gear and demand for fishing products has resulted in an increased fishing effort and steady declines in both marine animal abundance and diversity.

This study revealed a clear shift over time from fishing technology geared toward large, higher trophic level species, to types aiming for ones lower in the food web. The Lummi first began principally as salmon fishers, using low impact and sustainable reef net fishing. As salmon stocks declined, they converted to smaller fish, such as herring and rockfish. They invested in large platforms to pursue the industrial "spawn on kelp" industry to collect herring eggs from the kelp and herring from the bay (see Photo 7). As the herring disappeared in the late 1970s to the early 1980s, the salmon industry again picked up. They used a variety of gillnetters, seiners and skiffs to harvest the salmon. Within the last 20 years, as salmon stocks have again fallen, fishers have begun investing in once small industries, such as crab and

Photo 7. Lummi fishers use large platform to pursue industrial spawn on kelp industry.

shellfish harvesting. They upgraded their equipment to collect these stocks in larger volumes and in a decreased amount of time. Along with this change has come a shift in the regulations for the Lummi fisheries. Fish seasons are shorter and fewer, providing the Lummi an incentive to collect as large a catch as possible during these openings. Now that the crab and shellfish stocks are beginning to dwindle, the shift has pushed deeper into the seas.

According to anecdotal evidence acquired from interviews, during the last five to ten years the diving fishing industry for the Lummi has become increasingly popular. Over 25 of the Lummi fishers are certified divers, where they can make three to four times as much money in one day collecting sea cucumbers, sea urchins and geoducks, as they can in any of the other fisheries. Many of the elders, however, feel this is going too far. One 66-year-old Lummi fisher who fished in Puget Sound all of his life accounted for this change in an interview:

> "Today we have a different breed of fisherman. They are more aggressive than I have ever seen before. They go out farther, spend more time on the ocean and are going after species we have never fished before. They now are going after the sea urchins and sea cucumbers. When we get that far- we have gone too far. If we take our fishery down to that level, soon we will have nothing left. When do we stop? The cucumbers are the vacuums of the ocean. They clean all of the garbage off the ocean floor, and these fish are sometimes over 80 years old. This new generation of fisherman does not see that. Greed is the enemy of these new fishermen."

Many of the species mentioned by younger fishers are of little value to the Lummi population. Although not of "cultural" or "of dietary value" one could argue that they are of "economic value" since they do provide a source of income for the tribe. Species such as the sea cucumber and the other echinoderms are sent to overseas Asian markets. Lummi fishers neither consume nor use these products. Other species such as herring, pilchard, whale and sockeye salmon, cited primarily older generations as depleted, are of great importance to the Lummi, and

most are no longer available or exist only in a severely depleted state. These are key species to the survival of the Lummi and are also indicator species for the health of the Puget Sound.

The main problem and where the shifting baselines phenomenon is most apparent is that many younger fishers have only harvested these species that are lower on the food web and have less experience and recollection of higher trophic level species and more culturally significant species as the elder generations remember. In addition, there is a large generational variation between when the shift from a primarily fish-based economy to a shellfish economy took place. Younger fishers thought it took place on average ten years earlier than older fishers. While extreme, as this gap continues to widen and as shifting baselines occur, new Lummi fishers may reach a point in time where they are no longer able to remember a time when fish were an integral part of the Lummi culture or economy. While younger fishers could gain this knowledge from older fishers, it appears that in the case of the Lummi this complete knowledge transfer has not taken place.

6.3 Policy Implications

Several authors have proposed addressing the shifting baselines phenomenon by managing fisheries in a global network of marine reserves and marine protected areas (MPAs) (Bunce et al. 2008; Roberts 2007; Sàenz-Arroyo, A., et al. 2005; Bohnsack et al. 2003, Roberts 2003). These are protected, no-fish zones, where fishers are able to see what a fishing zone "can look like" when not fully exploited by commercial fishing. By protecting animals from capture, MPAs allow individuals to live longer, grow larger and become more numerous (Bohnsack et al. 2003; Roberts 2003, Ward 2005). They also produce refuges for reproductive stocks that can supply surrounding fishing grounds with eggs and larvae. "Because big fish produce many more times offspring than small fish, reserves can make disproportionately large contributions to

population replacement relative to their area" (Bohnsack et al. 2003). Additionally, MPAs that cross state, federal, and tribal boundaries would allow for the transfer of information over political boundaries and create a universal historical record of baselines for all species. According to the National Center for Marine Protected Areas, 61 MPAs currently exist within Washington State. They are managed by the Department of Fish and Wildlife, Department of Natural Resources, and the Department of State Parks (NMPAC 2007; Bargmann 1998).

While potentially successful, there is a very strong cultural, social and political divide that must be overcome before implementing such a system for the Lummi fishery. During my interviews I found there to be a prominent consensus among most Lummi fishers that non-Lummi fisheries biologists and the State should let the Lummi manage their own fisheries. Many tribal fishers feel the state regulations are impeding their harvests and are unfair in comparison to the sport fishermen or "cowboys." Many expressed animosity toward state officials for regulations they are impressing upon tribal members. According to Singleton (2009) Puget Sound tribes, in general, are skeptical of MPAs for a variety of reasons: Equitable allocation among treaty and non-treaty stakeholders; small group and government interests being masqueraded as "conservation efforts"; more regulation to an already heavily regulated tribal resource; and the fact that tribes are tied to location-specific areas- the tribe's "usual and accustomed grounds"- while non-treaty parties have no such obligations.

