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Event Ecology: An Analysis of Discourses Surrounding the Disappearance of the Kah Shakes Cove Herring (Clupea pallasi)

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Event Ecology: An Ecological Analysis of Discourses Surrounding the Disappearance of the Kah Shakes Cove Herring (*Clupea pallasi*)

by

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ABSTRACT

The conflict over the herring run at Kah Shakes is complicated. In 1991, the Alaska Department of Fish and Game (ADFG) expanded the commercial herring sac roe fishing boundary in the Revillagigedo Channel to include Cat and Dog Islands. Native and non-Native local residents of Ketchikan protested the boundary expansion, as did managers of the neighboring Annette Island Fishery managed by the local reservation. Using cultural anthropological research methods that include ethnographic data, semi-structured, qualitative interviews gathered in southeast Alaska in 2008, and a comprehensive literature review of historic data culled from newspapers and other texts, I examine the many political factors that contribute to this conflict, including the contest between anecdotal and scientific data, the construction of fisheries management boundaries, and issues of collective memory.

Using Vayda and Walters' event ecology methodology, bolstered by discourse analysis, I identify three discourses (local ecological knowledge, management and environmental). I use these discourses as comparative units to show that little coincident data can be identified between these discourses. I examine two areas of dissident data, stock definition and measures of abundance, and recommend that local ecological knowledge (LEK) be used to expand the scientific database on which current management techniques depend, to question the accuracy of current ADFG management boundaries and stock identification, and to recalibrate guideline harvest levels by exposing the effects of shifting baselines. I then outline how Geographic Information

Systems (GIS) may assist in the validation and integration of LEK into the current fisheries management paradigm to create a more holistic narrative of ecological change.

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Many people assisted in the completion of this thesis. First, I would like to thank the members of my thesis committee, Tom Thornton, Michele Gamburd, Jeremy Spoon and Virginia Butler for their thoughtful critiques of my thesis defense draft. I would like to extend special thanks to Tom for giving me the opportunity to expand upon the information we gathered as part of the Herring Synthesis Project and also to Michele who not only picked up the advising role halfway through this process and ran with it, but who also became the audience to my many, many frustrations during the thesis revision process and who helped push me onward when I thought I could go no further. I would also like to thank Connie Cash who kept track of me on paper, but who also acted as personal support when difficulties arose.

Not to be forgotten, I would like to thank the many participants who offered their time and expertise as part of the interview process. I would especially like to thank Andy and Peggy Rauwolf for their continued interest in the completion of this thesis as well as their assistance during my fieldwork in Ketchikan in 2008. Also included in this category is Priscilla Schulte. I would also like to thank Scott Walker, Hap Leon, Dustin Winters and Gary Frietag for walking me through the management processes and providing additional resources that assisted in my understanding of commercial herring sac roe fishing in southeast Alaska.

Last, but certainly not least, I would like to thank my husband and my son whom I said good-bye to each weekend to spend endless hours in front of a computer and folded into a book. I could not have accomplished this enormous task without the unending

support of my husband who helped me regain perspective again, and again. To this list I also add my parents, who have always cheered my accomplishments and without whom I would never have arrived at this juncture in my education. Thank you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

Our plane touched down in Ketchikan on a Wednesday in March 2008, my head still spinning from our whirlwind travel schedule: a five-day trip that began with a flight from Portland, Oregon to meet Dr. Thornton, my thesis advisor, in Sitka followed by a short stay in Juneau and then a final stop in Ketchikan before heading back home again. The purpose for the trip was to complete field research for a North Pacific Research Board (NPRB) funded project entitled *Herring Synthesis: Documenting and Modeling Herring Spawning Areas Within Socio-Ecological Systems Over Time in the Southeastern Gulf of Alaska (*Herring Synthesis Project*)*. The main focus of this study was to synthesize existing archaeological, ethnological, historical and biological records with data from interviews[1] with herring fishers with significant long-term observations and local and traditional knowledge (LTK) of herring populations to build a historical and

[1] Eighty-six individuals were consulted as part of this project as were 117 unpublished interviews from various historical documents, transcribed interviews conducted by Sitka Tribe and affidavits collected as part of court proceedings.

spatial database to address the gaps in the long-term historical and cultural ecological knowledge of Southeast Alaska herring (Thornton et al. 2010). I had taken on the role of research assistant for the project.

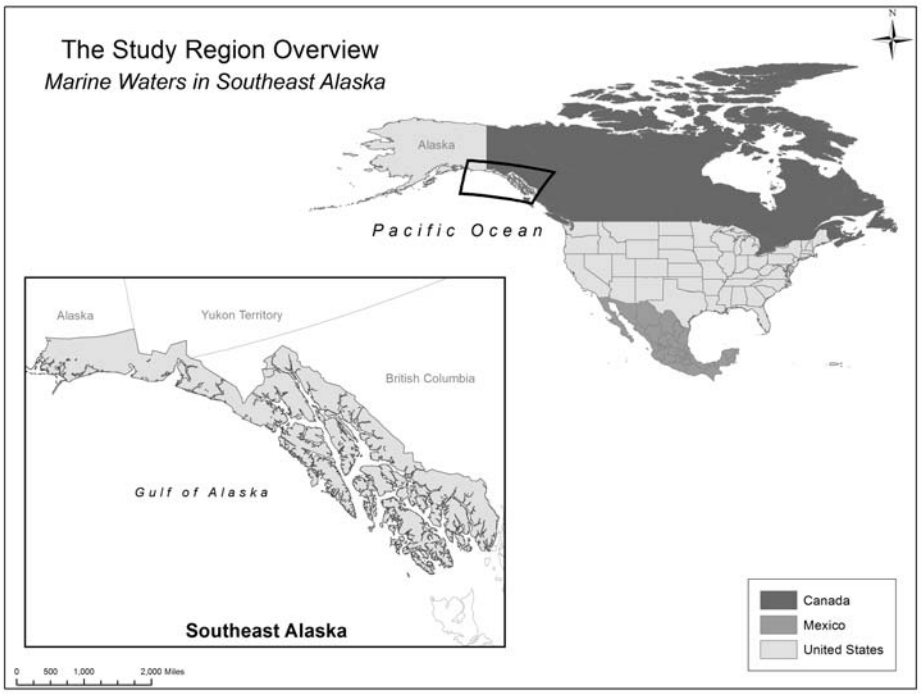

Figure 1: The Study Region Overview: Marine Waters in Southeast Alaska

In this, first experience conducting fieldwork, by the time we reached Ketchikan my brain was full of one big snarl of new faces, places and information. In Sitka, we had done eight individual interviews, an intensive 12 hours of pre-scheduled, back-to-back, conversation and data collection. In Juneau and Ketchikan, the schedule was more organic but much more hectic. As soon as the plane hit the ground, Tom began punching numbers into his cell phone. Having worked in southeast Alaska for more than twenty years, he had an impressive contact list and a great ability to dial-and-drive, which is

what we did for the entirety of our stay. If an informant had fifteen minutes to talk to us, it would take us five to drive to wherever the person was. We would haul out the oversized maps I had created to be used by informants to note herring spawning and massing locations. We would also bring out the tape recorder and the consent forms, scribble furiously during the duration of the conversation, pack up, and repeat the process as many times as we could fit into a day. Focus group sessions of eight or fewer people were scheduled for the evening hours. A similar process was followed in Ketchikan though the cadence of our interview process slowed a bit. The only scheduled meeting was on the evening of our arrival and took place with members of the Ketchikan Area Herring Action Group (Herring Coalition), which left the day open to spontaneous interview sessions.

I had been dozing when our landing at the Ketchikan airport jolted me awake. Despite my jet lag, I was excited to catch my first glimpse of the place I had read about during my early days conducting research for the Herring Synthesis Project. My interest in Ketchikan and the nearby Kah Shakes Cove had been piqued by two electronic documents, entitled “An Expose on the History of the Kah Shakes and West Behm Canal Herring Fisheries,” (Rauwolf et al. 2004) and “An Urgent Letter to the Governor” (Rauwolf and Harrington 2004), both published in SitNews, an online news source based in Sitka. The articles appeared to outline a classic struggle in political ecology: government against the little guy, in this case the Alaska Department of Fish and Game

and commercial fishermen versus local residents and Native resource users. And here I was at ground zero.

In Ketchikan, Alaska herring are caught in a net of complex and conflicting political and ecological discourses that circulate among long-time residents and institutionally based managers of the commercial herring fisheries. According to the local ecological discourse, the Natives and non-Natives with long-time associations with herring including some commercial and sport fishermen fear that the commercialized herring sac roe fisheries are in danger of depleting herring stocks beyond recovery, that herring numbers have been in decline for years, and that the Alaska Department of Fish and Game (ADFG) is maintaining a level of already depleted herring biomass.

As we rolled off the ferry ramp onto the mainland, a short ride from the airport on Gravina Island, we met our first contact, Andy Rauwolf, co-founder of the Herring Coalition. Hungry for food and introductions, we followed him to "The Place in Town to Eat," known as "The Landing," a restaurant attached to the Best Western. Scanning the crowd, nodding a greeting to those he knew, Andy eased his tall frame into the vinyl booth and settled in with a cup of coffee, eyeing us warily. I scanned the menu with half interest as Tom reiterated the purpose of the Herring Project and summarized our travels thus far. Andy sipped and nodded along, interjecting questions here and there, a spark of interest kindling as he described the status of herring decline in the waters around Ketchikan and the mismanagement of the commercial sac roe fishery at Kah Shakes Cove.

Subsequent interviews conducted that day in Saxman, a town neighboring Ketchikan, with Tlingit Native resource users Matilda Kushnik, Frank James, Sr. and Marvin James echoed Andy's observations of herring decline and concern about ADFG management practices. But it wasn't until later that evening at the focus group interview comprised of Herring Coalition members that I was again suddenly jolted awake, not necessarily because the shared dialogue describing the events at Kah Shakes was exceptionally unusual but because of who was doing the telling, namely commercial fishermen.

Sitting there in that focus group composed of Herring Coalition members, somewhere in my travel-weary, data-saturated brain I was struck with the incongruence. Here were three commercial fishermen, a pilot, a contractor, a sport fisherman and a former ADFG employee all describing the decline of herring in the waters surrounding Ketchikan, all of whom had supported the closure (and therefore loss of economic revenue for some) of the herring fishery at Kah Shakes in 1993 though none of whom would accept the label of "environmentalist."

According to the traditional configuration of participants engaged in a market-driven battle for "the commons" (Hardin 1968), these men were playing for the wrong "team." In the competition for scarce resources, in this case for herring at Kah Shakes, the Herring Coalition is an anomaly. Commercial fishermen and Native resource users should be adversaries but in Ketchikan, in 1993, many commercial fishermen, local

residents, and Native resource users joined forces against ADFG to try to close the commercial sac roe fishery at Kah Shakes.

Kah Shakes Cove, located approximately thirty-four miles (as the seagull flies) from Ketchikan, has been managed as a commercial gillnet sac roe herring fishery since 1976. In 1990, for the first time, the fishery did not open due to insufficient spawning activity in the Kah Shakes area. The following year, in 1991, spawning activity was once again questionable, both in its late timing and low biomass. At the same time, it was observed that herring spawning activity had become pronounced at nearby (approximately eight miles distant) Cat and Dog Islands. According to the management discourse presented by biologists at Alaska Department of Fish and Game, in 1991 the Kah Shakes regulatory herring stock migrated from Kah Shakes Cove west across the Revillagigedo Channel to the coast of Cat and Dog Islands (Doherty et al. 1991). In response to what was determined to be one stock of herring moving from one spawning ground to another, ADFG quickly reconfigured management boundaries to reflect this movement by filing an "emergency order" to the Alaska Board of Fisheries to expand the once entitled "Kah Shakes Stock" to include Cat and Dog Island (Doherty et al. 1991). The expansion of the Kah Shakes area to include Cat and Dog Islands was made permanent in 1992 and thereafter the area has been identified as the Revilla[2] Channel management area (see Figure 2), was made permanent in 1992. Gillnet sac roe fisheries

[2] Revilla is an abbreviation of Revillagigedo that is used by ADFG and local residents interchangeably in conversation but also in published documents. I will use Revillagigedo throughout the body of this thesis.

continued to open in the expanded area each year thereafter until herring spawning aggregates failed to return to either Kah Shakes or Cat Island in 1998. The fishery has remained closed due to insufficient biomass threshold levels since 1998.

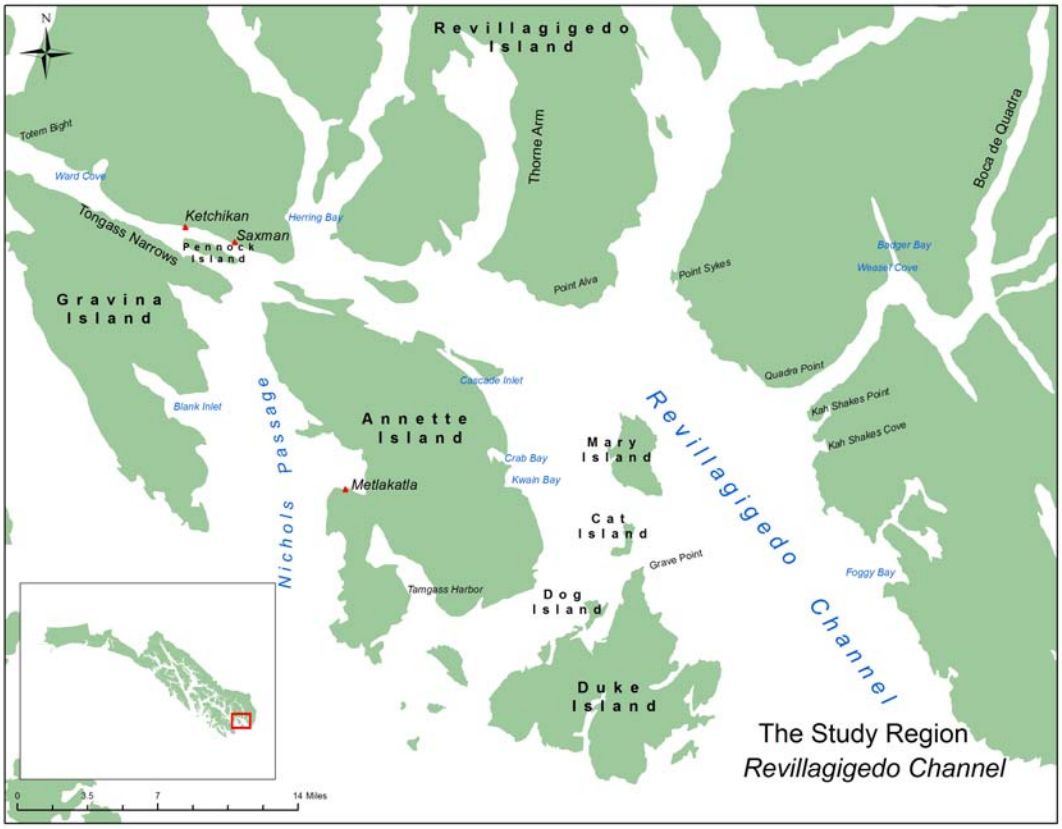

Figure 2: The Study Region: Revillagigedo Channel

The local residents of Ketchikan responded to the 1991 boundary change with alarm followed by outrage. According to preliminary testimony of both Native and commercial fishermen, the so-called movement of the Kah Shakes Cove herring and consequent management reconfiguration was a political maneuver to satisfy the economic needs of the commercial fishermen seeking to maximize their catch: a tragedy of

commoditization. Many local residents believe the Kah Shakes herring had simply been overfished, the stock was experiencing signs of depletion, and that the management boundary was implemented without the proper scientific data to support the stock movement theory.

As the focus group meeting came to a close, I knew I had to know more. Upon my return home, I conducted a literature review and prepared to return to Ketchikan six months later, in October 2008. During this second fieldwork trip, I completed eight additional interviews, this time including ADFG personnel Scott Walker and Gary Frietag, professor for the University of Alaska Southeast (UAS) Fisheries Technology Program, as well as revisiting Herring Coalition members and Native resource users. I also completed a review of newspaper and historical documentation during a visit to the Tongass Historical Museum. The following is a synthesis of these data sources and material collected as part of the larger Herring Synthesis Project. The goal of this analysis is to identify the ecological and political factors that have contributed to the dissidence between and within managerial and the local ecological knowledge discourses regarding the movement and perceived decline of herring at Kah Shakes.

Using event ecology, I analyze the conflict at Kah Shakes as the product of a dynamic interplay between culture, power *and* ecology (Vayda and Walters 1999, 2009). Event ecology is an open-ended analytical approach to environmental analysis. It is not structured by one theory or model, but instead requires an interdisciplinary practice that integrates myriad social and biophysical data sources including but not limited to

historical documentation, scientific literature, controlled experimentation, and semi-structured or structured interviews to fully describe the effects and identify all causes of environmental change. At Kah Shakes, however, there are conflicting views about what has actually happened. Many local residents of Ketchikan describe the herring stock at Kah Shakes as "collapsed," while ADFG maintains that herring within the region are healthy and that they have simply moved from the traditional spawning grounds at Kah Shakes.

Because descriptions of ecological events are framed within cultural models, and the power to describe environmental change is constantly negotiated through discursive actions, a thorough analysis of the situation requires a discussion of discursive politics, something that Vayda and Walters fail to address as part of event ecology. I resolve this issue by incorporating discourse theory into my analysis. Using a grounded theory approach (Bernard 2002), in chapter three I distill three discourses (management, local ecological knowledge (LEK), and environmental) from the many narratives about the Kah Shakes herring. I argue that the management and LEK discourses share very little coincident data. This dissonance exposes spatial and temporal gaps in the environmental discourse – the scientific knowledge of herring biology and behavior on which fisheries managers base current management techniques. I argue in this thesis that LEK provides a useful data source, in fact the only data source, to expand the knowledge of herring beyond the current management boundaries and backward in time to provide historical

measures of abundance. Integration of LEK into the current fisheries management paradigm is integral to a more holistic management scheme.

Legislative information provided in chapter four reveal that a participatory management structure already exists as part of Alaska's fisheries management discourse in the form of regional advisory committees composed of local stakeholders who make recommendations to the Bureau of Fisheries regarding herring management based on LEK-based observations. The system was set up at the time Alaska became a state in 1959. Unfortunately, since its inception this participatory management framework has become heavily influenced by political and economic factors that have gradually rendered the participatory structure ineffective. Many stakeholders who have made meaningful observations of declining herring abundance and who have relevant concerns regarding commercial management techniques have become frustrated with the ineffectiveness of the current processes. I hope that this thesis can make a useful contribution in showing how the integration of managerial and LEK data can lead to better informed and therefore more sustainable fisheries management practices.

In chapter five of this thesis, I identify areas of dissidence between the management and LEK discourses. Identification of dissonance is the first step that must be taken to integrate the management and LEK discourses and arrive at a fuller and more accurate environmental discourse. I focus on two particular areas of dissidence. The first concerns stock identification -- namely whether one or two herring stocks exist in the Revillagigedo Channel. The second concerns measures of herring abundance, which I

discuss in terms of shifting baselines and variable system equilibrium models. Integrating LEK observations into the current management model requires a recalculation of herring stocks that are not confined by the current management boundaries, and a reevaluation of the baseline levels of abundance that are maintained and described by ADFG as "healthy." Although I do not suggest a revised definition of "stock" or propose a new baseline in this thesis, I do show how integrating LEK into the management discourse can provide a wider spatial and temporal frame for subsequent analysis. In particular, using LEK will enable a clearer understanding of disequilibrium in herring movement over time. As I show in chapter 5, reassessments of the definition of "stock" and the accurate calculation of baseline healthy populations are imperative for a truly sustainable fisheries management paradigm.