While all of these are all concerns, they are issues that could be met through effective collaboration at all stages of the process. Unfortunately, Singleton (2009) states that there has been little "interagency MPA planning or coordination, either between state agencies or between state, federal, or tribal governments," and according to Lundquist & Granek (2005) the "lack of available information on local biodiversity, habitat structure, and other important ecosystem

variables that influence the placement of protected areas is often a major obstacle in planning and justification of marine protected areas." However, this obstacle can be overcome by including ecosystem-based knowledge of tribal fishers into the planning of MPAs. Tribal fishers have first-hand, locally-based information that is presently underutilized by fisheries biologists and wildlife managers (Huntington 2000; Johannes 2000).

Most fisheries managers use information derived from scientific catch data obtained by fisheries biologists to manage a fishery (Lundquist & Granek 2005). They are unfamiliar with social science methods such as gathering ecological knowledge and are not prepared to attempt to use these methods to gain access to information that otherwise remains out of reach (Huntington 2000). They do not adequately utilize the generational knowledge of fishers to create their laws and policies governing resource extraction or protection. While collaborative stakeholder processes that incorporate native concerns have been completed, many of these processes fail to "facilitate (effective) engagement of native people, who are a powerful force in marine resource management (Singleton 2009)."

While science must provide the foundation of resource management, it needs to be supplemented by social and cultural expertise such as traditional ecological knowledge. Collecting ecological knowledge from fishing communities is a long and tedious process, but it is knowledge that offers important insights into the former state of ecosystems, especially in populations where most of the knowledge is passed through oral means in contrast to written record such as in Native American communities. (Sàenz-Arroyo, A., et al. 2005; Johannes et al. 2000; Turner 2000; Gadgil 1993). Johannes, et al. (2000) emphasize fishers' critical role in providing information on "inter-annual, seasonal, lunar, diel, tide-related and habitat related differences in behavior and abundance of target species, and on how these influence fishing

strategies" (7). Where long-term data sets are unavailable, older fishers are also often the only source of information for historical changes in local marine stocks and marine environmental conditions (Lundquist & Granek 2005; Lichatowich 1996).

Another problem is that these numbers and scientific data are not being filtered down to the Lummi fishers. There appears to be effective communication between federal and state, state and local, but a clear disconnect was found between the local level and the fishers. These are the individuals who are harvesting the resource and they are not being provided with the data or consulted on the state of the very fisheries they are depleting at an exponential rate. This is crucial in managing a resource effectively. Without consultation from all stakeholders involved, especially the resource harvesters, effective management is difficult to achieve.

The foundation of change and effective management is widespread education of all parties involved. This includes the resource managers, the fishers and all others involved in the industry. The flow must be multidirectional. However, this flow of ideas and knowledge between the tribes and the resource managers, needs to take place prior to and independent of the "stakeholder process" that generally accompanies the implementation of marine conservation measures. Involving native people in the initial stages and as part of an ongoing consultation process will help to quell many of the concerns of tribes and additionally create MPAs that correctly reflect the needed fishery and marine ecosystem management in the region (Singleton 2009, Turner 2000; Gadgil 1998).

6.4 Future Studies

Specifically there are three main areas my study can be expanded. First, additional interviews should be collected from the Lummi fishers to gain a larger and more representative sample of the Tribe. Secondly, studies should be expanded to the other tribal fishing

communities throughout Puget Sound such as the Swinomish, Tulalip, Lower Elwha Klallam, Makah, Jamestown S'Klallam, Port Gamle S'Klallam, Squamish (Port Madison), Muckleshoot, Skokomish and Puyallip, to see if the conclusions found here hold true for other tribes. These studies could then be compared to non-tribal fisheries in Puget Sound focusing on how the two fisheries differ and if the lack of intergenerational communication and cultural dependence in non-tribal fisheries create a greater disconnect between younger and older fishers and thus a more rapidly shifting baseline. While I focus just on fisheries with this study, an understanding of environmental baselines is crucial when addressing any natural resource. The transfer of traditional ecological knowledge and its connection to shifting baselines is not exclusive to marine populations, but can be applied to any natural resource that is utilized or affected by humans. If there is not a ruler that all levels of society have access to, natural resources can and will easily be lost.

Photo 8. A mid-age fisher and his son on the Lummi reservation. Younger generations of fishers are becoming increasingly disinterested in the fishing industry.

7 Conclusion

As the phenomenon of shifting baselines occurs, older generations' stories of past abundance and size are often disregarded as inflated recollections by younger generations and scientists who have never experienced these conditions in their lifetimes. If these "tall tales" are not supported by scientific data, the management strategies that are implemented will not reflect

true past abundance or environments. Within the Lummi community there is a wide discrepancy among the three generations of fishers in regards to size of historic catches, where they caught them, and the species captured. Are these just inflated memories or are the younger generations catching just a fraction of what at one point in time was available? According to this study, the younger generations are beginning to forget. To avoid the hazards of shifting baselines two things need to happen: (1) historic conditions must be measured, estimated and documented and (2) this information must be conveyed through education or other cultural practices from one generation to the next in a way that is accepted and believed by each generation. As our society today is becoming increasingly mobile, no longer staying in one place long enough to notice incremental changes and as intergenerational communication continues to degrade, shifting baselines, in all aspects of our society will become an ever pressing issue.