A key source of tension in the integration of LEK into management discourse is the sense that LEK observations are "anecdotal" or "unscientific." One of the main contributions that this thesis makes to facilitate the conversation between LEK and management discourses is to convert the largely qualitative LEK data into quantitative datasets that can then be made comparable to management datasets. I do this using Geographic Information Systems (GIS) software, with the hope that mapping the data systematically collected by myself and the Herring Synthesis Project can increase the intelligibility of LEK to fisheries managers. GIS has the capability to juxtapose multiple datasets and manipulate data both spatially and temporally. With this tool, it may be possible to use both LEK and management data to arrive at an enhanced ecological

understanding of herring behavior and migration. The GIS software also has the storage capacity to model multiple ecological and climatic components to better illustrate multispecies interactions that may be affecting herring populations throughout the herring lifecycle and across the oceanscape.

The conflict at Kah Shakes is a prime, but not unique, example of the political struggles being fought throughout southeast Alaska and elsewhere in cases where LEK and management data do not coincide. For example, at Sitka, the struggle between Native resource users and ADFG personnel possesses some similarities to the conflict at Kah Shakes. Sitka Sound is the location of the largest commercial sac roe fishery in southeast Alaska. It is one of only three management areas the state continues to open for commercial sac roe harvest; the others no longer have enough herring to support them. Despite observations by Native Tlingit subsistence users that suggest herring resource depletion, ADFG have forecast a record returning herring biomass for the 2011 spawning season. As a result, the harvest quota has been calculated as the largest in ADFG management history. Many Sitkans recognize a relationship between falling levels of herring eggs available for subsistence and increased commercial harvesting. Although a participatory management relationship has previously been established between the Sitka Tribe and ADFG, many Sitka Tribal members regard these interactions as ineffective. The political and ecological issues at play in the Sitka case highlight the timeliness and importance of my work in the Ketchikan area. I argue that identifying the social and environmental factors contributing to the conflict around environmental change will

result in a clarification of the environmental discourse and will facilitate explicit dialogue between the managerial and LEK discourses, hopefully leading to the creation of more sustainable fishing practices.

Methodology

The research method employed during the length of this study can be divided into three segments: a literature review of the scientific information, a literature review of the historical documentation, and ethnographic fieldwork that included a targeted survey of key informants. The first of these was a comprehensive review of the anthropological, historical and biological literature on herring and herring fishing. A large portion of this work was done for the entire region of southeast Alaska as part of the Herring Synthesis Project, but I consulted additional sources that specifically addressed the history of commercial herring fishing at Kah Shakes. This included a visit to the Tongass Historical Museum in Ketchikan during which I worked with a curator to locate all historical documentation, including images, of herring harvesting at Kah Shakes and the surrounding waters of Ketchikan. The results were sparse. Searching the museum database for all mention of herring, not specifically related to abundance or decline, a total of seventeen articles that appeared in newspapers throughout Alaska and Ketchikan, beginning in 1885 and ending in 1970, were located. Most of these articles are brief reports of the comings and goings of commercial herring boats, some with catch statistics, and plant openings. Those articles that did identify declines or perceived

herring shortages are all included as data sources during my discussion of measures of herring decline in Chapter Five. One article discussed tagging methods underway in Chatham Straits in 1932. This information is included in my analysis of stock definition, also in Chapter Five. One image was located: a photo of a commercial herring boat docked at City Float in Ketchikan.

To supplement this historical data, I also spent a period of time in the Ketchikan public library searching out articles in the *Alaska Magazine* (formerly the *Alaska Sportsman*) a popular publication printed in Ketchikan from 1935-1972 that once had a circulation of 80,000 copies monthly. A total of seven articles mention herring. None of these were directly pertinent to the fishery at Kah Shakes and none of these sources were used directly in this analysis but do attest to a similar storyline of decline with articles like, “The Herring Days are Gone” by Katherine Bayou published in 1943, and of past measures of abundance with an article “They Came in the Millions” by Hal Gould in 1938. But while I did not find the information in *Alaska Magazine* to be particularly helpful in this analysis, I did find plenty of material to review in the archival material of the *Ketchikan Daily News*, the local newspaper.

In fact, the amount of information found in the *Ketchikan Daily News*, the primary news source in Ketchikan, regarding the commercial harvest of herring sac roe at Kah Shakes was nearly overwhelming. Most of the information presented in this local publication before 1990 was general fishery openings, harvest reports, and then notices of final closure. I chose to disregard much of this information, preferring to rely on ADFG

management reports for this data, and instead focused this literature review on articles that directly addressed the 1993 injunction filed by the Herring Coalition, and the court proceedings that followed.[3] From these articles, I have culled important dates and some comments made by local residents and Herring Coalition members and include them as part of this analysis as LEK observations.

My final source of historical data consisted of the commercial herring sac roe herring reports published by ADFG. These literature include the following: Management Reports, Board of Fisheries Briefing Documents, proposals submitted to the Board of Fisheries during public meetings, public memorandum published on-line during the fishing season to notify commercial fishermen and the general public of fishery openings and daily harvest tonnages, and a series of Powerpoints that illustrate ADFG management processes and calculations given to me by Gary Frietag, created by ADFG personnel as teaching tools for public presentations. I also received an unpublished Powerpoint presentation created by Annette Island fishery biologist Hap Leon. Because relations between ADFG and Annette Island personnel remains strained, I have been asked to keep statistical information contained within these slides confidential. All of these documents were reviewed and are referenced in this analysis as the management discourse.

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[3] After 1995, after the court case was dropped, mention of the Herring Coalition and supplementary herring information, for the most part, disappears. There are a few editorial letters addressing the issue that continue to be published, but for the most part, reports of herring return to fishery openings, closures and harvest reports. Surprisingly, the final closure of the Kah Shakes fishery in 1998 did not elicit the amount of public commentary one would expect.

The third segment of the research method employed during this analysis is a series of semi-structured, qualitative interviews (Thornton et al. 2010, Bernard 2002). Eighty-six interviews were carried out as part of the larger Herring Synthesis Project. I conducted eight of the interviews included in this number during my second fieldwork session in Ketchikan in October 2008. For this project, I chose to consult key informants who could provide both time-depth and valuable insight that is gained by those who have considerable experience fishing and harvesting herring in southeast Alaska. Consultants were chosen based on references provided by Tom Thornton who has twenty plus years of ethnographic experience in southeast Alaska, as well as input from local residents, Herring Coalition members and ADFG fisheries biologist, Scott Walker.

All of the interviews I conducted were done one-on-one and included the following questions:

- How have you been involved in the herring fishery during your lifetime?
- Show on the chart where you have observed herring spawning and massing around your community (or in the areas you've fished commercially)? Which of these areas are you most familiar with and how (through fisheries, etc.)? When (what months) do you usually observe them?
- How many herring stocks frequent these areas? On what basis do you differentiate these stocks?
- For what purposes where they fished (eggs, oil, bait, sac roe, etc.)?

- What trends or changes have you seen in the herring stocks that mass or spawn in this area (by decade)? Tell me about changes in mass/spawn, timing (how long, etc.), extent (length of spawned beaches), and intensity (thickness or width of spawn)? What factors do you believe have contributed to these changes/trends?
- [For Natives] Are their customary and traditional beliefs or practices associated with maintaining herring stocks and spawning areas? Explain.
- Are there places you think are important for juvenile herring? Which places and why?
- Where do juvenile herring (age 0-2 years, about 4 inches long) usually winter? How do they travel from season to season?
- What predators have you observed in concentrations feeding on massing and spawning herring?
- What other species of fish have you commonly observed in conjunction with herring?
- Where and when have you seen schools of adult herring? At each locale were they nearshore, offshore, surface or deep? How do you identify them?
- Have you ever noticed signs of disease in herring populations? When and where?
- Can you please provide a brief description of what happened during the Kah Shakes fishery in 1991? What is the status of that fishery today and why?

Each interview session was recorded while written notation was completed at the same time. Transcripts of these interviews were produced at a later time.

I began the interview process by reconnecting with Andy Rauwolf, co-founder of the Herring Coalition and also his wife, Peggy Rauwolf. I also revisited Coalition members, Steve Schrum, a pilot, and Lawrence "Snapper" Carson, a fish packer. In addition, I conducted an interview with Merle Hawkins, a member of the Ketchikan Indian Community Tribal Council member who addresses subsistence issues. Two consultants asked that they remain anonymous as part of this project. One of these was a Native Tlingit subsistence user and the other was a Native Tsimshian commercial fisherman whom I spoke with via phone while he was between sets on his boat. All of these participants are considered to contribute to the local ecological knowledge discourse. As part of the managerial discourse, I conducted interviews with ADFG fisheries biologist for the Ketchikan Area, Scott Walker, and with Gary Frietag, a researcher whose main area of expertise is the evaluation and management of salmon aquaculture programs for ADFG and more recently for the Southern Southeast Regional Aquaculture Association. Phone interviews were conducted with Dustin Winter, the current fisheries biologist for Annette Island and with Hap Leon, the fisheries biologist who was employed by Annette Island during the boundary change in 1991 and who continues to act as consultant for the Tribe (see Appendix B for a more detailed list of participants). It should again be noted that I chose to focus on key informants as part of this project and a broader, more systematic sampling method could be employed for the future to correct for over- and under-sampling of particular groups. Special attention

should be extended to Annette Island residents as this group was under-sampled as part of this analysis (see Limitations of the Data below).

I also included in this analysis the transcript from the focus group style interview with seven of the Herring Coalition members and transcripts from five additional, individual interviews with local residents and Native subsistence users, some of which were conducted in March 2008 and some that Thornton conducted in 2009. Information from a total of nineteen interview participants from Ketchikan is included in this analysis (see Appendix B).

In addition to these transcripts, I also included information gleaned from the fifty-seven affidavits submitted as evidence in the 1993 injunction filed by the Herring Coalition (see Appendix A). These affidavits provide testimony by local residents of herring abundance and many request that the Kah Shakes commercial sac roe fishery be closed. Information from these interviews and affidavits, specifically observations that relate to stock designation, measures of abundance, and multispecies interactions, was then entered into an Excel spreadsheet under the following headings:

- Time - a year, or when this information is not included in the observation, “past” or “present”
- Approximate Time - each year is assigned to a decade
- Location - the exact words or phrases used when making an observation about herring

- GIS Location - to account for colloquialisms and alternate placenames, location is standardized in order to be assigned a latitude and longitude for entry into GIS database
- Name/Agency - also included in this column is a background description of the participant when offered (i.e. commercial fisherman, salmon fisherman, etc.)
- Herring Level – observations have been coded as either “high,” “present,” ‘low,” “declining,” or “gone”
- Predators – comments are extracted from data sources that identify species interaction, most typically, predator-prey relationships
- Observations of Management/Conservation Measures – comments are extracted from data sources that identify the effects of management or conservation measures on herring populations
- Observations of Herring Abundance/Locations – comments extracted from data sources that identify herring abundance as “high,” “present,” ‘low,” “declining,” or “gone”
- Observations of Abundance (General) – comments extracted from data sources that identify a level of herring abundance, but fail to identify a specific geographic location
- Other Factors (Climate/Fishing Technique/Etc.) – comments extracted from data sources that identify additional factors that may affect herring abundance levels.
- Source – Data Source

I also include the following headings that are marked with an "X" where applicable: Spawn, Larvae, Juvenile, Adult, Season, Jig, Trolling, Seine, Gillnet, Reduction, Sac Roe, Bait, Subsistence/Kelp/Branches. I created an "Other" column to enter additional comments. This data was then transformed into "point data" and input into GIS software. The purpose of this form of data extraction is to include all observations of herring at all locations in order to fully grasp the extent of the managerial, scientific and local ecological knowledge (LEK) available for further examination and, as discussed in Chapters Four and Five, to visually represent incongruence between ADFG management areas and the extent of LEK observation.

This raises the question of weighing the quality of the data. I did not weigh or exclude any of the knowledge gathered in my research. Further analysis of the data is needed for verification. This can be done by looking at the repeatability of observations between all datasets (managerial, scientific, LEK, historical documentation) at each location but also weighting information provided by elders. For example, Martin Perez has been fishing in southeast Alaska for most of his 92 years. No one else has information comparable to this time-depth. Special consideration should be given to observations made by individuals with vast experiential and generational knowledge. GIS methodology allows for aggregate weighting of observations in the future, if one chooses to do so, but this was not necessary for my analysis of Kah Shakes since the central observations—that herring left Kah Shakes were they had historically spawned—was not in dispute. A more systematic analysis is needed to determine the coincidence or

dissidence between these observations at each herring observation location. This analysis is only intended to provide the rationale for such an undertaking.

In addition to this point data, linear data was also collected during the interview process. I had created maps of the geographic area that were used by interview participants to mark areas, usually coastline, where herring had been observed spawning. Included in these maps are observations of commercial harvest areas and massing areas. While pertinent to the larger issue of herring movement and the effects of commercial harvesting, I chose to only address spawning area observations in the maps presented in Chapter Four in juxtaposition with ADFG spawn documentation to show the discrepancies between data provided by LEK and management discourses.

Limitations of the Data

Despite every attempt to represent an accurate evaluation of the many ecological and political factors surrounding the conflict at Kah Shakes, there are inherent limitations within each data source that must be recognized. The first of these is the ability of my interview sample to represent an entire community, or an entire discourse. During the course of this project, I made it a point to search out a variety of people and text-based resources. When I arrived in Ketchikan, my contact list was fairly short and was expanded by a survey method of “snowball sampling.” Because of this, I was unable to contact as many commercial fishermen not affiliated with the Herring Coalition as I would have liked. The most notable on this list is Ron Porter who was mentioned several

times throughout my fieldwork but whom I never was able to make contact. Another individual who I was unable to contact is Phil Doherty, the fisheries management biologist for ADFG who actually made the call to the Board of Fish with the boundary expansion request. Future research should include a systematic survey of all commercial fishermen who harvested at Kah Shakes as well as all fishermen who harvested at Annette Island during the 1990s.

The second methodological implication that must be addressed is that LEK consists of memories and that memories are contextually situated observations (Wertsch 2008, White 2006). As White explains, "Memory must be studied in relation to the things they actually *do* with the past" (emphasis added, 2006: 331). This introduces the question of the politics of collective memory (Gold and Gujar 1997, Malkki 1995). I conducted this project ten years after the closure of the Kah Shakes fishery. Many point to the mismanagement techniques by ADFG personnel as the reason herring no longer spawn in large quantities as Kah Shakes. Perhaps my results would have been different had I conducted my interviews in 1992, before the Herring Coalition filed their legal injunction in 1993 and become a front page feature in the Ketchikan Daily News. One must continually ask, "To what purpose are these memories and observations of herring being applied?"

A total of fifty-seven affidavits were filed by members of the Herring Coalition in 1993 asking the courts to close the Kah Shakes until further scientific research could be done to clarify stock definition. Some of my interview participants authored these

affidavits. Some did not. Observations of herring decline and perceptions of Kah Shakes as a collapsed fishery were consistent, but perhaps the cause of this consistency is an artifact of a reading the same newspapers, listening to the same radio station programs, watching the same news programs, and discussing, forming, and reforming opinions during interactions with each other. As a result, discourses themselves become fluid (Vayda 1983). As part of this analysis, I identified three discourses (managerial, LEK and environmental), but discourses are intrinsically linked to context, and individual and group identity as they are defined by factors such as ethnicity, gender, and occupation. Knowledge itself is always undergoing continuous change. This is why consulting a variety of data sources, as prescribed by event ecology methodology (Vayda and Walters 1999, 2009), becomes such an important practice during the validation process.

The third precaution is one that must be considered when transforming LEK into GIS data. LEK, when input into a GIS program, is not then immediately transformed into scientific data (Robbins 2003). As with all new information, it must be subject to the rigors of scientific method. It should be understood that the LEK presented here has been treated as empirical observations in time and space, and neither marginalized as anecdotal nor reified as scientific, but have been synthesized and modeled using GIS software to illustrate the potential LEK has for expanding the current knowledge regarding herring movement through the oceanscape..

Despite these inherent limitations of the data, I remain confident that the research methods used in conjunction with the chosen analytical frameworks produce valid concerns and conclusions.

Overview of the Analysis

The conflict surrounding the disappearance of herring at Kah Shakes is a complicated one. I begin this thesis with a lengthy background chapter in which I describe Ketchikan, the people who live there, the importance and mechanics of a commercial sac roe fishery, and the sequence of events that begins with the preliminary closure of Kah Shakes in 1990, the reopening of the fishery and reconfiguration of the commercial fishing boundary in 1991, the legal battle that ensued to close the fishery and the final disappearance and closure of the Kah Shakes fishery in 1998.

I begin the analysis of the Kah Shakes event in Chapter Three with a description of political ecology and a recent critique of the field presented by Vayda and Walters (1999, 2009) who emphasize the need for researchers to not simply describe environment as a backdrop for the power struggle for access to resources, but to examine the implications and effects of these conflicts on the biophysical and ecological processes of the environment itself, a methodology they refer to as *evenemental* or *event ecology*. I then offer my own critique of event ecology and bolster this methodology with the addition of discourse theory, including the framing of events, which I describe briefly, before I begin the identification of the three discourses present in the Kah Shakes conflict

(which I label as management, local ecological knowledge and environmental). I then address the subject of scientific evidence and the erroneous dismissal of local ecological knowledge (LEK) as "anecdotal." I also explain how the contrast of these two discourses, management and LEK, can be useful in the identification of coincident and dissident data, the reconciliation of which is imperative for a truly sustainable fisheries management paradigm.

In Chapter Four, I address the coincident data at Kah Shakes and illustrate how sparse, both spatially and temporally, the knowledge is on which herring management is based and that integration of management and LEK discourses will result in a clarification of the environmental discourse, the natural history, biology and behavior of herring. I argue that the dismissal of LEK as anecdotal by ADFG is erroneous. I then contextualize the current participatory management framework that exists in southeast Alaska and describe it as ineffective due to political and economic influences. Finally, I describe how GIS can assist in the integration of LEK into the management paradigm, offering a means to validate LEK and model interrelated ecological and environmental processes.

After identifying the coincident data in Chapter Four, I examine the dissidence between the management and LEK discourses in Chapter Five, highlighting two areas of conflict for further analysis: stock definition and measures of herring decline. One of the major sources of dissidence regarding the ecological event at Kah Shakes is the identification and definition of herring stocks. ADFG (management discourse) identifies

one stock at Kah Shakes, and Cat, Dog and Annette Islands. Many local residents, the Herring Coalition (LEK discourses) and Annette Island fisheries biologists (management discourse) disagree with this assessment. I show how reconciling the dissident management and LEK discourses can assist with clarification of the environmental discourse and the reification or rectification of current stock definition in the Revillagigedo Channel by expanding herring knowledge outward in space, beyond the current arbitrary management boundaries. I then explain how GIS can assist with this process.