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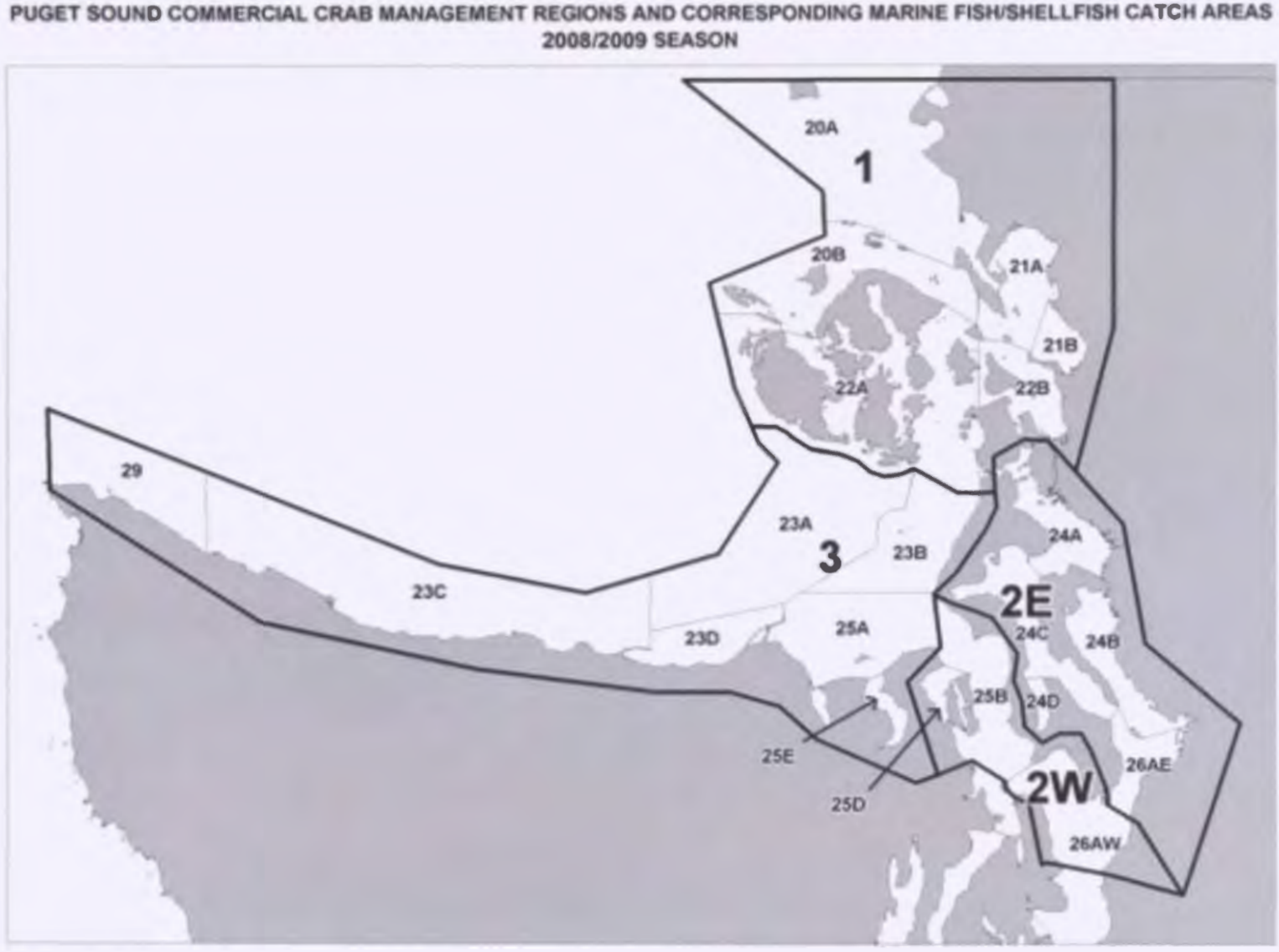
Appendix

Appendix A: 2009 Washington Department of Fish and Wildlife Puget Sound Shellfish and Crab Zones



Appendix B. 2006 Washington Department of Fish and Wildlife Commercial Fishing Zones Map

Source: 2006 Washington Department of Fish and Wildlife Puget Sound Commercial Salmon Regulations
Prepared by: Preston Gates & Ellis LLP

Puget Sound Salmon Management and Catch Reporting Areas
(WAC 220-22-030)

AREA 4B shall include those waters of Puget Sound easterly of a line projected from the Bonilla Point light on Vancouver Island to the Tatoosh Island light, thence to the most westerly point on Cape Flattery and westerly of a line projected true north from the fishing boundary marker at the mouth of the Sekiu River.

AREA 5 shall include those waters of Puget Sound easterly of a line projected true north from the fishing boundary marker at the mouth of the Sekiu River and westerly of a line projected true north from Low Point.

AREA 6 shall include those waters of Puget Sound easterly of a line projected from the Angeles Point Monument to the William Head light on Vancouver Island, northerly of a line projected from the Dungeness Spit light to the Partridge Point light, westerly of a line projected from the Partridge Point light to the Smith Island light, and southerly of a line projected from the Smith Island light to vessel traffic lane buoy "R" to the Trial Island light.

AREA 6A shall include those waters of Puget Sound easterly of a line projected from the Partridge Point light to the Smith Island light to the most northeasterly of the Lawson Reef lighted buoys (RB 1 Qk Fl Bell) to Northwest Island to the Initiative 77 marker on Fidalgo Island and westerly of a line projected from Reservation Head on Fidalgo Island to West Point on Whidbey Island.

AREA 6B shall include those waters of Puget Sound southerly of a line projected from the Dungeness Spit light to the Partridge Point light, westerly of a line projected from the Partridge Point light to the Point Wilson light and easterly of a line projected 155 degrees true from Dungeness Spit light to Kulakala Point.

AREA 6C shall include those waters of Puget Sound easterly of a line projected true north from Low Point and westerly of a line projected from the Angeles Point Monument to the William Head light on Vancouver Island.

AREA 6D shall include those waters of Puget Sound westerly of a line projected 155 degrees true from Dungeness Spit light to Kulakala Point.

AREA 7 shall include those waters of Puget Sound southerly of a line projected true east-west through Sandy Point Light No. 2 (48 degrees, 47.2 minutes north latitude, 122 degrees, 42.7 minutes west longitude, as per U.S. Coast Guard Light List No. 19880), northerly of a line projected from the Trial Island light to vessel traffic lane buoy "R" to the Smith Island light to the most northeasterly of the Lawson Reef lighted buoys (RB 1 Qk Fl Bell) to Northwest Island to the Initiative 77 marker on Fidalgo Island, and westerly of a line projected from Sandy Point Light No. 2 to Point Migley, thence along the eastern shoreline of Lummi Island to Carter Point, thence to the most northerly tip of Vendovi Island, thence to Clark Point on Guemes Island following the shoreline to Southeast Point on Guemes Island, thence to March Point on Fidalgo Island,

excluding those waters of East Sound northerly of a line projected due west from Rosario Point on Orcas Island.

AREA 7A shall include those waters of Puget Sound northerly of a line projected true east-west through Sandy Point Light No. 2 (48 degrees, 47.2 minutes north latitude, 122 degrees, 42.7 minutes west longitude, as per U.S. Coast Guard Light List No. 19880), terminating on the west at the international boundary and on the east at the landfall on Sandy Point.

AREA 7B shall include those waters of Puget Sound westerly of a line projected 154 degrees true from Sandy Point Light No. 2 (48 degrees, 47.2 minutes north latitude, 122 degrees, 42.7 minutes west longitude, as per U.S. Coast Guard Light List No. 19880) to the landfall on Gooseberry Point, easterly of a line projected from Sandy Point Light No. 2 to Point Migley, thence along the eastern shoreline of Lummi Island to Carter Point, thence to the most northerly tip of Vendovi Island, thence to Clark Point on Guemes Island following the shoreline to Southeast Point on Guemes Island, thence to March Point on Fidalgo Island, northerly of the Burlington Northern railroad bridges at the north entrances to Swinomish Channel, westerly of a line projected from William Point light on Samish Island 28 degrees true to Whiskey Rock on the north shore of Samish Bay, and westerly of the Whatcom Creek mouth, defined as a line projected approximately 14 degrees true from the flashing light at the southwest end of the Port of Bellingham North Terminal to the southernmost point of the dike surrounding the Georgia Pacific treatment pond.

AREA 7C shall include those waters of Puget Sound easterly of a line projected from William Point light on Samish Island 28 degrees true to Whiskey Rock on the north shore of Samish Bay.

AREA 7D shall include those waters of Puget Sound easterly of a line projected 154 degrees true from Sandy Point Light No. 2 (48 degrees, 47.2 minutes north latitude, 122 degrees, 42.7 minutes west longitude, as per U.S. Coast Guard Light List No. 19880) to the landfall on Gooseberry Point, and south of a line projected true east from Sandy Point Light No. 2 to the landfall on Sandy Point.

AREA 7E shall include those waters of Puget Sound within East Sound northerly of a line projected due west from Rosario Point on Orcas Island.

AREA 8 shall include those waters of Puget Sound easterly of a line projected from West Point on Whidbey Island to Reservation Head on Fidalgo Island, westerly of a line projected from the light on East Point 340 degrees true to the light on Camano Island (Saratoga Pass light #2, Fl Red 4 Sec) southerly of the Burlington Northern railroad bridges at the north entrances to Swinomish Channel and northerly of the state Highway 532 bridges between Camano Island and the mainland.

AREA 8A shall include those waters of Puget Sound easterly of a line projected from the East Point light on Whidbey Island 340 degrees true to the light on Camano Island (Saratoga Pass light #2, Fl Red 4 Sec), northerly of a line projected from the southern tip of Possession Point 110 degrees true to the shipwreck on the opposite shore,

southerly of the state Highway 532 bridges between Camano Island and the mainland excluding those waters of area 8D.

AREA 8D shall include those waters of Puget Sound inside and easterly of a line projected 225 degrees from the pilings at old Bower's Resort to a point 2,000 feet offshore, thence northwesterly to a point 2,000 feet off Mission Point, thence across the mouth of Tulalip Bay to a point 2,000 feet off Hermosa Point, thence northwesterly following a line 2,000 feet offshore to the intersection with a line projected 233 degrees from the fishing boundary marker on the shore at the slide north of Tulalip Bay.

AREA 9 shall include those waters of Puget Sound southerly and easterly of a line projected from the Partridge Point light to the Point Wilson light, northerly of the site of the Hood Canal Floating Bridge, northerly of a line projected true west from the shoreward end of the Port Gamble tribal dock on Point Julia to the mainland in the community of Port Gamble, excluding those on-reservation waters of Hood Canal north of Port Gamble Bay to the marker at the north end of the Port Gamble Indian Reservation, southerly of a line projected from the southern tip of Possession Point 110 degrees true to the shipwreck on the opposite shore and northerly of a line projected from the Apple Cove Point light to the light at the south end of the Edmonds breakwater at Edwards Point.