The second major source of conflict among the management and LEK discourses is the measure of decline of herring populations in the waters surrounding Ketchikan. I address the phenomenon known as ‘shifting baselines” and address issues of herring movement as a function of system equilibrium models. The then describe how dissident discourse reconciliation can assist with the expansion of herring knowledge backward in time, adding temporal depth to current estimates of a ‘pristine’ herring biomass. Finally, I show how GIS can assist with this process.

In the concluding chapter I argue that the discourses surrounding the ecological event at Kah Shakes, the disappearance of herring, is a prime but not unusual example of the consequences of ignoring the local ecological knowledge of long-time resource users in current fisheries science and management practices. Local ecological knowledge can and should be used to expand and challenge the biological assumptions of fisheries science in order to create more accurate and cooperative management paradigm.

In the following chapter I will provide much needed background information regarding the environmental change event at Kah Shakes that will be the focus of the rest of this thesis.

CHAPTER TWO: THE EVENT AND CONTEXT

The example of Kah Shakes is complicated. The following is the background information and much needed context to understand the commercial sac roe fishing industry and the many people involved in the environmental change event at Kah Shakes.

I first became interested in the conflict at Kah Shakes as a research assistant for a larger project, North Pacific Research Board Project #728, *Herring Synthesis: Documenting and Modeling Herring Spawning Areas Within Socio-Ecological Systems Over Time in the Southeastern Gulf of Alaska* (Thornton et al. 2010). That project documented and mapped traditional ecological knowledge of historical herring spawning areas in southeast Alaska. I joined the research team already in motion. Knowing absolutely nothing about southeast Alaska, and even less about the herring that swim its waters, I scrambled to familiarize myself with the project.

The premise of the entire project can be boiled down to the fact that herring are one of the most important food fishes in the world: a “foundation and bellwether species

for North Pacific marine ecosystems" (Thornton et al. 2010:17). They "provide a key link between lower trophic levels (typically crustaceans and small fish) and higher trophic levels" (Carls 2008:2.2) such as humpback whales, dolphins, birds (gulls, scoters, eagles, ducks), seals, Steller sea lions, larger fish (shark, dogfish, salmon, cod, halibut), jellyfish, crabs, sea anemones, sea cucumbers, snails (Haegele 1993) and of course, humans. According to Brown and Carls (1998:1):

> Few species are of greater combined ecological and economic importance in Prince William Sound (and in many other coastal ecosystems) than is the Pacific herring, *Clupea pallasi*. Herring of all life stages are central to a marine food web that includes humpback whales, harbor seals, a large variety of marine and shore birds, bald eagles, jellyfish and other invertebrates, and an array of other fishes, such as Pollock.

The status of herring populations, namely measures of abundance or decline, is a litmus test for marine health.

Currently there is a great discrepancy and a heated argument being played out in southeast Alaska regarding the accuracy of measures of herring health. Fisheries biologists working for ADFG manage commercial herring fisheries in the region and maintain that stocks are healthy and economically productive, but there are plenty of local residents (fisher and non-fisher) and Native subsistence users (Tlingit and Tsimshian) who disagree with this assessment, whose traditional and local ecological knowledge of the herring describe a state of decline and project a possible collapse of the entire species in the near future. Mike Miller, a member of the Sitka tribe who both gathers herring eggs for subsistence and fished for herring roe commercially in the past,

relates both the ecological importance and alarming depletion of herring to the loss of buffalo experienced by the Native Americans on the Great Plains:

> I think [herring are]…really key to the different populations of fish here … [C]ompromise of the overall biomass it's definitely going to have a big effect on the salmon fisheries and the halibut fisheries and the marine mammals. … It's the key to the ocean it seems like. It's our buffalo (Miller, 2008).

Just as the once massive herds of buffalo were slaughtered for their hides, expansive schools of herring in southeast Alaskan waters are being harvested in mass quantities to fill a commercial market (largely Japanese) for their sac roe, the eggs that they carry to shore each spring during the spawning season. The disappearance of herring at Kah Shakes is considered by many Ketchikan residents to be a prime example of this type of overharvesting supported by inaccurate management techniques employed by ADFG whose fisheries managers were pressured to maintain high harvest levels by the fishermen who depend on the herring to make a livelihood. And initially, this appears to be the case, but there is more to the story.

But before discussing fish, it is important to discuss people – and the culturally constructed jigsaw puzzle(s) that have been overlain across southeast Alaska to create political and ecological rifts. There are two carving techniques at play. The first of these is purely political. Ketchikan is home to two Native groups, the Tlingit who occupy Ketchikan, Saxman and Cape Fox (Tongass or Taant'a Kwáan), and the Tsimshian who occupy Annette Island, the only reservation in southeast Alaska.

The Tlingit of the Tongass Narrows (see Figure 2) area, (known to the Tlingit as the Taant'a, Kwáan) adopted their name from their original home, Prince of Wales Island (Tàan, “Sea Lion). The name was applied due to the prevalence of sea lions along the western shores of the island and at Forrester Island, Southeast Alaska’s largest sea lion rookery. The Tlingit were largely displaced from Prince of Wales Island, however, by the Kaigani Haida, who colonized the southern portion of the island in the past two centuries. As a result, the Tongass Tribe, as they are also known, began moving eastward, first to Annette Island (now Tsimshian territory), where they established villages at Port Chester and Tamgas Bay (Ch'èix' Àani, “Thimbleberry Town”), and then to Tongass Island (Taagwaas') in Portland Canal, where they settled at Kadúk xuka (On the Cottonwood), and finally to Ketchikan (Kichxáan) on Revillagigedo Island, where they are centered today (Emmons 1991, Goldschmidt and Haas 1998, Thornton et al. 2010). The Tlingit of the Taant’a Kwaan, like other Tlingit and Haida tribes in southeast Alaska, were subject to (but did not sign) the Alaska Native Claims Settlement Act (ANCSA) in 1971 and were divided into two village corporations, the ANCSA-based Cape Fox Corporation (which includes Saxman), and the Ketchikan Indian Corporation with the latter receiving no land. The purpose of this agreement was to establish monetary autonomy to these villages, but at the same it extinguished aboriginal hunting, fishing, and marine rights. While the success of ANCSA is debatable (and not explored any further here), it does not create a separate governing body as a reservation would. Native members of these corporations are subject to federal laws and regulations provided by United States.

The Tsimshian tribe of Annette Island, in contrast, opted not to sign the ANSCA agreement, and instead retained the reservation sovereignty and government-to-government relationship that was established in 1891. The Annette Islands Reserve, defined as the Annette Islands in Alaska, is set apart as a reservation by section 15 of the Act of March 3, 1891 (26 Stat. 1101, 48 U.S.C. sec. 358), and includes the area identified in the Presidential Proclamation of April 28, 1916 (39 Stat. 1777), as the waters within three thousand feet from the shore lines at mean low tide of Annette Island, Ham Island, Walker Island, Lewis Island, Spire Island, Hemlock Island, and adjacent rocks and islets, and also the bays of said islands, rocks, and islets.

Members of both Tlingit and Tsimshian groups harvest herring commercially and for subsistence purposes, which brings us to the second culturally constructed overlay: the management boundaries of the herring fisheries. Tlingit commercial fishermen are required to file for state permits subject to regulation by ADFG while the Tsimshian operate and regulate their own herring fishery, both for commercial and subsistence purposes. ADFG management areas are based upon single stock management techniques (Murawski 2000), as opposed to ecosystem management principles. Based on these stock determinations, ADFG has divided Southeast Alaska into six commercial herring management areas regulated by catch method (winter bait, gillnet, purse seine, pound) and product (sac roe, bait/food): Seymour Canal, Revillagigedo Channel (which includes Kah Shakes), Lynn Canal, Sitka Sound, Hobart/Houghton and West Behm Canal (ADFG 2008). When Tlingit commercial gillnet sac roe fishermen apply to ADFG for state

fishing permits, they are allowed to fish only in those areas managed by that department. Tsimshian commercial gillnet sac roe fishermen apply to their own fisheries department at Metlakatla on Annette Island and are restricted to a fishing boundary three thousand feet from the shoreline of Annette Island as identified in the 1916 Presidential Proclamation mentioned above. Unfortunately, neither of these boundary schemes reflects an accurate natural history, biology and migration of herring across the oceanscape.

There are also social and political divisions within the Ketchikan population that must be contextualized. I visited Ketchikan twice to conduct interviews as part of my fieldwork. Herring are at the heart of this community. Ketchikan is a city embellished with tourist shops and boardwalks structured to receive massive cruise ships that swell the population of 14,070 by the thousands for most days from Memorial Day through late September. At heart however, Ketchikan is a fishing community. The residents are buffeted by harsh winters and summers measured by liquid sunshine, reliant upon an unpredictable ocean and their own determination. Everyone lives by the ocean, many live *on* the ocean fishing the waters commercially or for subsistence in, around, and beyond Ketchikan, throughout southeast Alaska.

Everyone has some relationship to herring. Commercial fishermen harvest large quantities either in the winter (these are used to supply halibut and salmon fishermen with bait), or the spring (herring eggs/sac roe/roe, are the target at this time of year. Female herring are caught right before they spawn, the eggs are removed and sold, usually to the

Japanese market where the roe is considered a delicacy). There are subsistence fishermen, who harvest herring for their flesh, but also submerge kelp or branches in herring spawning areas to collect the eggs which are then dried and eaten. There are also Alaska Natives of Tlingit and Tsimshian heritage, sports fishermen (who often run local guide businesses that cater to tourists looking to catch salmon, halibut and other 'big game' fish), and local residents who are retired commercial fishermen, related to commercial or subsistence fishermen, or who fish locally for their own consumption.

Commercial herring fisheries are an economic staple. The impacts of a closure or the collapse (when fish fail to return to a spawning location in sufficient quantities to open a fishery) of a commercial herring fishery can be detrimental to the entire region. The voluntary organization of commercial and subsistence fishermen and local residents into the Ketchikan Area Herring Action Group (hereafter known as the Herring Coalition) in 1993, whose sole purpose was to close the commercial herring fishery at Kah Shakes and who took legal action to do so in 1994, is no small event.

Andy Rauwolf is co-founder of the Herring Coalition along with Terry Kline, Lawrence 'Snapper' Carson and John Harrington. I first 'met' Andy online in a byline. Sitnews, an internet-based publication, had published a series of articles co-authored by Andy, Harrington, and Carson in 2004 describing the disappearance of herring and ultimate closure of the commercial fishery at Kah Shakes. This news in itself is, unfortunately, unremarkable as many of the commercial fishery management areas in southeast Alaska (Lynn Canal, Auke Bay, etc.) have closed due to the decline or

disappearance of herring populations. What caught my interest was the vehemence with which Andy and his co-authors accused the ADFG of succumbing to economic and political pressures, altering management data to maintain harvest quotas and the bank accounts of commercial fishermen. They wrote:

> Ample evidence suggests that ADF&G's [sic] field supervisors have made several decisions under pressure from the industry that have allowed overfishing on most occasions, opened the fishery when it was below a harvestable threshold on at least two occasions, depleted discrete herring stocks, created a mixed-stock fishery, manipulated data and testimony in public and before the Board of Fish in an attempt to cover up the mismanagement and loss of a huge resource with unknown consequences to the ecosystem in greater Dixon Entrance, Boca de Quadra, Portland Canal, Kah Shakes, East Behm Canal, Revilla Channel, and the Cat, Duke and Mary Island chain (Rauwolf et al. 2004).

It is no surprise that ADFG did not take kindly to these accusations. In fact, the department still maintains that although Kah Shakes remains closed, the herring population is healthy, the fish have moved and are currently spawning in Annette Island waters. Scott Walker, the current fisheries biologist in Ketchikan with whom I spoke at length and who provided me with spawning maps, graphs, tables and Powerpoint presentations describing herring movement in places other than Kah Shakes, predicts that they will return to their more traditional spawning grounds at Kah Shakes sometime in the future:

> I know that probably within my lifetime, those herring will move back out of Annette Island and then we'll have fisheries again [at Kah Shakes]. But right now, … that stock is predominately spawning in Annette Island waters (Walker 2008).

Perhaps Walker is right. But many local residents disagree with this assessment. The fact is, nobody really knows. Scientific data regarding spawning behavior of herring at Kah Shakes and the surrounding waters of the Revillagigedo Channel are temporally shallow. Systematic survey and data collection largely began in 1976 when ADFG began operating herring roe fisheries at Kah Shakes. But large scale herring operations precede this date by almost 100 years, particularly reduction plants that extracted herring oil and produced fertilizer and meal (farm animal feed, but check your dog food label too) (Thornton et al. 2010). Current fisheries management paradigms calculate harvest quotas (the number of tons that can be caught each fishing season) that maintain the productivity of a baseline biomass first measured in the 1970s, but many Ketchikan residents describe declining herring populations beginning in the 1920s. According to Martin Perez, Sr., a 92 year-old Native Tlingit and commercial fisherman, "People won't believe when you tell them how much herring used to be around…. [You could] go up in any harbor where you anchor and you … [could] jig herring with treble hooks and you'll get 'em for eating, just jigging them" (Perez 2009).

Unfortunately, ADFG regards these descriptions as anecdotal. In 1993, the Herring Coalition collected more than fifty-seven written affidavits from local residents concerned that the commercial sac roe fishery at Kah Shakes was harming the herring populations and requested a closure of the fishery until further scientific research could verify the sustainability of ADFG management techniques. The court denied these pleas

citing a lack of 'biological emergency.' Commercial fishing continued at Kah Shakes each spring until 1998 when the herring failed to return. And they have not returned.

Kah Shakes Cove is the location of one of six commercial herring fisheries managed by the ADFG throughout southeast Alaska. The Kah Shakes management area (Section 1-F) had supported a gillnet sac roe fishery since 1976, suffered one closure in 1990 due to low threshold (a lack of fish to catch), reopened in 1991 and has remained closed since 1998 again, due to low threshold.[4]

The sac roe harvest occurs in the spring and includes gillnet, purse seine and, more recently, spawn-on-kelp or 'pound' fisheries (see Chapter Three for more on this). The target of these fisheries is not the meat of the fish, but rather the eggs.

[4]From 1976 through 1991, the sac roe fishery conducted at Kah Shakes Cove every spring was known simply as 'Kah Shakes.' For clarification to the reader, and for reasons to be explained below, the name of the fishery was changed to the Kah Shakes/Cat Island fishery and was then formalized into the present Revilla (Revillagigedo) Channel fishery. While the name has changed over time, many informants still reference the fishery as Kah Shakes, and I will do the same.

Figure 3: Herring Spawn at Crab Bay Flats on Annette Island. Note the milky white clouds of herring eggs and sperm along the shoreline. *Photo courtesy of Hap Leon*.

Herring are a migratory fish that arrive from the depths of the ocean in enormous schools each spring, usually during late March and early April, to spawn in shallow coastal waters. The target of the sac roe fisheries is the female herring, laden with eggs that she will disperse on tidal floor substrates (kelp, seaweed, etc.). Once the eggs are deposited, the male herring passes over to release sperm (also called milt) that will fertilize these eggs. Spawning herring are highly visible from both the shore and from the air, the milky white eggs and sperm appearing like underwater clouds that often extend along miles and miles of coastline (see Figure 3).

Figure 4: To Catch a Herring

Most commercial sac roe fisheries in southeast Alaska are open to purse seine boats, a catch method that utilizes a large net that encircles the fish and is then drawn closed at the bottom, or 'pursed.' This net is fitted on one side with many colorful bouys, the float line. The other side of the net is weighted and will sink when released into the water. This is called the lead line. When a herring school is located, the net, which has been stacked on the deck, is released into the water while the boat travels around the fish, enclosing them for capture. A power skiff holds one end of the net stationery while the boat closes the circle. Once the fish have been encircled, the purse line is pulled closed and the net is drawn to the side of the boat using a hydraulic power block, also called a winch. The herring are then either transferred to the boat's hold, or more often, loaded aboard another boat called a tender using a fish pump. The fish are then transported to fish processing plants where the roe is removed and sold to consumers.

The Kah Shakes herring fishery does not permit this method of catch. Instead, commercial fishermen employ a gillnet to harvest herring. Similar to the purse seine net, a gillnet is a large net with both a float line that stays above water and a weighted lead line that sinks. A gillnet, however, does not close at the bottom. It is simply placed in the path of the migratory fish traveling toward the shore to spawn. These nets target a certain, usually larger, size of fish. As the fish swim into the net, the larger ones will become entangled or 'gilled' in the mesh. Once the fish have been gilled, the net is pulled back into the boat by either a bow picker, or stern picker, large drums on either the bow or stern operated by large hydraulic motors. Herring are then picked by hand from the net and transported to tenders nearby.

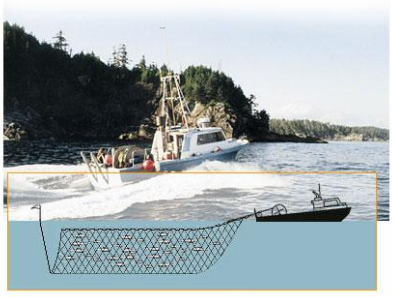

Image of a gillnet boat. http://www.goldseal.ca/wildsalmon/harvesting.asp

This is how the fishery at Kah Shakes had been conducted every year since it first opened in 1976 until 1990 when the fish did not return to Kah Shakes in sufficient quantities to open the fishery. In 1991, the herring arrived offshore and test sets were done, but numbers were low and fish behavior was erratic. There had been no fishery the year before, a loss of income for herring fishermen. Two years of lost income would leave many herring fishermen hurting.

This is where the “event” in question begins.

On March 28, 1991, the day dawned gray and heavy with expectation. A fleet of seine boats swayed gently in the Ketchikan harbor. The gentle rhythm of their empty bellies rocking in the harbor belied the static energy of the fishermen. Perched on their radios, their nerves crackling with each new transmission, the waited for the ‘ready’ to be broadcast by ADFG personnel, the signal that the annual herring gillnet sac roe fishery at Kah Shakes would soon open for harvest.

ADFG had begun monitoring spawning activity at Kah Shakes on March 6 and continued to conduct aerial surveys through March 17. Hydro-acoustic surveys by ADFG personnel aboard the R/V Sundance began on March 18. According to these hydro-acoustic surveys, herring were present in the deeper waters of the Kah Shakes area through March 27, but no active spawning had been observed (see Chapter Four for a full description of survey techniques). “It was obvious by this time, that the spawning behavior of the herring at Kah Shakes was very different than in previous years. Of primary concern was the delay in spawning; in the previous three years the spawning had

occurred much earlier" (ADFG 1991:6) (see Table 1). The department noted that the weather that March had been very poor and attributed the delayed spawning behavior to the unusual weather.

Table 1: ADFG Documented Herring Spawning Dates at Kah Shakes (ADFG 1992)

YEAR	Date of First Spawn	Date of Last Spawn	Opening Date	Closing Date
1976	31-Mar	N/A	2-Apr	2-Apr
1977	29-Mar	4-Apr	1-Apr	1-Apr
1978	30-Mar	5-Apr	4-Apr	5-Apr
1979	27-Mar	1-Apr	29-Mar	31-Mar
1980	23-Mar	4-Apr	25-Mar	29-Mar
1981	19-Mar	6-Apr	20-Mar	26-Mar
1982	18-Mar	7-Apr	26-Mar	31-Mar
1983	22-Mar	8-Apr	24-Mar	25-Mar
1984	27-Mar	6-Apr	29-Mar	31-Mar
1985	26-Mar	8-Apr	29-Mar	30-Mar
1986	31-Mar	5-Apr	31-Mar	1-Apr
1987	26-Mar	1-Apr	26-Mar	27-Mar
1988	23-Mar	2-Apr	25-Mar	25-Mar
1989	18-Mar	8-Apr	20-Mar	21-Mar
1990	N/A	N/A	N/A	N/A
1991	31-Mar	13-Apr	8-Apr	11-Apr

As the fishermen watched another sun sink below the horizon, so did their hopes of a commercial opening. The weather had become unpredictable and with it, the behavior of the herring. Despite this, ADFG announced that Kah Shakes would be put on thirty-six hour notice meaning in thirty-six hours, the fishermen should be prepared to fish.