AREA 9A shall include those waters of Puget Sound known as Port Gamble Bay southerly of a line projected true west from the shoreward end of the Port Gamble tribal dock on Point Julia to the mainland in the community of Port Gamble and those on reservation waters of Hood Canal north of the Port Gamble Bay to the marker at the north end of the Port Gamble Indian Reservation.

AREA 10 shall include those waters of Puget Sound southerly of a line projected from the Apple Cove Point light to the light at the south end of the Edmonds breakwater at Edwards Point, westerly of a line projected 233 degrees true from the Azteca Restaurant near Shilshole Marina through entrance piling No. 8 to the southern shore of the entrance to the Lake Washington Ship Canal, westerly of a line projected 185 degrees true from the southwest corner of Pier 91 through the Duwamish Head light to Duwamish Head, northerly of a true east-west line passing through the Point Vashon light, easterly of a line projected from Orchard Point to Beans Point on Bainbridge Island, and northerly and easterly of a line projected true west from Agate Point on Bainbridge Island to the mainland.

AREA 10A shall include those waters of Puget Sound easterly of a line projected 185 degrees true from the southwest corner of Pier 91 through the Duwamish Head light to Duwamish Head.

AREA 10C shall include those waters of Lake Washington southerly of the Evergreen Point Floating Bridge.

AREA 10D shall include those waters of the Sammamish River south of the state Highway 908 Bridge and Lake Sammamish.

AREA 10E shall include those waters of Puget Sound westerly of a line projected from

Orchard Point to Beans Point on Bainbridge Island and southerly and westerly of a line projected true west from Agate Point on Bainbridge Island to the mainland.

AREA 10F shall include those waters of Puget Sound easterly of a line projected 233 degrees true from the Azteca Restaurant near Shilshole Marina through entrance piling No. 8 to the southern shore of the entrance to the Lake Washington Ship Canal and those waters of the Lake Washington Ship Canal westerly of a line projected from Webster Point true south to the Evergreen Point Floating Bridge including the waters of Salmon Bay, the Lake Washington Ship Canal, Lake Union, and Portage Bay.

AREA 10G shall include those waters of Lake Washington northerly of the Evergreen Point Floating Bridge, easterly of a line projected from Webster Point true south to the Evergreen Point Floating Bridge and those waters of the Sammamish River north of the state Highway 908 Bridge.

AREA 11 shall include those waters of Puget Sound southerly of a true east-west line passing through the Point Vashon light, northerly of a line projected 259 degrees true from Browns Point to the landfall on the opposite shore of Commencement Bay, and northerly of the Tacoma Narrows Bridge.

AREA 11A shall include those waters of Puget Sound southerly of a line projected 259 degrees true from Browns Point to the landfall on the opposite shore of Commencement Bay.

AREA 12 shall include those waters of Puget Sound southerly of the site of the Hood Canal Floating Bridge and northerly and easterly of a line projected from the Tskutsko Point light to Misery Point.

AREA 12A shall include those waters of Puget Sound northerly of a line projected from Pulali Point true east to the mainland.

AREA 12B shall include those waters of Puget Sound southerly of a line projected from Pulali Point true east to the mainland, northerly of a line projected from Ayock Point true east to the mainland, and westerly of a line projected from the Tskutsko Point light to Misery Point.

AREA 12C shall include those waters of Puget Sound southerly of a line projected from Ayock Point true east to the mainland and northerly and westerly of a line projected from Ayres Point to the public boat ramp at Union.

AREA 12D shall include those waters of Puget Sound easterly of a line projected from Ayres Point to the public boat ramp at Union.

AREA 13 shall include those waters of Puget Sound southerly of the Tacoma Narrows Bridge and a line projected from Green Point to Penrose Point and northerly and easterly of a line projected from the Devil's Head light to Treble Point, thence through lighted buoy No. 3 to the mainland and westerly of the railroad trestle at the mouth of Chambers Bay.

AREA 13A shall include those waters of Puget Sound northerly of a line projected from Green Point to Penrose Point.

AREA 13C shall include those waters of Puget Sound easterly of the railroad trestle at the mouth of Chambers Bay.

AREA 13D shall include those waters of Puget Sound westerly of a line projected from the Devils Head light to Treble Point, thence through lighted buoy No 3 to the mainland, northerly of a line projected from Johnson Point to Dickenson Point, northerly of a line projected from the light at Dofflemeyer Point to Cooper Point, easterly of a line projected from Cooper Point to the southeastern shore of Sanderson Harbor, easterly of a line projected from the northern tip of Steamboat Island to the light at Arcadia to Hungerford Point and southerly of a line projected true east-west through the southern tip of Stretch Island.

AREA 13E shall include those waters of Puget Sound southerly of a line projected from Johnson Point to Dickenson Point.

AREA 13F shall include those waters of Puget Sound southerly of a line projected from the light at Dofflemeyer Point to Cooper Point.

AREA 13G shall include those waters of Puget Sound southerly of a line projected from Cooper Point to the southeastern shore of Sanderson Harbor.

AREA 13H shall include those waters of Puget Sound southwesterly of a line projected from the northern tip of Steamboat Island to the light at Arcadia and those waters easterly of a line projected 64 degrees true from Kamilche Point to the opposite shore.