On April 4, 1991, the herring finally made a move. Spawning was observed along the shores of Kah Shakes. Anticipation of the opening signal rose even further. Gillnet samples indicated that the roe maturity had reached 11.4%. The opening of the fishery

was imminent. But wait! Suddenly the number of fish at Kah Shakes began to decline, information that could not have been received well by the commercial fishermen. The sudden decline of herring at Kah Shakes put ADFG calculations in danger of falling short of the 5000-ton threshold needed to open the fishery. If the herring failed to spawn in sufficient levels at Kah Shakes, the guideline harvest level (GHL) of roe, set at 680 tons this season, would be off-limits to commercial harvest, and it would be another year of lost income for commercial fishermen.

Then, the herring did an unprecedented thing. They began to move offshore. Aerial survey and observations made by commercial fishermen revealed that herring had begun to spawn approximately 12 miles west, at Cat Island. As a result, ADFG personnel began conducting dive surveys on the spawning activity at Cat Island. During the next two days, spawn density and shoreline activity increased from three miles of spawn to six.

> The department kept the commercial gill net fleets apprised of the spawning occurring in the Cat Island area. There were many opinions expressed that the area should be opened to the gill net fleet; many fishermen were convinced the Kah Shakes herring had shifted to the Cat Island area. Up to that time, department staff had not given much thought to moving the fishery to Cat Island because there were still schooled herring in the deeper waters at Kah Shakes (ADFG 1991:7).

Add this information to the mix: the herring at Annette Island exhibited similar behavior that year, had hung around offshore for a few days, made some motions that they would spawn, and then headed toward Cat Island. Annette Island biologists monitoring herring within their jurisdiction were also left with empty nets. And there sat Cat and Dog

Islands, encircled by herring spawn, outside management areas for both ADFG and Annette Island fishermen.

In response to these spawning observations made by commercial fishermen, ADFG personnel conducted a skiff survey at Cat Island. Egg deposition was 'very heavy.' Aerial survey showed over seven miles of spawning activity. Based on this information, ADFG concluded that:

1) The intense spawn at Cat Island was representative of the biomass that had been observed at Kah Shakes

2) The continuing poor weather may have caused the herring to shift spawning location

3) The Cat Island was close, approximately 10 miles away

4) The spawning activity at Cat Island had started to diminish and if the registration area was not modified, the fishery would be lost for the year

5) Although other 'non-Kah Shakes stocks' may be present in the spawning population, no other spawning stocks of that size had ever been documented in the immediate area.

Given these factors, the department filed an emergency order with the Board of Fisheries requesting permission to alter the commercial gillnet fishery area to include "that portion (between Point Sykes to a distance two nautical miles from the shore:) south and east of a line from Point Sykes to Twin Island Light to Form Point and north of a line from Form

Point to Foggy Bay" (ADFG 1991:14), an area that encompasses Cat and Dog Island (see Figure 5).

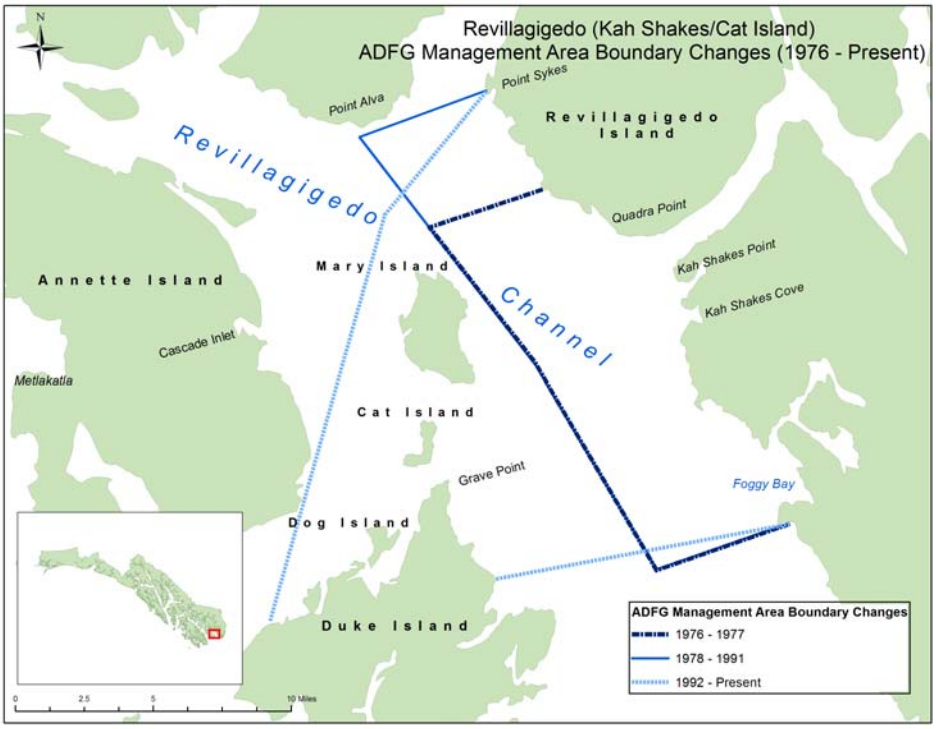

Figure 5: ADFG Management Boundary Changes (1976 – Present). The Annette Island Reservation Boundary (not illustrated) encompasses an area 3,000 feet from the coastline of Annette Island.

Meanwhile, an aerial survey revealed spawning activity (200 yards) at Kah Shakes. "However, department staff were still convinced that the major spawn had occurred at Cat Island" (ADFG 1991:8). The request was granted. By doing so, ADFG gained permission to add spawning masses found at Cat Island to the dwindling numbers already found at Kah Shakes. The 5000-ton threshold was finally met and the commercial fishermen readied their nets eagerly to fish, for the first time, at Cat Island, as well as Kah Shakes.

The neighboring fishing community at Annette Island was furious. Fisheries biologists at Annette Island had been concurrently monitoring and choreographing their own commercial gillnet herring fishery within their own waters, a distance of 3,000 feet offshore. During a phone interview, Dustin Winters, currently the fisheries biologist for Annette Island, and a commercial fisherman at the time of the 1991 Kah Shakes boundary change, explained how poor weather conditions had prevented the herring from spawning at Crab Bay Flats in Cascade Inlet:

> Weather was an issue: a northeast [wind] was blowing so the fish moved off. Like I said, you know, we need to have fairly calm water before they can spawn. At the same time, they're not going to hold out. When they need to spawn, they're going to spawn. So what happened when that northeast hit, all the fish started moving to the south and they ended up going to the closest place that has calm water which would be on the leeside of those islands [Cat Island], which would be you know, five miles away, or four miles away from our shores. And they started spawning there. And we had the whole fleet was ready to fish on our shore and it never happened. So we couldn't—once they're past 3,000 feet, we can't touch them.

The response by the Annette Island fisheries management team was immediate. Annette Island fisheries biologists approached department personnel to present evidence that the fish found at Cat Island migrated from Annette Island, not Kah Shakes. They argued that when ADFG decided to include Cat Island as part of the State commercial fishery boundary, they opened up harvest on a stock of fish that, under normal circumstances, would have spawned within Annette Island jurisdiction.

The following is a brief description of the events surrounding the Kah Shakes 1991 boundary change as explained to by Hap Leon, fisheries biologist at Annette Island

from 1977 to 2005. Leon describes the survey techniques and tracking measures employed by himself and his staff on Annette Island in 1991:

> I was on Annette Island 1990 [Leon corrects the date to 1991 later in the interview] and we had a lot of herring there at the beginning of the season and we brought the [Annette Island] fleet out. And oh, about the time we brought the fleet out the weather kind of went bad on us and it stayed bad on us, oh, on-and-off for a week or so. And then the weather mellowed out and we thought, 'Oh, ok now we'll be able to fish here pretty soon,' but you know we were not seeing the fish. And then you know, we waited a couple of days and the fish came in, they were close to the beach. And we were all ready to open the fishery and then the weather went bad again on us. … We were getting like 6 and 7-foot seas right on the spawning grounds. And long story short, the herring backed off the spawning grounds and they went and spawned at Cat Island. And I mean, it happened all inside of about a day. Like the very next day, they were spawning at Cat Island. And I don't have any—well, almost no doubt in my mind that it was the same fish. I mean, all they had to do was move about three or four miles away from Annette, well not just from Annette Island but from where we saw them to get to Cat Island.
>
> And the biomass, we actually went over and did a spawn survey at Cat Island, even though it was in state waters. We put divers in the water and did a spawn survey there and the biomass that had spawned there, it was a couple thousand, it was 2,000-some odd tons and what we were seeing on Annette was 2,000-some odd tons that was gone. So what we concluded was yeah, those fish moved off of Annette Island and they spawned at Cat Island just to get out of the weather. I mean, it was close. And they don't know that one is a reservation and one is state waters, they're just trying to find somewhere to spawn. They were ripe and they were ready to go and they had to spawn (Leon 2008).

According to Leon, the fish that spawned at Cat Island, the fish that ADFG sought to harvest by expanding the state management boundary, were intending to spawn on the shores of Annette Island, but due to rough weather conditions, found calmer waters along the shore of Cat Island.

Prior to the start of the fishery, several representatives of the Annette Island Natural Resource Council came aboard the ADFG survey vessel, the R/V Sundance, to formally protest the fishery at Cat Island, all to no avail.

On April 8, 1991, major competition for the sac roe fishery began. At 10:45 am, ADFG opened the expanded commercial fishery. Two gillnet boats from the Annette Island fleet, without State permits began fishing in open defiance. Fish and Wildlife Protection officers confiscated these two boats and the fishermen were reprimanded.

Despite the protestations of the Annette Island Fishery Reserve representatives, the gillnet fishery at Kah Shakes continued until 6:30 p.m. Only 280 tons of the 680 tons GHL had been reached. Plans were made by ADFG to open the fishery again the next day, and if spawning activity continued at Kah Shakes, the fishery would be moved back to the traditional area. “This decision was reached, in part, because of the increased spawning at Kah Shakes (approximately one half mile). It was also apparent that the spawning and the amount of herring in the Cat Island area was diminishing” (ADFG 1991:8).

On April 9, the gillnet fishery opened once again at 10:30 a.m., this time at Kah Shakes. The fishery closed again that afternoon due to hazardous weather conditions. Eighty more tons of herring had been harvested, but still the GHL had not been reached. The gillnet fishery opened again on April 10 at Kah Shakes. Two hundred and forty tons of herring were harvested.

The gillnet fishery opened one more day, on April 11. Sixty tons of herring were harvested bringing the total tons of herring harvested to 660, 20 tons short of the GHL.

The fishery is considered a success by ADFG, but many local residents, fishermen and Natives are critical of the boundary change. Some critics like Ben Fleenor, a salmon fisherman and Ketchikan resident since 1942, accuse ADFG of improper management techniques.

> The ongoing controversy concerning the management (mismanagment) of herring stocks bring to my mind certain problems relating to the actions of the State Department of Fish and Game personnel. This must be the largest and most powerful of the many State bureaucracies and it seems accountable to no one. Even our most powerful legislators are unable or unwilling to get involved with problems of inappropriate behavior, even malfeasance regarding actions of this department and individuals therein.... I find it incredible that Fish and Game continue to pursue this fishery into oblivion (Fleenor 1993).

Many attribute the ultimate closure of the Kah Shakes fishery in 1998 to the boundary change made by ADFG in 1991. The following is a description boundary change as explained by three members of the Ketchikan Area Herring Action Group, Andy Rauwolf, John Harrington, and Lawrence “Snapper” Carson, as it appears in an article published by Sitnews, an online news resource, on April 1, 2004. According to the authors, since the introduction of sac roe fishing in 1976, the Kah Shakes fishery is only one of the many herring sac roe fisheries that have failed to open due to inability to meet threshold as a result of overharvesting permitted by the Alaska Department of Fish and Game.

> By 1980, West Behm Canal collapsed followed by Auke Bay, Lynn Canal, Kasaan Bay, Zimonia Straits, Duncan Canal, Hydaburg, Tokeen, Keku Strait,

> Farragut Bay, Port Houghton, Stephens Passage, Port Pybus and Gambier Inlet, Seymour Canal, Angoon, Hoonah, Idaho Inlet, Tenakee and several others (Rauwolf et al. 2004).

The sequence of events that lead to the ultimate closure of the Kah Shakes fishery in 1998 is thought to have begun in 1989 when "ADF&G allowed a fishery to proceed on a spawning biomass of herring that was 1,212 tons below the minimum threshold level of 5,000 tons, below which no fishery is supposed to occur." The following year:

> In 1990, ADF&G closed the Kah Shakes fishery due to the low projected threshold as determined by their 1989 spawn deposition surveys. However, the biomass of herring that ADF&G recorded after the 1990 season was much greater than their forecasted biomass which angered the fishermen who were not allowed to fish (Rauwolf et al 2004).

Hap Leon made a similar comment:

> It was [19]89 they [ADFG] didn't get enough spawn [to meet threshold at Kah Shakes], so 1990 they didn't fish. But then in 1990 they got some spawn and I didn't see the analysis, but I guess they came up with a biomass estimate that was big enough that it allowed for a fishery in [19]91. And they brought the fleet out there in [19]91, you know, early in the season and people waited and waited (Leon 2008).

He was hesitant to comment on any additional motives that may have contributed to the boundary change at Kah Shakes, but he did say this:

> I can sort of speculate about what all went on but as I understand it, the—Phil Doherty who was then the area management biologist for Fish and Game, that he announced to the fleet that they couldn't fish over there because that was not in the legal area that was outlined by the Board of Fisheries for the Kah Shakes fishery. I mean it was state waters but it wasn't in the right boundaries. And somebody called somebody and somebody called somebody, and eventually it gets up to Juneau and Phil got a call from Juneau, or somebody communicated with somebody and they got back to Phil that it's ok, you can go ahead and open

> at Cat Island. So they moved their whole fishery from Kah Shakes across the Revillagigedo Channel, which is I think is about 15 miles or so, to Cat Island (Leon 2008).

Leon alludes to the pressures placed upon ADFG by commercial fishermen eager to open the fishery but the authors of the Sitnews article spell out the pressure the commercial fishermen placed on the department to open the fishery in 1991.

> On April 7th, under pressure from the fleet, an ADFG field biologist was heard to say on the radio, "Hold on, we'll get you guys some fish." They then conducted a skiff survey at Cat Island and concluded that these were Kah Shakes herring. No scientific evidence supported this conclusion; it was based solely on weather conditions, lack of big schools on their depth finders at Kah Shakes, and fear that the fishery would be lost for the year (Rauwolf et al. 2004).

Determined to conduct a fishery, ADFG filed an emergency order to expand the boundary of the Kah Shakes fishery to include the biomass at Cat Island. According to Rauwolf, co-founder of the Herring Coalition:

> At that moment, ADF&G violated three of its own rules. They conducted a sac roe fishery outside of the designated legal boundary with no data or history of the area, they opened a fishery in which two separate agencies [ADFG and Annette Island] could be targeting the same stock of herring and they allowed a fishery on a mixed-stock which is a spawning biomass originating from more than one discrete stock. Conservative management was tossed out the window. No sooner had they started fishing at Cat Island than they were informed of herring spawning at Kah Shakes thirteen miles to the east. Only 280 tons were harvested by 6:30 PM at Cat Island. With spawning decreasing at Cat Island and increasing at Kah Shakes, the decision was made to move the fleet back across to Kah Shakes. It took three days, April 9th, 10th, and 11th for 86 boats to catch another 380 tons for a total of 660 tons between Cat Island and Kah Shakes which was still 20 tons short of the 680 ton quota that ADF&G had set for Kah Shakes alone and a whopping 33% of the spawning biomass! (Rauwolf et al. 2004).

Because the Kah Shakes boundary had been expanded to include Cat Island under an emergency order filed by ADFG, the change could not be considered permanent until reviewed and voted upon by the members of the Board of Fisheries. Rauwolf continues:

> Later that year, [in 1991] ADF&G submitted a proposal to the Board of Fish[eries] to extend the Kah Shakes boundary to include Cat Island, along with a thirty-one page briefing document filled with data that the average board member would have difficulty understanding, in order to justify their actions. The request was granted. By now, it was apparent to many that ADF&G was more concerned about their jobs than they were the conservation of the resource (Rauwolf et al. 2004).

A sentiment that appeared to be validated when the following year, in 1992, when herring failed to spawn at Kah Shakes. They also failed to spawn at Annette Island.

Herring did, however, return to Cat Island. Because ADFG had requested that the Board of Fish make the expanded management boundary a permanent alteration, fishermen with state permits were allowed to harvest 1246 tons of sac roe from Cat Island, 46 tons above the 1200 ton quota.

Many local residents, including some fishermen, were outraged and fearful that continued overharvesting at Kah Shakes and Cat Island would cause what appeared to them to be an imminent collapse of the herring population. Maxine M. Mason, an Alaskan resident since 1955 made this plea: “If there is to be any hope of replenishing the herring - roe [sic] fishing must be stopped now” (Mason 1993).

Charles H. Zieske, an Alaskan resident since October 1949 and a retired commercial fisherman, made a similar statement regarding not just the Kah Shakes fishery, but all sac roe harvest: “[I]t is my opinion that all commercial herring harvests in

Southeast Alaska should be put under (at least) a lengthy moratorium" (Zieske 1993). The number of individuals in the Ketchikan who shared these sentiments was so great that it fueled an organized effort to place a moratorium on the commercial sac roe fishery at Kah Shakes and Cat Island.

To this purpose, the Ketchikan Area Herring Action Group (Herring Coalition) was formed in 1993. That same year, the Herring Coalition, with assistance from the Metlakatla Indian Community, presented a formal proposal to the Board of Fisheries requesting that the expanded boundary at Kah Shakes and Cat Island be returned to its original configuration in order to preserve what the Herring Coalition and its members perceived as a declining number of herring in and around Ketchikan. The Board, in consultation with those very fisheries biologists who expanded the boundary in the first place, declined the motion presented by the Herring Coalition to reinstate the original boundary, a conundrum regarded by some as "foxes guarding the henhouse" (Rauwolf 2008).

Working with a sense of urgency, and unwilling to wait for the next round of Board of Fisheries meetings to submit another round of proposals, on March 19, 1993, the group filed a legal injunction requesting that the Court implement a restraining order that would close the fisheries not only at Kah Shakes but also at Sitka Sound until "a complete review of the resource has been considered at next year's board meeting" (Chase 1993a:1).

The case was reviewed by Superior Court Judge Larry Zervos who ruled that the "plaintiffs did not show irreparable harm to support a restraining order. Also, the plaintiff would have to provide a bond for the entire economic loss of the herring fisheries" (Chase 1993b:A-1): an estimated 10 million dollars. The sac roe fisheries opened in April of 1993. Fisheries biologist Phil Doherty was quoted in the *Ketchikan Daily News* as saying, "It looks like we're going to have a real healthy herring population for the next few years" (Miller 1993). The Herring Coalition, however, feared an imminent collapse.

The Herring Coalition filed another proposal (#342) at the 1993/94 Board of Fish meeting requesting a reversion of Kah Shakes management boundaries to the pre-1991 configuration. The Metlakatla Indian Community also asked that the boundary be reverted to the previous extent. The "board [Board of Fish] deemed there was no biological emergency" (Chase 1993b) and the proposal was declined.

That same year, the Herring Coalition and the Metlakatla Indian Community, sensing the urgency of the situation and not willing to wait until 1996 when the Board of Fish would again hear proposals regarding commercial herring fishing at Kah Shakes, jointly filed a permanent injunction to stop commercial sac roe fishing at Kah Shakes and Sitka Sound (the Southeast Alaska Herring Seiners Marketing Association joined these defendants later) until a complete review of the ecological evidence could be conducted by ADFG and "until stocks are restored to 1982 levels" (Chase 1993b:A-1). The plaintiffs cited a community-shared concern that the Kah Shakes/Cat Island fishery consists of mixed stocks, some of which originate from Annette Island, and that state

herring management threatens the sustainable yield of herring in the Kah Shakes area (Bowlen 1995). The injunction:

> [enjoined] the defendants [the state of Alaska, state Board of Fisheries, state Department of Fish and Game and former Fish and Game Commissioner Carl Rosier], from authorizing a herring sac roe fishery in the vicinity of Cat Island, Dog Island and Graves Point until such time as the defendants demonstrate that a fishery can be conducted without adverse impact upon one or more herring stocks located in the fishery waters (Bowlen 1994:A-1).

Court hearings were held in March of 1994 where Superior Court Judge Larry Zervos declined to stop the 1994 fishery but did allow the lawsuit to go forward. A trial was scheduled for May 30, 1995.

Despite this, the lawsuit was dismissed in March of 1995 following an adjunct agreement made between the Metlakatla Indian Community and ADFG to transfer ownership of Warburton Island, an island whose ownership has been disputed since a 1991 Bureau of Land Management survey included the island within the boundary of the Annette Island Reserve, from ADFG to Metlakatla (Bowlen 1995). Rauwolf puts it this way: “The state managed to buy off the Reserve by offering them Warbutton [sic] Island, the subject of a territorial dispute” (Rauwolf 2003:1).

Leon also commented on the settlement:

> And then later on, I think it was later on that year, you know the lawsuit was still outstanding and the community and the state settled on that lawsuit based on a whole other issue about drawing boundaries throughout the reservation and enforcement and other things. So the community agreed to drop the lawsuit and I guess their incentive, as far as the court was concerned, their incentive was this how the boundary lines are drawn, but they were also more willing to go for that

> settlement because they got their herring back. [Inexplicably, the herring returned to spawn at Annette Island in 1992] (Leon 2008).

The Herring Coalition, unable to pursue the lawsuit for lack of funds, was forced to drop the case. The Kah Shakes commercial fishery, now officially referred to as the Revilla Channel commercial fishery, continued to produce a herring harvest within the expanded management territory until the 1997 season when only 616 of the 636 ton quota were caught. The fishery closed in 1998 and has remained closed due to low threshold and an absence of herring spawn. Annette Island continues to conduct a commercial sac roe fishery each spring to this day.

Now that I have presented the event and its context, I will begin my analysis by presenting an enhanced event ecology that includes discourse theory. I will describe the three discourses (management, LEK and environmental) that are integral to the identification of coincident and dissident data that must be compiled and reconciled to achieve a more holistic and sustainable herring fishery.

CHAPTER THREE: EVENT ECOLOGY AND DISCOURSE THEORY

In this chapter I will present an enhanced event ecology of the disappearance of Kah Shakes herring spawners, including discourse analysis. I have modified this approach for the purpose of this study by integrating discourse analysis. I will show how the patterns of individual narratives describing the environmental change at Kah Shakes can be classified into larger discourses (in this case local ecological knowledge and management) and how these discourses can be used as comparative units to identify both similar (coincident) data, the environmental (natural history and biology) narrative of the Pacific herring, and dissimilar (dissident) data. Clarification of the environmental discourse and reconciliation of the dissident discourses will facilitate explicit dialogue between the managerial and LEK discourses focused on the creation of more sustainable fishing practices.

The Analytical Tools

Political ecology is a multidisciplinary field defined by the school of thought that the researcher identifies with. “Anthropology, sociology, geography, biology and political science, have embraced political ecology as an approach that addresses the concerns of both political economy and cultural ecology” (Gexon and Paulson 2005:1). Each field defines political ecology a bit differently, each emphasizing differing degrees of political activism and Marxist ideas of distribution of rights and resources, but a general definition offered by Forsyth is the explanation of “environmental problems as the phenomenological interaction of biophysical processes, human needs and wider political systems” (Forsyth 2003:3). Though definitions of political ecology vary, the field itself has grown from intellectual roots in the 1970s when issues of political economy and ecology were first addressed in the context of environmental movement (Paulson et al. 2005).

Political ecological practices as they were formulated in the 1970s were a reaction to the apolitical environmental determinism and cultural ecology of the 1950s and 1960s (Robbins 2004). Andrew Vayda and Roy Rappaport (1967) were the first to turn away from Steward’s model of cultures as comparable units and develop an “ecosystems model that treated human populations as one of a number of interacting species and physical components” (Paulson et al. 2005:20). At the same time, during the 1960s, Aldous Huxley (1963) and Rene Dubos (1964) began to explore how ecological relationships

could be used to better understand environmental change. The intersection of thought between these two fields marked a paradigmatic shift in what political ecology has become today; from past conceptualizations of small, homeostatic, subsistence communities in equilibrium with their physical environment, toward critical analyses linking culture, power and ecology that integrate concepts of non-linear equilibrium, maladaptation and disruption (Paulson et al. 2005).

Since the 1970s, political ecologists have sought to lay bare the political implications of environmental change by focusing analyses on the identification of power relations as causal factors (Escobar 1999). Some say the pendulum has swung too far in this direction (Vayda and Walters 1999, 2009), as too often researchers approach the analysis of environmental change only to describe the political processes rather than the ecological implications; a "politics without ecology" (Bassett and Zimmerer 2004: 103). Others have argued the opposite (Robbins 2004, Peet and Watts 1193), that "the accusation of 'politics without ecology' is an exaggeration" (Walker 2005:76). For example, Bryant and Bailey offered this critique in reference to political ecological practices in developing, or Third World countries:

> Political ecologists tend to favor considerations of the political over the ecological… It is true that political ecologists ought not to ignore advances in the understanding of ecological processes derived from the 'new ecology,' since, in doing so, they might miss an important part of the explanation of human-environment interaction…. Yet greater attention by political ecologists to ecological processes does not alter the need for a basic focus on politics as part of the attempt to understand Third World problems (1997: 26).

The most outspoken critics of this notion of political ecology without ecology are Vayda and Walters (1999, 2009). They argue that that current practices in political ecology "prioritize politics and power relations in explanations of human-environment relations" (Vadya and Walters 538:2009) (Simmerer and Basset 2003, Walker 2005) and propose a balanced analysis of both political and apolitical factors of environmental change using a methodology they refer to as *evenemental* or *event ecology*.

Vayda first identified environmental change events in 1983 as a means to address the dynamism between culture, power *and* ecology using a method he called "progressive contextualization." Progressive contextualization requires researchers to focus "on significant human activities or people-environment interactions and then explaining these [resource and ecosystem] interactions by placing them within progressively wider or denser contexts" (Vayda 1983: 265). Building upon this framework, Vayda and Walters again brought forward this methodological approach in 1999 in the form of event ecology to favor a more contextualized understanding of environmental change events and their causes while bringing to the forefront the focus on ecosystem dynamics.

Event ecology is an open-ended analytical approach to environmental analysis that is not structured by one theory or model, requiring the research to become an interdisciplinary practice that integrates myriad data sources, both social and biophysical, including but not limited to historical documentation, scientific literature, controlled experimentation, and semi-structured or structured interviews to fully describe the effects and identify all causes of environmental change.

> With event ecology, research is guided by open-ended questions about why specific environmental changes of interest (i.e. events) have occurred. It then seeks to explain such changes by making causal connections to prior events, in so doing constructing causal chains backward in time and usually outward in space from effects to causes (Vayda and Walters 2009:537).

Practicing event ecology, according to Vayda and Walters (1999, 2009), begins with the objective identification of an event or environmental phenomenon (e.g. the disappearance/movement of herring at Kah Shakes). Theoretical paradigms are considered only after a full understanding of the biophysical components of the environment in question has been reached.

> Rather than beginning actual research as directed by a hypothesis, model, or theory that presumes causal relationships in advance of field investigations, event ecology starts with concrete, describable, and sometimes empirically measurable environmental events of interest and seeks to explain these in terms of open-ended questions about why the events have occurred (Vayda and Walters 2009:540).

Unfortunately, the identification of 'concrete, describable' events is not the atheoretical practice that Vayda and Walters would like to suggest. The very definition of an environmental phenomenon is a subjective and sometimes contested practice as the situation at Kah Shakes clearly illustrates.

Vayda and Walters are aware that there may exist, multiple descriptions of one environmental phenomenon and that one description may not be more objective than the next, but fail to expound upon this observation (2009:541) and address issues of framing. "Different stakeholders … may frame events, and the processes behind them, quite differently in terms of their origins, development, magnitude and duration" (Thornton et

al. in review). But this oversight does not negate the methodological utility of event ecology. It is still useful, as long as one maintains an awareness of the political implications of event identification and boundaries in time and space, and one is prepared to examine environmental events not as the apolitical narratives that Vayda and Walters would like to portray, but as multidimensional discourses.

Every event is composed of multiple narratives or discourses (used interchangeably here though meanings of each may differ elsewhere). A discourse, according to Peet and Watts, is "a particular area of language use related to a certain set of institutions and expressing a particular standpoint.… Discourses vary among what are often competing, even conflicting, cultural, racial, gender, class, regional, and other differing interests, although they may uneasily coexist within relatively stable ("hegemonic") discursive formations" (Peet and Watts 1993:228). As defined by Maarten Hajer (2003), identifying an event can be a source of conflict, a "complex and continuous struggle over the definition and the meaning of the environmental problem itself" (Forsyth 2003:16). Therefore, my event ecology *begins* with discourse analysis, the identification of the multiple, often conflicting, narratives used to describe a particular environmental change or ecological phenomenon, and cannot be viewed as an atheoretical and apolitical practice as Vayda and Walters suggest (Potts 2000). Therefore, I start my analysis with a classification and description of these three discourses (i.e. the many stories/narratives describing the disappearance or movement of herring at or from Kah Shakes) and the comparison of these discourses for the purpose of identifying

dissident (conflicting) and coincident data. The reconciliation of dissidence and the aggregation of coincident data can then be stitched together to create one cohesive narrative of environmental change – the environmental discourse.

Practicing Event Ecology: Identification of Discourse

As described above, ecological events in human consciousness are framed and maintained within cultural models of the way the world works, which are themselves built up not only through individual perceptions of the environment but a "constant interaction and negotiation between people" (Bernard 2002:460) for the power to describe environmental change (Escobar 1995; Foucault 1966). A discourse is the result of these dialogic negotiations (Peet and Watts 1993; Forsyth 2003). Peet and Watts define discourse as "a particular area of language use related to a certain set of institutions and expressing a particular standpoint" (2008:228) (Adger, et. al. 2001). The first step in practicing event ecology is the collection of narratives, individual descriptions of the event. In this case I have collected multiple narratives describing the disappearance of herring from Kah Shakes and I have organized these narratives into discrete discourses, as they express a similar standpoint.

First are the commercial fishermen, both Native and non-Native, who have state permits to fish at Kah Shakes. Next are the commercial fishermen from Annette Island. They fish within the reservation boundary, up to three thousand feet from the shoreline of Annette Island and are permitted and self-regulated. The local residents, Native and non-

Native, who could be commercial fishermen, recreational fishermen, subsistence gatherers, and non-fishermen, all, in some way or another, have a relationship with herring fishermen, herring harvesters, or the herring themselves. Some of these residents are members of the Ketchikan Area Herring Action Group (Herring Coalition). Key narratives are those of the fisheries biologists employed by ADFG and by Annette Island, as these are the individuals who govern and choreograph the commercial herring fisheries at Kah Shakes and Annette Island.

All narratives are incomplete and can only describe portions of an entire event. For example, when investigating a crime scene, investigators collect multiple testimonials from individuals who witnessed some portion of the crime, or event. The investigator then compares each of these bits of information and determines, based on coincident data, the most plausible unfolding of the event. Event ecology methodology uses similar techniques. "Analysis is the search for patterns in data and for ideas that help explain why these patterns are there in the first place" (Bernard 2002:429). Using coincident data from multiple witnesses of the event, I will determine the most plausible ecological factors of the environmental change (the environmental discourse). Then, using dissident data, I will identify the political factors that make describing the environmental change event at Kah Shakes so difficult.

For the purpose of this analysis, I have organized individual narratives into three discourses (two of them human created). The first of these is what I call the 'management discourse.' This discourse is the description of the event as told by sources

such as ADFG personnel (reports submitted to the Board of Fisheries, memorandum, annual management reports, and a series of Powerpoint presentations provided by Gary Frietag and used with permission by Scott Walker) and an interview with Scott Walker, the current fisheries biologist in the Ketchikan office. Also included in this discourse are the interviews I conducted with Hap Leon, fisheries biologist working for Annette Island during the time of the Kah Shakes reconfiguration and Dustin Winter, the current scientist employed by the Annette Island Fishery Reserve to manage the fishery, and the written documentation (newspaper articles and a Powerpoint presentation provided by Hap Leon) provided by these informants. All of these data will be referred to as the "management discourse," to highlight the importance of politics and economics that influence the decisions made by these groups. State fisheries research is constrained by its imperative to serve commercial fishing interests which leads to a neglect of small scale spawning and herring populations and a fragmented picture of the herring into fishing management areas. Annette Island fisheries managers are limited by the Annette Reserve boundary that extends 3,000 feet from the coastline of Annette Island. The term is used with the caveat that discourses, though identified as discreet units for the purpose of this analysis, are always fluid to some degree (Vayda 1983). Although both ADFG and Annette Island fisheries managers regard themselves as operating upon scientific evidence, they fail to agree upon the reasons that herring have disappeared from Kah Shakes (see Limitations of the Data). This disagreement may be a caused by the limitations posed on both management parties by the boundaries in which they are

required to operate and maintain. LEK is not spatially limited by these artificial management boundaries.

The second discourse I termed the local ecological knowledge (LEK). This discourse is the description of the event as gleaned from a combination of texts (court affidavits, letters, newspaper and journal articles, written notes provided by members, etc.) and a focus group interview held with members of the Ketchikan Area Herring Action Group (Herring Coalition) describing the events at Kah Shakes. Also included in this categorical discourse are comments made by local residents, both Native and non-Native, found in written sources (newspaper articles, other published materials) and during interviews conducted with individuals who are not affiliated with the Herring Coalition. Again, the sources that comprise the LEK discourse share a commonality: these sources are regarded as "anecdotal" by ADFG personnel and by the US Court System. There are divisions within this discourse that must be recognized: a distinction must be made between members and non-members of the Herring Coalition. The Herring Coalition is composed of local residents, but these individuals share not only the opinion that herring at Kah Shakes have diminished due to overfishing but also a purpose: to close the commercial sac roe herring fishery. There are local residents who are not members of the Herring Coalition who have variable opinions regarding the status of herring abundance in and around Ketchikan and may, or may not, support the closure of the commercial sac roe fishery. Regardless, the LEK presented by the Herring Coalition and local residents is not considered to be scientific in nature and has therefore been

discarded by the fisheries biologists responsible for the management of the sac roe fishery at Kah Shakes, perhaps because it cannot easily be fitted into current datasets.

There is a third discourse to be described as well. The third discourse is not solely human-created, but includes a combination of environmental, ecological and biological actions and reactions. This is the natural history and biology of the herring, the environmental discourse. The environmental discourse is where ecological processes become agentive, acting and reacting in response to agentive forces that are both human (fishing, pollution, etc.) and non-human (wind, temperature, substrate etc.). In this case, non-human agents (Pacific herring) "push back" or react to human and environmental processes like harvesting, including commercial fishing or the avoidance of excessive tidal action. One example of this is the process whereby corn changed from a wild grass to one that thrives in the presence of human agricultural techniques. Humans have acted upon, or cultivated, those plants that are easier to harvest and are most palatable, but the plant species itself can be seen as changing in response to this interaction, moving into an unoccupied niche in the environment and entering into a symbiotic relationship with humans[5]. A similar example is the manipulation of scrub savanna by the Gorotire Kayapo of Brazil. As explained by Anderson and Posey, the Indians play an active role in the formation of apete through the transference of litter, termite nests and ant nests to

[5] This approach is similar to multispecies ethnography, a fairly new genre of anthropology, that Eduardo Kohn defines in Kirksey and Helmreich as "an anthropology that is not just confined to the human but is concerned with the effects of our entanglements of other kinds of living selves" (2010:545). Similarly, I suggest that Pacific herring are not merely objects to be acted upon, but are actors themselves.

selected sites (1989). “This manipulation appears to have influenced not only the physiognomy of the vegetation but also its floristic composition…” (Anderson and Posey 1989:159). It is important to understand from these examples that not only are humans acting upon organisms, the organisms are responding to these interactions. Similarly, herring retain a form of agency in their commercial and subsistence harvest relationship with humans.

With the three discourses defined (management, LEK and environmental), comparative analysis can begin. Laying these narratives side-by-side, what can we say about what happened to the herring at Kah Shakes? Or rather, what are the herrings’ actions telling us about environmental change and management? To begin the analysis, I will address the coincident data (of which there is very little) that exists between discourses. These data are those facts on which everyone agrees, and become the basis of environmental narrative. In the case of Kah Shakes, the list of coincident data is significant for the information it does contain, but more so for the information it is lacking.

First, I will address the management discourse.

The Management Discourse

The following is a brief history of commercial herring fishing in southeast Alaska. This information is pertinent for understanding the economically driven production framework on which current fisheries management was first built upon and for later

recognition of these relics in the description of the management discourse and single-stock management technique that are described below. It will also provide contextual background for the discussion of participatory management structures that will arise in the proceeding chapter.

Commercial herring processing in Alaska began in 1878, usually in the form of oil reduction and canning. According to Cobb (1906) "As early as 1878 persons in Wrangell engaged in the business of catching herring, from which they extracted the oil [i.e. reduction plants], in addition to salting and drying the fish." The first two canneries in Alaska were operated by the North Pacific Trading and Packing Company and were located at Redoubt at Old Sitka and at Klawock. By 1889 there were 37 canneries in operation. The number decreased to 15 canneries in operation by 1892, but increased to 64 canneries in 1902 and then declined to 47 canneries in 1905.

As government interest in herring processing increased, The United States Fish Commission sent the first research vessel the Albatross to collect the first 'official' catch statistics for southeast Alaska in 1897 visiting all of the canneries in operation in Alaska outside of the Bering Strait (Funk 2009). Shortly thereafter, annual reports entitled "Fisheries of Alaska" began to be published by the Bureau of Commercial Fisheries (Cobb 1907; Marsh and Cobb 1908, 1909, 1910, 1911; Evermann 1912; 1913). The title of these reports changed to the "Fish and Fur Seal" reports, but the information contained therein remained similar (amounts of fishery products prepared, kinds, value of fishing gear, and boats).