AREA 13I shall include those waters of Puget Sound southwesterly of a line projected 64 degrees true from Kamilche Point to the opposite shore.

AREA 13J shall include those waters of Puget Sound northwesterly of a line projected from the light at Arcadia to Hungerford Point.

AREA 13K shall include those waters of Puget Sound northerly of a line projected true east-west through the southern tip of Stretch Island.

Appendix C. Questionnaire (adapted from Sàenz-Arroyo (2005)

Survey of Lummi Fishing History Questionnaire

1. Date _____
2. Profession_____ Lummi ( )
3. Age_____
4. Years fishing in Puget Sound_____
5. Do you own a boat? If yes, how many?_____
6. Gender: F ( ) M ( )
7. What are the names of all the fish and shellfish you have caught in your lifetime?

Chum/Pacif/Dog Salmon
Spring Chinook (King)
Sockeye Salmon
Humpback /Pink (humpies)
Coho/Silver Salmon
Steelhead
Pacific Herring
Northern Anchovy
Eulachon (Columbia River Smelt)
Longfin Smelt Stocks
Rock Fish
Cockle Clams
Butter Clams
Mussels
Olympia Oyster
Shrimp
Abalone
Prawns
Dungeness Crabs
Geoduck Clams
Hardshell Clams
Manlia Clams
Halibut
Surf Smelt

Other:_____

8. What Puget Sound Site do you most often use for **fishing** now versus when you first began fishing?

   *(Please locate your main **fishing** area on the attached map)*

   a. Then:_____ _____

   b. Now: _____

9. What Puget Sound Site do you most often use for **shellfish harvesting** now versus when you first began harvesting?

   *(Please locate your main **shellfish harvest** area on the attached map)*

   a. Then:_____ _____

   b. Now: _____

10. How would you describe the condition of the fishery stocks of Puget Sound?

Underfished ( ) Fully Exploited ( ) Depleted ( ) Severely Depleted ( )

11. Are there any places in Puget Sound that were once productive fishing grounds but are now depleted?

    (Please locate the places on the attached map)

    Yes ( ) No ( ) I do not know ( )

    If the answer was yes, list those places that were formerly productive.

    _____

12. Do you know of any species that were once important in commercial or sport fisheries but are no longer or very rarely caught?

    Yes ( ) No ( ) I do not know ( )

    If your answer was yes, list each species and the main cause you think was responsible for their disappearance.

    _____

13. Over the years, has the majority of your harvest changed from fish to shellfish?

    a. Yes ( )

    b. No ( )

If your answer is yes, then when did this occur? _____

14. What would you consider a good catch for one day of fishing (in pounds) now versus when you began as a fisher?

    a. Then (pounds):_____

    b. Now (pounds): _____

15. How many hours does it take for you to make your daily quota now versus when you began as a fisher?

    a. Then (hours): _____

    b. Now (hours): _____

16. During your career, which species has made up the majority of the Lummi tribe harvest?

    ____ Wild, native salmon

    ____ Hatchery salmon

    ____ Wild, native shellfish

    ____ Cultured shellfish

17. List the top 5 species of shellfish and fish you harvested on an annual basis (specify if wild or hatchery) when you started as a fisher and in the present.

    a. Then (top 5 species): _____

    _____

    b. Now (top 5 species): _____

    _____

18. How many days a week do you and/or your family consume fish/shellfish products?

    a. 1-2 ( )

    b. 3-4 ( )

    c. 4-5 ( )

    d. 6+ ( )

19. What percentage of your annual income comes from the fishing and/or shellfish industry?

    a. 10-30% ( )

    b. 30-50% ( )

    c. 50-70% ( )

    d. 70-90% ( )

    e. 100% ( )

20. How did you learn about the state of the fisheries in Puget Sound?

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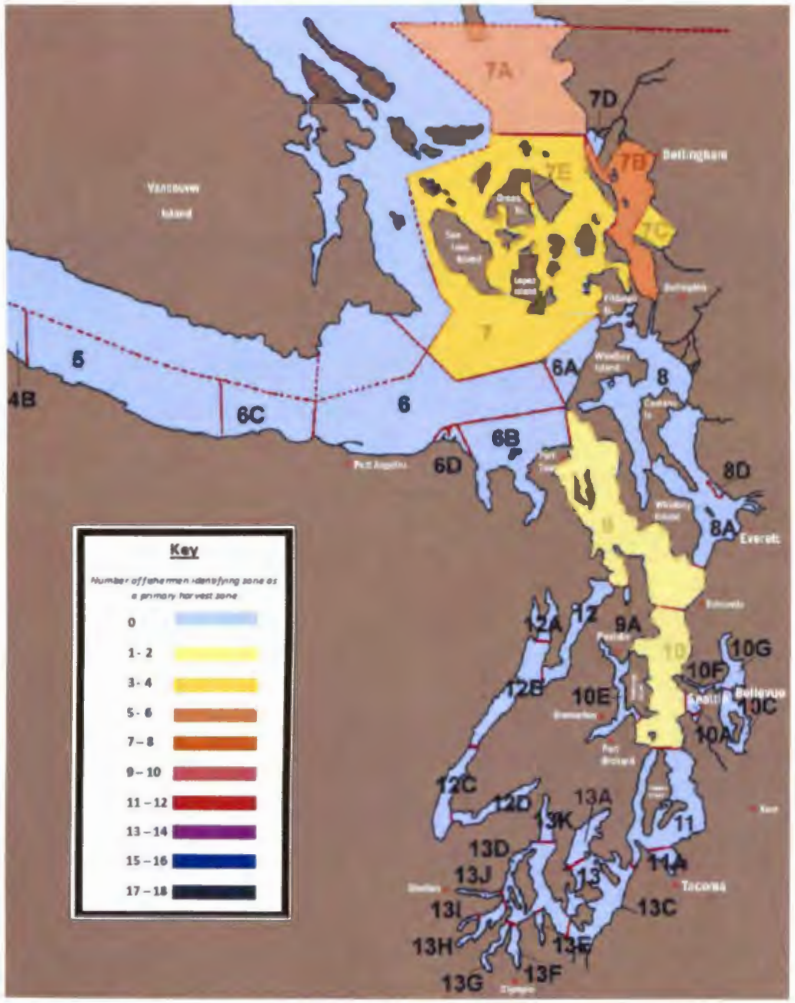
21. What are your recommendations for improving the depletion of the fisheries?