From 1900-1960 approximately 56 reduction plants in Southeast Alaska processed a yearly average of 50,000 tons of herring. The first herring reduction plant began production in Southeast Alaska at Killisnoo in Chatham Strait. Originally constructed as a trading post by the Northwest Trading Company, by 1882, the plant had reached an annual production rate of 30,000 gallons. Production at Killisnoo increased in the 1920's and 1930's reaching as many as 250 million lb (113,400 mt) to meet increased demand for fish oil and meal (see Funk 2009 for more information regarding early reduction plants). Reduction plants most often produced herring as food items alongside the processing of fish for oil and meal. Salted and pickled herring reached maximum annual production rates of 28 million lbs (12,700mt) after World War I and salt-curing ceased to occur after 1948 (Huizer 1952).

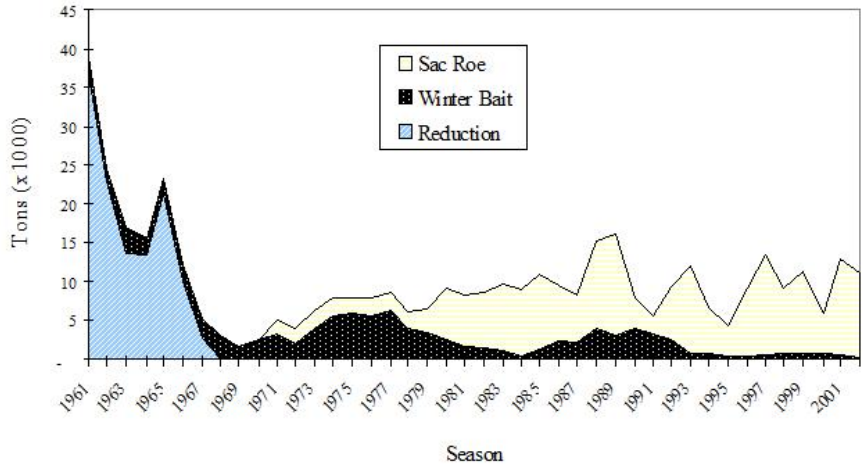

Figure 6: SE Alaska Herring Catch by Fishery for 1961 to 2002 Seasons. *Image courtesy of Scott Walker, ADFG*

The herring bait fishery grew alongside the halibut fishery since its inception in 1895. The New England Fish Company plant in Ketchikan was the first processor to freeze herring for bait, creating a year-round supply (Marsh and Cobb 1911). This fishery expanded to an annual harvest of 4,000-6,000 tons in the 1970s due to the increased demand from expanding shellfish fisheries, but has declined to an average of 700 tons annually in the last ten years (Funk 2009).

Reduction fishing efforts expanded after World War I (Funk 2009) fueled by technological improvements in fishing boats and gear. By 1927, there were 18 reduction plants in operation in southern Chatham Strait. The small boats using labor intensive beach seines, gill nets and a form of Norwegian seining that were used in the 1900s were gradually replaced with larger boats powered first by gasoline and then by diesel. Purse seining, a fishing technique introduced shortly after 1900 reduced the labor intensity and increased total catch in less time than the older seining methods. The increased fishing effort was coupled with what Dahlgren and Kolloen (1944) identified as 'three successive recruitment failures'6 between the years of 1932 and 1934. Herring reduction peaked in 1937 at 250,000 tons processed (Reid 1971). By 1938, the reduction fisheries were experiencing the first indications of decreased herring stocks and "regulations were enacted prohibiting all commercial herring fishing except for bait purposes in the vicinity of Cape Ommaney" (Funk 2009:240). On August 2, 1939 the U.S. Bureau of

[6] Herring require three years to mature enough to begin spawning. A recruitment failure occurs when all of the mature herring have been caught and not enough young herring have matured to the point of reproducing.

Commercial Fisheries prohibited all commercial fishing for herring other than for bait to cease. That same year, “political pressure from the fishing industry forced the U.S. Bureau of Commercial Fisheries open an ‘exploratory’ fishery” (Funk 2009:241) in attempt to locate herring and possibly reopen the commercial fishery. No herring was found. In 1942 all of southeast Alaska was closed to allow herring populations to rebuild. The fishery reopens in 1943 with a quota set at 12,500 tons, but actual catch numbers remain low. In 1948, the quota was actually increased to 50,000 tons, but only 16,144 tons of herring were actually harvested (Funk 2009).

Fishing was usually done at twilight and at dawn when the herring are found near the surface exhibiting a behavior referred to as ‘flipping’ or ‘balling’ (Huizer 1952). Nearly all boats now rely on electronic depth finders to locate schooling herring. Jonathan Dewitt describes how he used to observe herring school this way in Tongass Narrows while salmon fishing: “It used to be at any time of year the bays inlets and the Tongass Narrows were filled with schools of herring. It used to see school after school of herring on my fish finder, that was just five years ago, now I don’t see any herring to speak of “(Dewitt 1993).

Despite increased fishing effort, in the 1950s, herring reduction plant production began to decline until the last herring reduction plant closed due to failing profits, in 1966 (Reid 1971). In response to declining herring populations, fishing technology continued to become more efficient. By the 1950s, boats were “diesel powered and capable of carrying up to 1200 barrels of herring (rated at 250 pounds per barrel” (Huizer 67:1952).

Japanese and Russian ships also began trawling for herring in the Bering Sea in the 1950s reaching 320 million lb (146,000 mt) in 1970. In an attempt to regulate and privatize ocean resources, the Magnuson Fishery Conservation and Management Act (MFCMA) was established in 1976. MFCMA created a "fishery conservation zone between the territorial seas of the US and 200 nautical miles offshore" (MRS 1997), and a basis for US fishery management and regulation that excluded foreign fishing.

In 1959, the state of Alaska first began managing herring fisheries. At the same time, herring fisheries in Hokkaido, Japan collapse providing a void in the market for sac roe providers. In the late1970s, the Alaska Department of Fish and Game began to harvest herring sac roe from southeast Alaskan waters in order to fill this market demand. These already depleted herring stocks, having been subject to reduction and bait fisheries for centuries, are the basis for the current "pristine biomass" standards. While the sac roe market has declined since its peak in the 1980s (Funk 2009), it is the herring sac roe industry that continues to carry the majority of herring production both in volume and in capital today.

Management Techniques

Fisheries biologists employed by both ADFG and Annette Island manage their commercial sac roe fisheries very similarly. Survey techniques (dive and aerial survey, test sets) begin when the herring arrive offshore, before they begin to spawn. Using single stock management techniques, biomass estimates, threshold and guideline harvest

levels (GHL) calculations are made using the information gathered during this time (Blankenbeckler 1980). There are significant differences between the two management paradigms. I will first examine the similarities.

Annette Island gained jurisdiction of its coastal waters (3,000 feet from the shoreline at low tide) in 1916. The state of Alaska has managed the herring populations in Alaskan waters since 1959. Commercial herring harvesting (mostly for winter bait) was not strictly regulated until the 1970s when the market for herring eggs opened up due to a collapse of herring populations in Japanese waters.[7]

During a phone interview, I spoke extensively with Hap Leon, the fisheries biologist at Annette Island from 1977 until 2005. (He still continues to act as a consultant for the tribe calculating the pre-season forecasts.) According to Leon, before his arrival:

> The fishery wasn't very intensively managed. In fact, it wasn't really managed at all. Pretty-much, the guy that was the cannery manager at the time [was also in charge of all herring harvesting done in Annette Island jurisdiction]—and this is a long time ago—but he would go out flying and as soon as he saw the herring spawning, he would just tell the fishermen, 'go on out and go fishing.' And they'd fish and fish and fish, until they were getting all spawned out fish. Well then they weren't making any money, so they'd pull their gear and go home (Leon 2008).

[7] The herring sac roe fishery began in the 1970s and is the largest and most profitable market (86% of total earnings). Most of the herring are caught using purse seines and gill nets and transported directly to Japan (China and Canada to a smaller extent) after freezing. Once there, the roe is extracted from the fish and the remnants are processed into fish meal and integrated into myriad products including animal feed. Herring sac roe itself is a prized product in Japanese culture sold as a "specialty gift item and subject to periods of high discretionary income" (AD of CED 2002:2). In 1996 sac roe fisheries earned over $56 million (56 cents per pound/$1,118 per ton). In 1999 the market fell to $10 million (14 cents per pound/$280 per ton). This decline is attributed to a weakening of the Japanese markets (ADofCED 2002).

The winter bait fishery in the waters surrounding Ketchikan, including Kah Shakes, were managed, or rather not managed, in a similar manner (Chase 1993b).

Fishery management by ADFG and Annette Island has undergone vast changes since that time. ADFG began to monitor herring spawning areas using aerial survey methods in the 1960s. In 1970s, with the introduction of the herring sac roe industry, both commercial fisheries at Annette Island and Kah Shakes were subject to additional survey methods (hydroacoustic and dive surveys) and fishery management efforts intensified. Although survey techniques and catch methods are similar for both of these commercial sac roe fisheries, the success of these two fisheries has varied considerably.

Both ADFG and Annette Island manage their commercial herring sac roe fisheries using single stock management techniques[8] (Murawski 2000). The boundary of the Annette Island fishery is defined by the 1916 Presidential Proclamation that allows members of the Tsimshian Tribe to fish in waters 3,000 feet from the shoreline of Annette Island. This is the Annette Island management "stock." ADFG has divided herring in Southeast Alaska into six "stocks" or stock management areas that in turn are

[8] Formulaic stock-recruitment models that rely on equilibrium system dynamics intent on limiting fishing effort through calculated quotas and threshold levels to maintain maximum sustainable yield (MSY). In theory, maintaining an exploitation rate based on the ratio of stock size to MSY allows levels of abundance to remain near the environmental carrying capacity or virgin biomass: the level of abundance that a fish population would reach in the absence of harvesting pressures, where only environmental factors such as food or space would limit population growth. MSY calculations attempt to predict at what harvest rate the population will be both sustained and yet provide maximum product for the economic market (Hilborn et al. 2003). The concept of MSY continues to influence fisheries management in the US where "target exploitation rates are tied to the estimated stock size in relation to virgin biomass" (Hilborn et al. 2003:378). When a stock is estimated to be 40% above the virgin biomass, this is considered a threshold

regulated by catch method (winter bait, gillnet, purse seine, pound) and product (sac roe, bait/food): Seymour Canal, Revillagigedo Channel, Lynn Canal, Sitka Sound, Hobart/Houghton and West Behm Canal (ADFG 2008). Each of these areas possesses a "threshold level" a minimum "herring biomass needed to ensure sustained yield and maintain biological productivity" (ADFG 2009:2). Each catch method has a unique threshold level between 1,000 to 20,000 tons although areas with less than 2,000 tons of spawning biomass are not considered for harvesting with the exception of a Hoonah Sound spawn-on-kelp fishery (see Table 2). For example, the West Behm Canal has a threshold level of 6,000 tons. This threshold has not been met since 1998. As a result, the area remained closed to both gillnet and purse seine fishing, the two gear types that are approved for use in the area.

Table 2: ADFG Management Areas and Corresponding Thresholds

Fishing Area	**Threshold Level**
Seymour Canal	3,000 tons
Revilla Channel (*Kah Shakes/Cat Island*)	6,000 tons
Lynn Canal	5,000 tons
Sitka Sound	20,000 tons
Hobart/Houghton	2,000 tons
West Behm Canal	6,000 tons

In addition, each management stock is regulated by what used to be referred to as a guideline harvest level (GHL) and is now referred to as the sliding scale harvest rate. It is not known why the terminology was changed, but the premise remains the same. When a management stock forecast biomass reaches the minimum threshold level, the total allowable catch or harvest is 10%. If the management stock continues to grow and

exceeds the minimum threshold required to hold a fishery, the total allowable harvest "increases an additional 2% for every spawning stock biomass increase of an amount equal to the threshold level and reaches a maximum of 20% when the population is six-times the threshold level" (ADFG 2008) (see the calculation below). For example, when the boundary at Kah Shakes was expanded to include Cat Island, the minimum threshold level was increased from 5,000 to 6,000 tons. The fishery has remained closed since 1998, but if the herring biomass at these locations once again reaches 6,000 tons, the fishery would be opened with a total harvest rate of 10% or 600 tons. If the herring biomass continued to grow to 36,000 tons (six times the minimum threshold level), the total harvest rate would be increased to 20% or 7200 tons.

$$\textit{Percent Harvest Rate} = 8+2 \left(\frac{\textit{Forecast Spawning Population Size}}{\textit{Threshold Level}} \right)$$

Herring management stocks at Annette Island and at Kah Shakes are assessed annually to determine if the estimated biomass reaches the minimum threshold level. The methods for conducting these assessments have varied, but have followed similar revisions at both locations.

At Annette Island, beginning in the spring, usually the third week in March, hydro acoustic surveys are completed, assisted by aerial surveys (weather permitting) that can identify concentrations of eagles, sea lions and sometimes whales that indicate the presence of large schools of herring. The hydro acoustic surveys are conducted at night when herring are schooled tightly and rise to the surface. Using a side-scanning sonar and

an echosounder that records school size and density, the biologists are able to calculate a biomass density for each school located. This process is completed every night for about two weeks:

> We'll do the survey maybe every night for a couple of weeks and whatever is the largest survey we've seen, well we figure, well at least there's that much herring out there. There might be more, but we don't want to double-count, you know. We don't want to say all of our survey Tuesday night got this many tons and our survey on Wednesday night got that many tons and we total them up, because we might be looking at the same schools twice (Leon 2008).

In addition to these hydro acoustic surveys, the biologists will also conduct both test gillnet and test purse seine fisheries once the fish begin moving toward the spawning grounds. The reason for these two techniques is because a gillnet is size selective and will only sample the larger and therefore older fish. Fish that are caught using this method are tested for ripeness, or how mature the roe is. In contrast, the purse seine is not size or age-selective, and these fish are used to examine age-composition. Using a combination of the calculations derived from the hydro acoustic surveys (biomass), the test fisheries (age-composition), and the information obtained from the dive surveys done the previous harvest season (pre-season forecast, see below for further information), a quota is set for that year's herring sac roe fishery.

According to Leon, the quota used to be calculated at ten percent of the observed herring biomass. That technique has changed over the years to take into the selectivity of gillnet fishing practices toward the capture of the large and therefore older (usually five years and older) fish:

> Well, it's evolved, how we set the quota. It evolved over the years. It used to be that it would be just a flat 10 percent of the biomass that we see. And, oh probably over about the last 15 years, we've looked at it, not so much that it should be a percentage on the total biomass out there, but because they're fishing with gillnets, and gillnets select for large fish, we've got to recognize that whatever we're taking out of there is large fish and we don't want to take them all. So we set it as a—it's more than 10 percent of the large fish, but I don't think we've ever gone to 20 percent of the large fish (Leon 2008).

Leon explains the reasoning for this method:

> Leaving a whole lot of large fish in the population is pretty important because larger herring have larger eggs and larger eggs have larger yolks, and the larger yolks help the larvae survive better. So then there seems to be some relationship between the survival of the larvae and how old their parents were (Leon 2008).

Once the biomass has been calculated, roe has reached 11-12% maturity, the quota has been set and the fish begin to advance or "commit" to the spawning grounds, the fishery is opened and the fishing fleet is allowed to set their gear.

ADFG conducts similar surveys before and during the sac roe commercial season to determine biomass and harvest quota (guideline harvest level). "Before 1970, herring abundance was assessed through visual estimates made from vessels using depth sounders and sonar immediately prior to spawning or on wintering aggregations" (ADFG 2010:3). Miles of observed herring spawn are also recorded using aerial or skiff surveys, a method continued today. In the 1970s, vessel hydroacoustic surveys were implemented (see Blankenbeckler 1980 for a more in-depth description of this process) but were discontinued during the 1993/4 season "because the method is thought to be less reliable than egg deposition estimation" (ADFG 2008:3). In 1976, spawn deposition surveys were

introduced and continue to be used today. “The spawn deposition method combines diver estimates of herring egg deposition on the spawning grounds along with estimates of total area receiving spawn, average fecundity, average weight at age, and age composition to yield an estimate of spawning biomass” (ADFG 2008:3). These spawning biomass estimates are then used to predict the following year’s spawning biomass and annual catch quotas are calculated using these figures.

The ADFG has managed a herring gillnet sac roe fishery at Kah Shakes since 1976 (regulatory Section 1-F). Since that time, landings have ranged from a low of 171 tons in 1978 to a high of 3,250 tons in 1983. In 1990, the herring biomass failed to reach the minimum threshold and no fishery occurred. Spawn deposition surveys conducted by ADFG estimated that 6400 pounds of herring had spawned at Kah Shakes during the 1990 spawning season. Using these estimates, a 10.6% harvest rate was calculated for the 1991 season using the sliding harvest scale. The GHL for the 1991 gillnet sac roe fishery at Kah Shakes was set at 680 tons.

In April of 1991, the two commercial sac roe fisheries at Annette Island and Kah Shakes were undergoing the rigors of pre-season survey and testing techniques. Both management bodies were recording the movement and odd spawning behavior of herring in a holding pattern offshore. And both management bodies watched as their commercial sac roe herring catch swam away and settled at Cat and Dog Islands, out of reach.

This is when ADFG took action and filed an emergency order to expand the fishing boundary at Kah Shakes to include the new territory at Cat and Dog Islands,

allowing state permitted fishermen to fill their nets and pockets. Annette Island fisheries biologists protested the reconfiguration by boarding the ADFG survey vessel the RV Sundance, argued that state permitted fishermen were harvesting fish that traditionally spawned in Annette Island jurisdiction, but to no avail.

Further protests came from the Ketchikan community. The Herring Coalition filed a lawsuit supported by the Metlakatla Community to cease fishing at Kah Shakes, Cat and Dog Islands until further research could be conducted to verify sustainable fishing practices. The lawsuit was unsuccessful for a variety of reasons, but the fact remains that commercial sac roe fishing continued at Kah Shakes and in the expanded management area only eight more years until herring failed to return in numbers sufficient to reach threshold. In 1998, the commercial sac roe fishery closed at Kah Shakes. It has remained closed ever since.

At Annette Island, the fish have returned. A sac roe commercial fishery continues to be conducted annually to this day although my research failed to determine to what extent the fishery has returned to previous levels of productivity.

The Local Ecological Knowledge (LEK) Discourse

Various terms appearing in scholarly works describe the knowledge of ecological relationships and processes obtained through both cultural transmission and environmental symbiosis: traditional ecological knowledge (TEK), local knowledge,

indigenous knowledge (IK), and ecological knowledge (Berkes 1999). Berkes defines each of these terms:

- Traditional Ecological Knowledge: “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission about the relationship of living beings (including humans) with one another and with their environment” (Berkes 1999:8).
- Indigenous Knowledge: “the local knowledge held by indigenous peoples or local knowledge unique to a given culture or society” (Berkes 1999:8).
- Local Knowledge: “recent [nontraditional] knowledge” (Berkes 1999:8)
- Ecological Knowledge: “a branch of biology concerned with interrelationships in the biophysical environment” (Berkes 1999:6).

More recently, researchers have begun to identify Fishers’ Ecological Knowledge (FEK) apart from the above-listed definitions (Haggan et al. 2007, Ames 2007, Williams and Bax 2007, Baelde 2007, Stanley and Rice 2007, Haggan et al. 2007) where fisherman possess "detailed knowledge of the sea and the species they exploit...including depths, currents, bottom type, lunar tides cycles, vegetation, food sources, and so on" (Acheson 2005:352). Murray, et al., describes the FEK of fishermen in Newfoundland and Labrador, as:

> Shaped by varying combinations of observations acquired during fishing, knowledge transmitted from previous generations, and information from other sources such as harvesters from other areas, the media, managers, fisheries

> scientists and so on. It is also to some extent unevenly held, and not every individual has equal knowledge (Murray 2006:552).

For the purpose of this analysis, I prefer the term "local ecological knowledge" (LEK) to describe the knowledge acquired by long-time herring resource users and observers in and around Ketchikan. Local ecological knowledge encompasses the entirety of knowledge, practice, and worldview communicated through generational and institutional cultural transmission about ecological relationships of both living and non-living items and beings without presupposing functionalist terms of hierarchical evolution or adaptation, and including indigenous or Native as well as more recent accumulation of ecological knowledge. LEK is both individual and shared experiential knowledge (Haggan et al. 2007).

Local ecological knowledge in the case of Kah Shakes is a discourse that encompasses an expansive body of knowledge about herring biology and behavior based on direct observations by "non-scientists" (e.g. the Herring Coalition and local resident narratives). The people of Ketchikan (Native and non-Native, fisher and non-fisher) are intricately tied to herring by profession, relation, or tradition and sometimes by all three. They *know* herring because in many cases their livelihood depends upon them.

Current marine research has begun to show that local residents can possess specialized knowledge of ecological processes and environmental change[9]. I argue that

[9] Studies have focused on a variety of species such as whales (Noongwook et al. 2007, Huntington et al. 1999), sea turtles (Johannes and Neis 2007), geese (Fienup-Riordan 1999), seals (Moore 2003) polar bears (Keith et al. 2005) and a variety of fish including tuna (Moreno et al. 2007), cod (Ames 2007), the

the Tlingit, Tsimshian, commercial fishermen, and long-term residents of Ketchikan are no exception.

Long before commercial harvesting began, the Tlingit and Tsimshian people became acquainted with the return of herring to spawn as a return of spring. In general, oral history of the Natives of the Northwest Coast indicates that herring spawn and meat has been an economic, cultural and biological staple for the Tlingit and Tsimshian for centuries. Herring are used in trade, have become embedded in local traditions (as a meal at potlatch) and cultural identities (such as the Herring Rock in Sitka), and as a much needed resource, a welcome sight to those whose "winter food stores were running low and fresh sources of meat, oil, and protein were at a premium" (Thornton et al, 2010:54). The eggs are collected on various substrates (hemlock boughs, kelp, etc.) that have been strategically submerged in shallow waters where herring are known to return to spawn. Herring meat is also harvested (raked, jigged, netted) to be smoked, pressed to obtain the oil, or eaten fresh. Matilda Kushnik, a Saxman resident remembers when "the bays

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Carangidae fishes (Hamilton and Walther 1999), gagoid fishes (Bergmann et al. 2004), Mekong Basin river fishes (Valbo-Jorgensen and Poulsen 2000), Brazilian coastal fishes (Silvano et al. 2006), bumphead parrotfish (Dulvy and Polunin 2004; Aswani and Hamilton 2004), morwong (Williams and Bax 2007), and herring (Jones 2007, Stewart 1977; Schroeder and Kookesh 1990; Victor-Howe 2008; Thornton 2008). These studies focusing on species behavior throughout the lifecycle including nocturnal and seasonal migrations (Johannes et al. 2000, Mathooko 2005, Silvano et al. 2006, Poizat and Baran 1997; Valbo-Jorgensen and Poulsen 2000, Noongwook et al. 2007; Huntingdon et al 1999; Mymrin et al. 1999; Silvano and Begossi 2005), reproduction (Fienup-Riordan 1999; Hamilton 2005; Huntingdon et al. 1999; Mymrin et al. 1999) ocean conditions, tide cycles and how these cycles affect productivity (Mathooko 2005, Aswani and Hamilton 2004), spatial distribution of living and non-living resources (Ames 2007; Bergmann et al. 2004; Williams and Bax 2007), and stock size (Johannes et al. 2000, Jones 2007, Sadovy and Cheung 2003, Lajus et al. 2007; Johannes and Neis 2007).

[around Ketchikan] were full of Herring [sic] from December on throughout the summer months" (2008). Johnathan Dewitt, a commercial troller originally from Kake, but a Ketchikan resident for the last 35 years, remembers how he used to be able to catch fish at any time of year:

> There was a time I could go out fishing at any time of the year and catch fish, well that is not the case anymore. I'm lucky if I can catch a fish at all. Each year I catch less and less fish, the reason, there are no herring for the fish to feed on (Dewitt 2008).

Native subsistence users own a wealth of knowledge regarding these fish not only as a resource, but as a keystone species required for the continued health of our oceans.

Commercial fishermen, though a more recent class of observer of herring biology and ecology, are also excellent sources of information. Although commercial herring sac roe fishing has been only been practiced since the early 1970s, reduction fisheries (and fishermen) were harvesting massive quantities of herring in the late 1800s. Oftentimes, commercial herring processing is a family operation and tradition as explained by Ken Keiffer, a member of the Herring Coalition who attended the focus group in Ketchikan:

> My name is Ken Keiffer. I was born and raised here, been near 68 years. My grandparents moved here in the early 1920s and became loggers and then fishermen shortly after that. And they started fishing somewhere in the early 30s. And I've been fishing, personally fishing my own boat since 1970. I fished with my dad from the late 40s on (Keiffer 2008).

It is interesting to note that salmon fishermen know just as much, or even more about the migration of herring schools than do herring sac roe fishermen. This is because sac roe fishermen have no reason to follow herring anywhere but toward the shore as they ready

to spawn. Once the spawning season is over, it is the salmon fishermen who begin to track the herring movements, as salmon predate heavily on herring while they are out in open waters and herring become prime indicators of salmon schools in pursuit of their next meal. The decreasing number of salmon is a major concern for many fishermen. Some salmon fishermen noted the lack of herring in the stomachs of the salmon they caught, evidence that the salmon are feeding on alternate fish species, a sign that herring populations are declining. Sonny Campbell, owner of Sonny Campbell's Fishing Charters and sport salmon fisherman by trade, made this observation: "As we cleaned our catch [of salmon] we patiently checked each fish stomach for Herring. None!! Not one! (Campbell 1993). Campbell recognizes the importance of herring as a food source for salmon. He is concerned that the absence of herring in the bellies of the salmon he catches indicates that herring have become scarce and that the salmon populations may be adversely affected as a result.

Fishermen are not the only Ketchikan residents who have been observing herring for years. Commercial and private pilots have a unique visual perspective of herring schools from the air. Steve Schrum and Tom Kopeland have observed the movement and spawning behavior of herring from an aerial perspective.

> When we used to fly Kah Shakes when it was down there you would be four miles away and you could see the milky water. And then it would go up and down the beach for ten miles and it would go offshore probably a half a mile and then about '91 it was half of what it was. '92 it was a quarter of what it was. '93 it wasn't there. So where it went who knows? (Schrum 2008)

Divers who have been conducting herring surveys for ADFG also have a distinctive viewpoint of herring behavior from beneath the water's surface. Scott Walker describes his experiences as a diver:

> When you're diving—I've done a lot of diving—after the spawning, the whole water is just filled with little eyeballs. Because they're only like that long [less than an inch]. … And so, you just see these two little, tiny, black eyeballs. And the whole water is just filled with them. … And then there's these other little fish that are just zinging around: zing, zing, eating them. And so, I don't even know [what they are], but it's a fish. They [the herring] have to have enough plankton to support them and they tend to come out [of their eggs] right at the plankton blooms. But who knows [all of their predators], mackerel and juvenile black cod and there's all kinds of things that just hammer on them from day one (Walker 2008).

Tom Kopeland described his experience as a dive surveyor:

> Then they take, when we did this in Sitka … we would sub sample a square meter and you would take everything [eggs and substrate] that was in that square meter. You bag it, write it up, get it back to the surface and then this was taken back to our lab down here and then I did volumetric analysis of all these eggs that we sampled which was a lot. That's what we did for months and months at a time. … What they don't tell you in the data [is] that sometimes … my visibility in Sitka was maybe eight or ten inches. That was it. And so when I finished the end of the survey I would just, exhale, and I'd watch which way those bubbles went and I would follow it to the surface. That's the only way you got out of there. Because you had these giant plankton blooms there (Kopeland 2008).

During the course of this project, I found that everyone can speak authoritatively about their experiences with herring. Native, non-native, fishers, non-fishers, local residents, pilots, and dive surveyors, all possess a perspective regarding herring behavior and ecology that can include, but is not limited to, those spring months when herring appear at traditional spawning grounds, but extends throughout the herring lifecycle to

include larval and juvenile stages and massing behavior in the winter. Lawrence "Snapper" Carson describes how herring winter near his home in Ward Cove:

> Now, I live right here [Ward Cove] and there was some fairly good spawn here last year. I was pretty happy with it. There's a native family spot in the middle out here and I've kinda watched that bait [a school of herring] this winter and it laid right on the bottom there, they're just starting to move now. I think it probably was the same fish that spawned here last year, you know, in that area (Carson 2008).

Dennis Diamond also commented on herring in Ward Cove during the winter months:

> There was still herring in there in the wintertime in the '70s. … Well, there was a little spawn like right around where Steve's [a pilot] got his hangar. But I haven't seen a spawn in there. I might have missed it (Diamond 2008).

Many observations contain a temporal depth that is lacking in the current ADFG records that begin in earnest only in 1975. Martin Perez has been a commercial fisherman for most of his 92 years. He describes the abundance of herring he observed over the course of his career:

> Well, the herring population now is just a drop compared to what it used to be. We had herring all through here, all through the—so far south, we went through herring: schools and schools of herring in my young days. Even as far down as—I fished down, way down, all the way down to Washington, Oregon. But the herring up in this country all the way down into Hecata Straits—that's Canadian waters—all the way up to above Juneau and all over. I remember when there was schools and schools of herring. Now we don't see that any more (Perez 2008).

While not all interview participants could compare with Perez's lengthy relationship with herring, many could recall herring observations from prior decades, expanding our knowledge of herring not only beyond the temporal limitations of ADFG

data that begin in the 1970s but also beyond the spatial limitations, outside the current management boundaries. Franklin James, Sr. made this observation about herring massing during the winter months in Thomas Basin in the 1950s:

> Well, when it was—this herring right here, this whole channel, during the winter months you can go right into Thomas Basin and if you want herring you just go on the dock and dip and you got a big net full. That was all the time into the later part of the 50s (James, Sr. 2008).

It should also be noted that much of the local ecological knowledge about spawning and massing collected as part of this project, references areas outside of the current ADFG management boundaries. Martin Perez, Sr. remembers herring spawn at Sargent Bay:

> Then there used to be another big spawn—I was just a young guy, a kid then. Sargent Bay in Behm Canal.… Big spawn there, yeah. I remember when I was a little guy, I see all the killer whales used to come up in their spawn time, you know. You don't see no spawn up there any more (Perez 2008).

He also recalls observing herring at Lucky Cove. "Oh they used to spawn Ham Island, and across Lucky Cove" (Perez, Sr. 2008). And Badger and Weasel Bays: "The first bay—Badger Bay and Weasel Cove [had herring spawn] (Perez, Sr. 2008).

The following is a list of locations where herring spawning and massing was recorded as part the Herring Synthesis project and my own fieldwork as being in abundance or decline over a period of the last 50 or 60 years: Badger Bay, Behm Canal, Betton Island, Blank Inlet, Blank Islands, Boca de Quadra, California Head, Carroll Inlet, Cat Island, City Float, Clover Pass, Foggy Bay, Fox Island, George Inlet, Gravina Island, Herring Cove, Kah Shakes, Ketchikan Harbor, Knudsen Cove, Loring Cannery, Lucky

Cove, Mary Island, Mountain Point, Point McCartey, Sargent Bay, Saxman Village, Spacious Bay, Thomas Basin, Thorne Arm, Thorne Bay, Tongass Narrows, Totem Bight, Walkers Cove, Ward Cove, Weasel Cove, Wistanley Island, Yes Bay/Why Bay (see Figure 7).

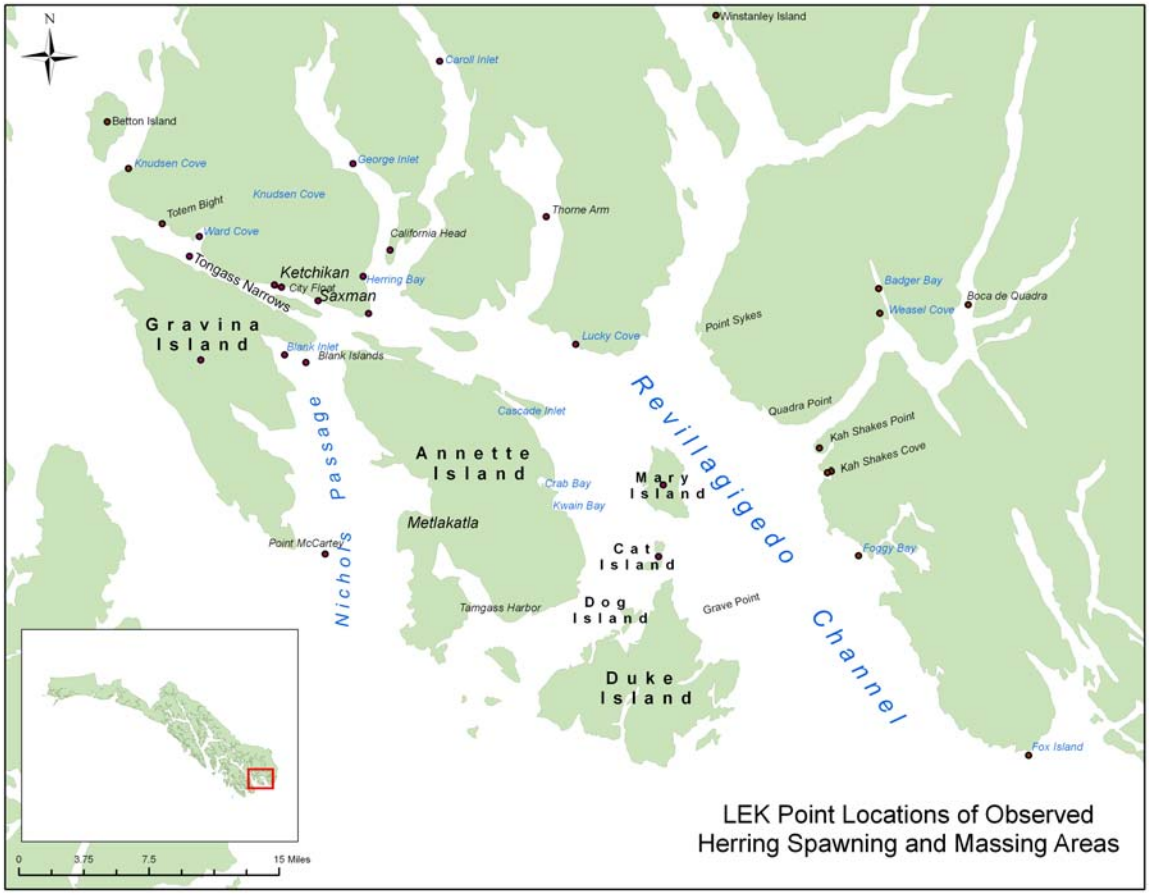

Figure 7: LEK Point Locations of Herring Spawning and Massing Areas

Most of these areas are not monitored by fisheries biologists in charge of managing commercial herring fisheries, including the one at Kah Shakes. LEK provides the means to address the shortcomings currently found in the management data. Because LEK

observations are long-term, multispecies, envelope a wider area and possess a great temporal depth, they compliment management data that is shorter-term, single-species, limited by management boundaries quite well. Reconciling these two discourses and combining the datasets has the potential to clarify the environmental discourse which will create more sustainable fishing practice and management techniques.

The Environmental Discourse

Ecology has been defined in various ways. I define ecology here as simply the study of the dynamic interrelationships of humans and other species within a given environment. The definition of ecology, however, is often influenced by politics aimed to scientifically legitimize environmental policy. According to a critique posed by Forsyth, "Science is undoubtedly used to legitimize a variety of environmental policies, yet there is often little appreciation of the biophysical uncertainties or political conflicts behind many supposedly well-known problems" (2003:10). Single-species stock management techniques that rely upon equilibrium dynamics (Acheson and Wilson 1996), MSY for example, are often used as scientific legitimization of management policy (e.g. expanding management boundaries) by ADFG at Kah Shakes and throughout the region of southeast Alaska. Unfortunately, these models fail to incorporate ecosystem attributes that affect the health of herring populations that include: "technical (by-catch) interactions, biological interactions (including predation and density dependence), the impacts of abiotic (climatological) factors on species and fisheries, spatial processes (the geographic

range of stocks and fisheries, and patterns of density and catchability), and temporal (seasonal, annual, decadal) scales" (Murawski 200:650; see also Hilborn et al. 2003, Hughes et al. 2005). Likewise, the management discourse is limited both spatially by the current confining management boundaries, and temporally by a lack of historical depth in the management records. I argue that in order to create a more sustainable commercial herring fishery, fisheries biologists must recognize the dynamic, non-linear, and even chaotic (Acheson and Wilson 1996) characteristics of ecosystem interactions that affect herring health throughout the herring lifecycle. Making this shift from a single-stock management to an ecosystem perspective would shift the penultimate question from "Where have the herring gone?" to "Why are there fewer herring here at Kah Shakes?" This is a question that cannot be answered at this time because the knowledge of herring natural history, biology, behavior, and multispecies interactions is riddled with uncertainties.

The following is a summary of what I have determined is the environmental discourse, the natural history and biology of Pacific herring. I describe this as a "discourse" to illustrate the agency of Pacific herring as an active organism with reproductive and biological impulses that cause these fish to act and react to biotic and abiotic factors.

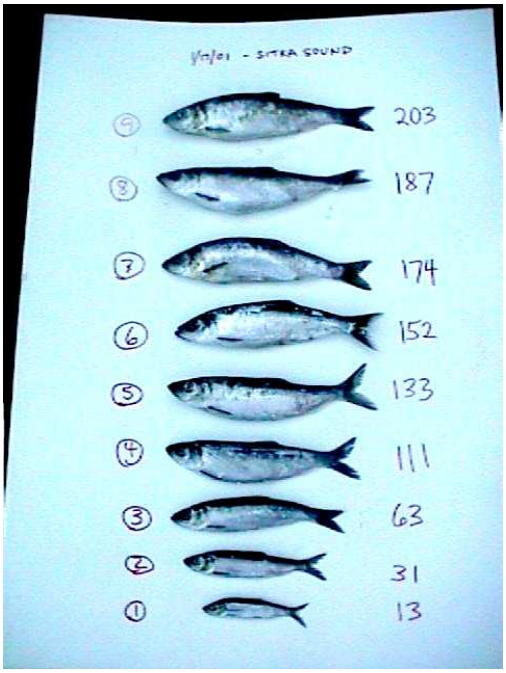

Figure 8: The average length of a Pacific herring in millimeters at each year of life in Sitka Sound. *Image courtesy of Scott Walker, ADFG.*

Herring are small schooling fish in a big ocean. The average length of a mature Pacific herring can be anywhere from 13 to 46 cm (5 to 19 inches) (Carls 2008)[10]. The ADFG report that a 9-inch herring is considered large (ADFG 2007a) (see Figure 8). Herring are a slippery fish, quite literally, but also in terms of their small size and movement throughout the ocean. Cycling between shoreline and deep ocean troughs depending on both the stage of life and annual cycle of migration, they become difficult to track. Many researchers have tried and

[10] Pacific herring, as the name implies, inhabit the Pacific Ocean the length of the North American coast, as far south as the continental shelf of Baja California, as far north as Alaska and the Bering Sea, and follow along the coast of Asia south to Japan. Herring are found along the coast of Alaska from its southern boundary at Dixon Entrance (55° N) to Norton Sound (64° N) in the north (ADFG 2007). Major concentrations are found in the Bering Sea (Haegele and Hourston 1980).