Appendix D. Shift from near shore to offshore fisheries for old fishers

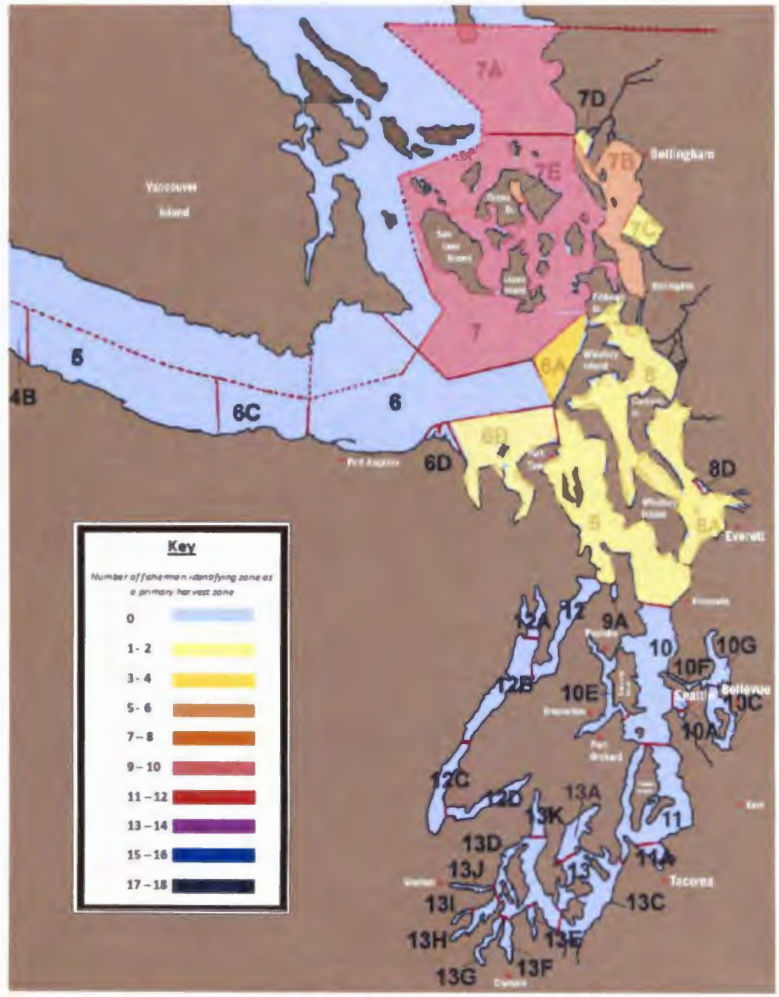
Old Fishers "Then"



Source: 2006 Washington Department of Fish and Wildlife Puget Sound Commercial Salmon Regulations
Prepared by: Preston Gates & Ellis LLP

These maps indicate the distinct shift from near shore fisheries for the old fishers when they began fishing and expansion to offshore fisheries presently. The darker the color, the greater the number of fishers indicated the area as a primary fishing zone, as indicated by the key. As fishers are unable to obtain their harvest quotas from their previous historical fishing grounds, they have had to move farther and farther out into the Sound.

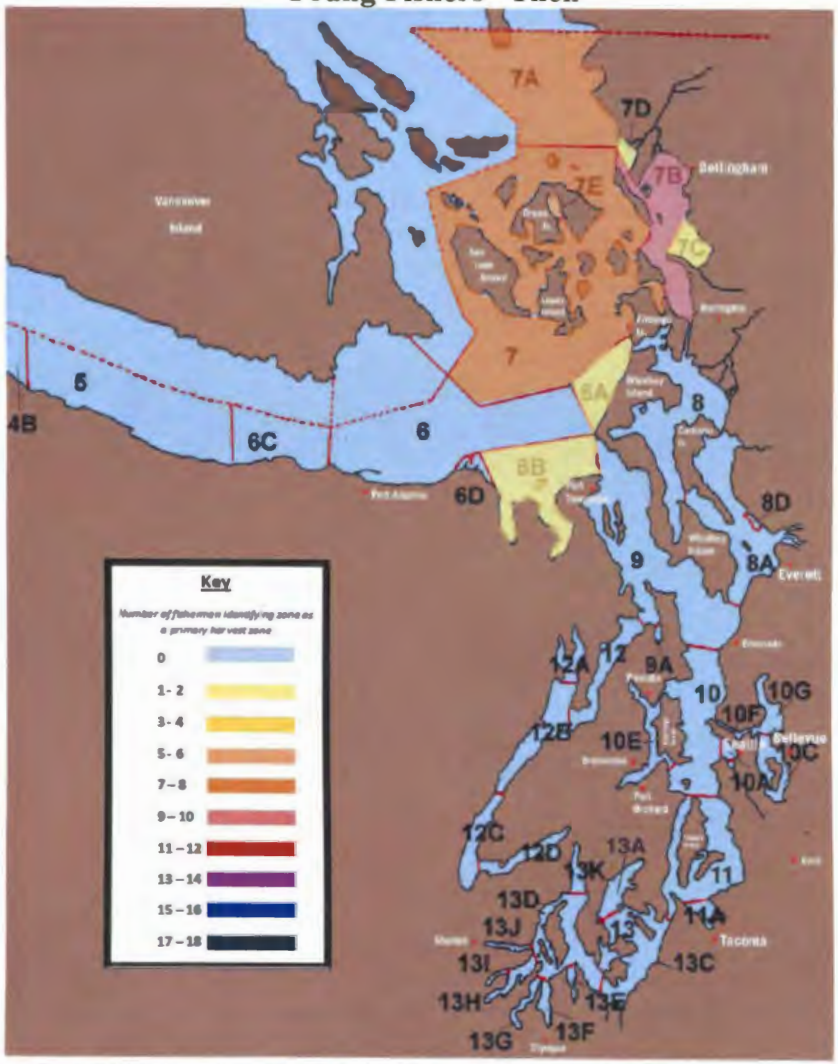
Old Fishers "Now"



Source: 2006 Washington Department of Fish and Wildlife Puget Sound Commercial Salmon Regulations
Prepared by: Preston Gates & Ellis LLP

Appendix E. Little shift in fishing zones for young fishers

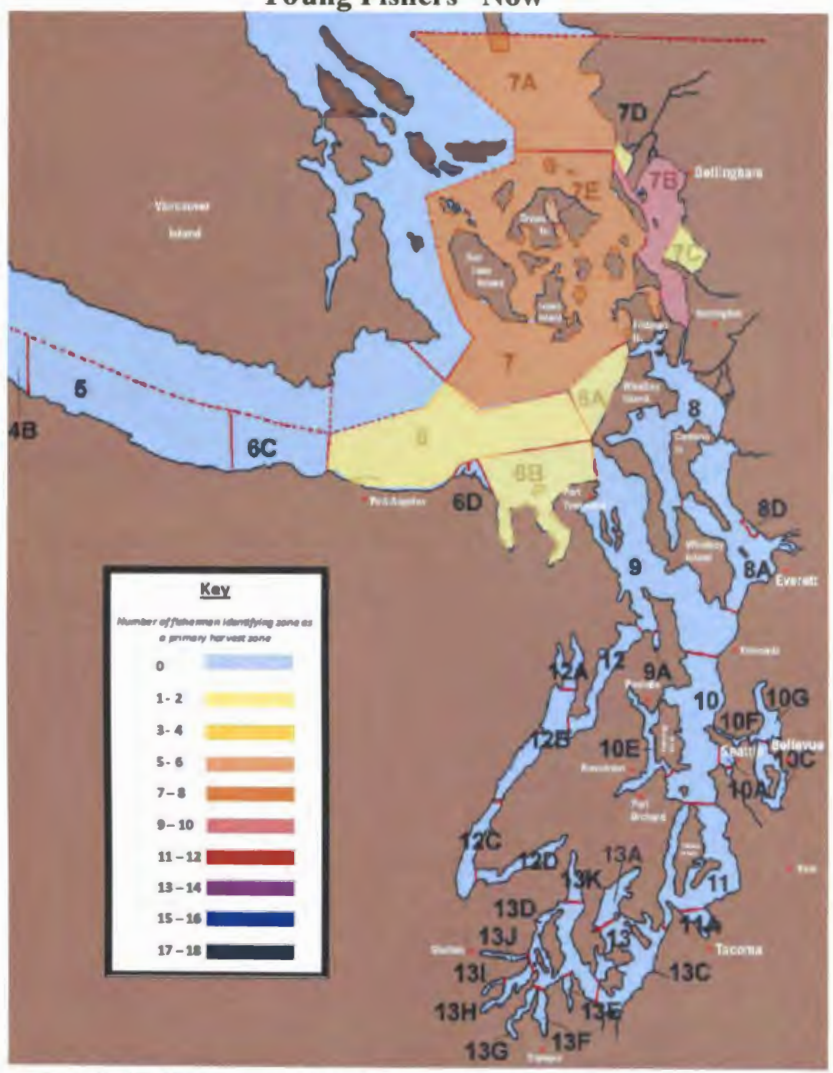
Young Fishers "Then"



Source: 2006 Washington Department of Fish and Wildlife Puget Sound Commercial Salmon Regulations
Prepared by: Preston Gates & Ellis LLP

When asked to identify their primary fishing sites when they began fishing in comparison to their current fishing sites, the young fishers indicated very little change. The sites where they began fishing when compared to where they fish now are almost identical. They do not remember many of the sites that were indicated by the older fishers.

Young Fishers "Now"



Source: 2006 Washington Department of Fish and Wildlife Puget Sound Commercial Salmon Regulations
Prepared by: Preston Gates & Ellis LLP