Pacific herring belong to the Clupeidae family, which consists of approximately 330 species of herrings, shads and sardines, and menhadens (Whitehead 1985). There are fifteen species of herring (also referred to as sardines or pilchards). Clupeidae are generally slender with elongated bodies. The body is rounded, scutes without prominent keel. There is no median notch in upper jaw. The gill cover (operculum) does not exhibit radiating bony striae. All clupeidae have eight pelvic finrays. The fish are fairly plain, bluish green on the dorsal surface and silver on the sides and belly (Carls 2008) and there are no distinctive markings on the body or fins. (FAO 2007).

continue these attempts – see Stock Definition section in Chapter Five for more information on this.

The Pacific herring life cycle can be broken into three stages: Larvae (0-2 months), Juvenile (2 months-2 years), and Adult (2 years+).

Larvae (0-2 months)

Spawning seasons (Thornton et al. 2010) vary by geographic region, occurring between December and July depending on the latitude, tidal action (Hay 1990), and water temperature (Bardach and Santerre 1981; Haegele and Schweigert 1985b). In southeast Alaska, herring begin to spawn in late March and can continue through mid-July depending on the location (Huizer 1952, ADFG 2007a, Food and Agriculture Organization of the United Nations 2007). At Kah Shakes, ADFG approximates the spawning season to be somewhere between March 20 and April 15 (ADFG 1979) (see Table 1).

The eggs of Pacific herring are 1 to 1.5 mm in diameter, pale, amber and translucent (Huizer 1952), and tolerant to temperatures ranging from 5–14 °C and salinities in the range of 3–33% (Haegele and Schweigert 1985). Eggs exhibit adhesive qualities and when deposited by females on intertidal and subtidal vegetation (kelp, seaweed, eelgrass, spruce boughs) and stick to the substrate in large masses (Huizer 1952, ADFG 2007a). According to Scott Walker, ADFG fisheries biologist:

> Probably the best spawning substrate is kelp. They do spawn on rocks and gravel and logs and everything else and there are certain species of kelp that have better suitability for herring spawn (2008).

Speaking specifically about the terrain and spawning areas around Ketchikan, Walker notes:

> They'll spawn on eelgrass and hair grass and large bladed kelps. You know, around here, you can look at—it's really more area specific. We have places that are very steep and there's very little substrate to spawn on. Other areas have long expansive, multi-species kelp flats and they are great areas to spawn in. But some of the most densest [herring spawn] I've seen are [deposited on] these macrosystis kelp beds (Walker 2008).

Once the females have deposited the eggs, males then pass over releasing milt, or sperm, to fertilize them. Herring will gather near prospective spawning grounds (sheltered inlets, sounds, bays, estuaries, etc.) sometimes weeks before an actual

Figure 9: Herring spawn on kelp

Figure 10: Herring spawn on eelgrass

Images courtesy of Scott Walker, ADFG

stages [larval and juvenile stages] are particularly vulnerable to physical variability, resulting in high inter-annual variability and reproductive success" (Carls 2008:2.2). Egg mortality can range from about 67 to 100 percent depending on tidal action, depth of spawn deposition (hypoxia and exposure to ultraviolet light) (Alderdice and Hourston 1985), thickness of spawn (Alderdice and Hourston 1985, Hay 1985, Haegele and

Schweigert 1985), water temperature and salinity (Alderdice et al 1979; Alderdice and Velson 1971), predation (Carls 2008) and other factors such as water contamination in the form of oil (for example oil from the Prince William Sound spill).

Herring larvae that survive the egg stage will begin to feed on zooplankton near shore at a depth of about 5 meters. At this stage, they remain unable to swim and are greatly dependent upon tidal action to remain near shore in sheltered bays and kelp patches throughout the summer. Mortality is high and largely determined by predation, food supply (copepods and diatoms) (Lassuy 1989), and water salinity (Duenas 1981; Griffin et al. 2004). “Larval survival is the prime determination of year-class strength” (Carls 2008:2.4) (see also Hay 1984).

Juvenile (2 months – 2 years)

Juvenile pacific herring (at around 35 mm in length) are able to swim and begin to form schools as a form of protection against predation (Blaxter and Hunter 1982), their greatest source of mortality (Carls 2008), though food availability, competition and disease are also survival factors. They continue to remain near shore during this time (Carlson 1984) and continue to feed on copepods (a form of zooplankton) in preparation for the oncoming winter during which water temperatures drop, light levels decrease and food becomes scarce (Cooney et al. 2001). During the winter months, herring are commonly active at night and can be easily located as they bunch in characteristic feeding frenzies known as “balling.”

At this time, there is very little knowledge regarding the juvenile stage of herring development (Barton and Westpestad 1980:27). Once herring leave the larval stage, they become less visible, making it difficult to track their movement through the water, and less viable as an economic commodity. As a result, fisheries biologists employed by ADFG and Annette Island have very little funding available to monitor the juvenile fish because at this life stage they are no longer commercially valuable. All that is currently known is that herring simply "disappear" into the ocean two months after the spawning season and return two years later as part of a large school, migrating with the mature herring toward shore, practicing the motions of spawning.

Adult (2+ years)

Herring reach maturity at about three years of age when they become reproductively viable, joining already existing schools of herring in the annual migration between the deeper waters of the open ocean during the winter months and shallow coastal spawning behavior in the spring. The exact migratory path and wintering areas of the herring that spawned at Kah Shakes are unknown, but ADFG "assumes" that they spend much of their time in the Dixon Entrance area (ADFG 1993/94).

Spawning adult herring and the eggs that they leave behind to enter the larval stage are the most accessible forms and the most noticeable behaviors, and therefore the most researched portion of the herring life cycle. Once commercial herring sac roe fishermen have filled their harvest nets for the last time, these large schools of fish quite literally fall off the radar (or fathometer in this case). Managerial monitoring ceases by

both ADFG and Annette Island fisheries biologists[11] and only become of interest again when they arrive to spawn again the following spring. But where the course of managerial observation ends, local ecological knowledge does not stop.

Even the ADFG is aware of the deficiencies surrounding the ecological knowledge of herring: "Little is known about the larval and juvenile biology of herring in Alaskan waters. Overwintering areas, feeding areas, migration routes and stock definition have yet to be established" (ADF&G 1985: 340). Further research to clarify these areas of herring biology and migration has progressed very little since that statement was made. ADFG admits that "The department monitors only areas that are or have been commercially exploited where significant spawns are known to occur. Limited resources are not expended monitoring small populations or spawn events" (2007d:11). As stated by Scott Walker, ADFG fisheries biologist, Division of Commercial Fisheries in Ketchikan: "If it doesn't generate better fishing or safer fishing or more conservative fishing--the State does research for pure research sake too, but that's kind of more of a University sort of a thing. To do research for pure research is quite often underfunded" (Walker 2008). For example, in 2007, at a hearing held by the Juneau Douglas Fish and Game Advisory Meeting, Advisory Committee Member, Kathy Hansen commented that "we need some basic research into herring in the northern Southeast area. We had a hearing [regarding the stock status of herring in Lynn Canal] and there's lots of questions

[11] See the Management Discourse section in this chapter for a more in-depth look at fisheries management practices by both entities.

but not good data to answer the questions" (ADFG 2007c). When another Advisory Committee member at this meeting asked what would happen if the stock were to go extinct, ADFG employees Kevin Monagle and Marc Pritchett responded that they "were not sure what else could be done other than research and restricting fishing" (ADFG 2007c), neither of which are measures being actively pursued by ADFG due to financial restrictions and political pressures respectively. Further research, however, is greatly needed.

In this chapter, I have shown how analysis of the environmental change at Kah Shakes using event ecology enhanced by discourse theory will enhance and target these research projects to identify areas of uncertainty regarding herring biology and behavior and expand the limits of available spatial and temporal information. First, I identified three discourses using grounded-theory: management, LEK and environmental. I then used these discourses as comparative units to identify both similar (coincident) data, the environmental (natural history and biology) discourse of the Pacific herring, and dissimilar (dissident) data. I argue that the integration and reconciliation of the coincident and dissident data that I have identified will clarify the environmental discourse and that GIS will be a useful tool during this process that will facilitate explicit dialogue between the managerial and LEK discourses focused on the creation of more sustainable fishing practices.

As I will show in the proceeding chapter, however, there are very few coincident data from which to construct an accurate environmental discourse of herring biology and

behavior. This makes local ecological knowledge “the only available source of local, historical, place-based fisheries information” (Ames 2006: 352) for many fisheries (Johannes et al. 2000), including the herring fisheries in Southeast Alaska. And yet, LEK is one data source that has been largely ignored by the scientific community as “anecdotal” and therefore not useable. Next, I discuss this power struggle to define what constitutes scientific data and place this within the wider historical context of participatory fisheries management in southeast Alaska. I conclude the chapter with an explanation and example of how LEK can be validated and then integrated into the current fisheries management paradigm assisted by GIS software.

CHAPTER FOUR: INTEGRATION OF DISCOURSES

I argue that the integration of management and LEK discourses will result in a clarification of the environmental discourse, the natural history, biology and behavior of herring. In this chapter I begin with a comparison of the managerial and LEK discourses from which I identify points of coincident data and determine where gaps exist in the current environmental discourse. ADFG has been hesitant to consult or recognize LEK as useable data within the management paradigm despite the fact that existing participatory management structures were created in 1959. Unfortunately, the participatory structures, as they exist today, have become saturated with political and economic influences and have rendered the framework ineffective. I maintain that LEK as a form of citizen science (Fortmann 2008) remains an invaluable data source that will expand our understanding of herring biology and behavior outward in space, beyond the current management boundaries, and backward in time, beyond the limitations of ADFG documentation. I

follow this with an explanation of how I have used geographic information systems (GIS) to validate and integrate LEK and then translate objective data into maps that transcend cultural, linguistic and politically charged barriers of communication. Finally, I conclude that GIS software is highly capable of storing and modeling both LEK data that is often multispecies and larger-scale, in addition to management data that is single-species and site-specific. GIS provides the means to both compare and combine many forms of data to create a more accurate environmental discourse on which more sustainable fisheries management practices can be derived.

Coincident Data

Coincident data from which to determine environmental discourse of herring at Kah Shakes is sparse. All informants agree that the herring did not spawn at their traditional spawning grounds during the 1991 commercial fishing season. Even local residents not directly involved in fishing as an occupation are familiar with the peculiar behavior exhibited by the herring at Kah Shakes during that time. Merle Hawkins, a Ketchikan Indian Community Tribal Council member, made this comment: "Oh yeah, that's because they had that weird fishery about that time where usually they were at Kah Shakes and they moved over to Dog and Cat Island" (2008). But while the movement of the fish is coincident between all discourses recorded here, the cause of the degree of abnormality of the movement is contested. Scott Walker, fisheries biologist for ADFG, offered this explanation: "So they moved approximately eight miles to the east here. And

then they moved another approximately…so approximately like about 15 miles or so, here to here. So, for this stock to move back and forth 15 or 20 miles is really fairly common" (2008). All discourses coincide on this point, that the herring moved from Kah Shakes to Cat and Dog Islands during the 1991 fishing season.

Many informants, both managerial (Annette Island fisheries biologists Leon and Winters, ADFG fisheries biologist Walker) and LEK (Herring Coalition and local residents) discourses describe a blustery northeasterly wind and generally nasty weather and ocean conditions shortly after the herring arrived offshore in preparation for spawning. Leon (2008), the Annette Island herring biologist at the time remembers:

> This northeasterly wind coming out of the interior of British Columbia, shooting down Behm Canal and then across from Revillagigedo Channel and hitting the east side of Annette Island. It was, I mean, we were getting like 6 and 7-foot seas right on the spawning grounds. And long story short, the herring backed off the spawning grounds and they went and spawned at Cat Island.

Winters (2008) also identified weather as a factor: "Weather was an issue: a northeast [wind] was blowing so the fish moved off. Like I said, you know, we need to have fairly calm water before they can spawn" (Rauwolf 2008). Walker agreed with this assessment: "Cascade Inlet is on the southeast end of Annette Island adjacent to the traditional spawning grounds of the Crab Bay flats, and two miles north of Cat Island. In 1990, strong winds buffeted the Crab Bay flats" (Walker 2008). And while Walker, when asked if wind was a factor in the movement of the Kah Shakes herring, found the movement to be within the parameters of normal variation (about 20 miles), there is agreement that

"the Kah Shakes herring population that supported a fishery simply left that area" (Shelton 2007), though the reasons are points of dissidence.

The second point of coincident data is that herring exhibit 'skittish' behavior during the spawning season, meaning they are highly attuned to environmental conditions (e.g. weather, tidal action, noise from boats), though not all informants agree about what these conditions are and to what degree they affect spawning behavior. Walker (2008) made the following comment: "The younger ones tend to be more skittish and but you know, your guess is as good as mine on some of these questions." One informant who declined to be identified by name also commented on herring's preference for sheltered areas for spawning where there is not as much wave action and disturbance. Leon (2008) explained how noise is an irritant to spawning herring and describes how the commercial fishery in Annette Island waters is conducted with this characteristic in mind:

> [W]e try to keep the fishing fleet away from the spawning grounds most of the time, except for when the fishery is open because too many boats for too much time, making too much noise, it scares the fish off and then they don't spawn in the place where they usually seem to like to spawn (2008).

Merle Hawkins, a Ketchikan Indian Community Tribal Council member, also commented on the effect of sound on herring spawning behavior:

> [H]erring, from what I've heard, I mean I've never done [the] herring fishery, but I know I've been with herring fishermen, that herring can get spooked pretty easily. Just make a loud noise, metal on metal or something like that, and the whole school as a group will go, move away.

There was also mention by more than one informant that there may be some indication that the acoustic sounding sonar utilized by the submarine training facility, north of

Ketchikan at the entrance of Behm canal may somehow affect herring behavior (Hawkins 2008, Kopeland 2008). Merle Hawkins describes these concerns:

> Back Island, the acoustic sounding that they use for the submarine.... [S]ince they've been there, our eulachon [another migratory fish] disappeared in the rivers. They haven't been returning so herring and eulachon are pretty close in some behaviors. They travel in large schools and they only come back at certain time of year. Sensitive to noises (Hawkins 2008).

Tom Kopeland describes how he has seen side scanning sonar effect herring movement:

> Another thing I've seen also this area here right along the edge the 20 fathom back this is where our nuclear subs come up and I've seen them out there fishing and when I'm flying back and forth and I know when we used our side scan sonars in Sitka and other areas, Kristovich he said, it would scare the herring. I said no way and what I could do with this sonar is I could (woosh) and I could move them. (woosh) I could move them. Any place. I could push those herring around (Kopeland 2008).

He also describes his experience during one of his dive-surveys with how vibration carries through the water and suggests that the noise created by boat bilges also effect herring movement:

> I'm swimming along the bottom and I swim in to this area of vibration and I go into convulsions. I can't breathe. My heart just goes (makes noise of heart beating fast). And I know what it is, it's just vibration coming through the hull of that boat. So I just kick and go through it, but when you get areas like that where they're sounding, I think it really affects them. I personally think that's one of the main reasons we don't have a lot of our fisheries down in Quadra. Because they had wall to wall packers there pumping their bilges … and in power skiffs and everything running around through this spawning area (Kopeland 2008).

Coincident data suggests that herring spawning behavior is influenced by external environmental factors such as weather (perhaps wind), tidal action, noise and/or sonar.

The degree to which these factors affect herring is yet another level of dissidence, the resolution of which will greatly assist in management of these fish. Once external factors that deter spawning behavior have been identified, those that are human-caused can be balanced and regulated to ensure healthy spawning conditions as well as a healthy economic bottom-line.

The last point of coincident data found throughout multiple discourses recorded as part of this project is not a direct observation of herring behavior, but one of whale population. Certain species of whales (humpbacks were the most commonly cited) are known to prey upon schools of herring. There has been a noted increase in whale abundance in the Ketchikan as illustrated by the coincident data found in multiple discourses. Gary Frietag, a researcher whose main area of expertise is the evaluation and management of salmon aquaculture programs for Alaska Department of Fish and Game and more recently for the Southern Southeast Regional Aquaculture Association made the following comment: “We’re seeing a lot…well, I don’t think there’s any real good estimates, but there’s no question. The abundance of humpbacks has increased in this area. Of course and they’re very, very dependant upon the herring population” (Frietag 2008). Walker agrees with Frietag’s assessment: “So the whales know where they’re [the herring] at. The whales are feeding on them too. And that’s something else too. Whales are taking a tremendous amount of herring because the whale populations have increased” (2008). Terry Wills (1993), Dennis Diamond (2008), and Steve Schrum (2008) also noted a rise in marine mammal populations, including whales. Snapper has

observed schools of 30 whales at one time (2008) and Rauwolf speculates that one whale could eat up to 15 tons of herring a day.

In a recent study done by Witteveen (2003) prey consumption of humpback whales was calculated to be about half a ton of feed per day. J. Straley (2009) is quoted by Thornton et al. as saying that, "Despite the significant increase in whale numbers, most scientists do not find them to be a primary force in driving herring populations down. However, in areas where herring populations are already depressed or in trouble, whales may be having the effect of preventing rebounding (2010:139) (Straley et al. 2008). The full effect of rising whale populations on herring abundance is not known, but according to the coincident data, it does appear that it is a consistent concern across discourses.

In total, the coincident data regarding herring behavior at Kah Shakes may not appear particularly impressive, nor particularly helpful at first glance. It does however allow the following statements to be made:

1. The herring at Kah Shakes moved from one spawning ground to another during the 1991 commercial sac roe fishing season, a behavior that no one predicted beforehand.
2. Herring spawning behavior is greatly affected by some or many environmental factors that may include weather, wind, tidal action, noise, and sonar, but the full effects of these variables is not fully known, making the spawning fish appear to be fickle or 'skittish.'

3. Whales consume herring in vast quantities. Whales may affect herring populations in ways yet to be determined.

The list of coincident data is short. The significance of these findings therefore lays not in what is known about herring, but what is *not* known. LEK is a useful data source, in fact the only data source, that exists that can expand the knowledge of herring beyond the current management boundaries and backward in time to suggest historical measures of abundance

Unfortunately, ADFG has been unwilling to introduce the LEK of long-time resource users in Ketchikan, most directly in reference to the perceived decline in herring populations in and around Kah Shakes. David Carlile, ADFG Southeast region biometrician is quoted as saying: "The unfortunate thing is we have to base our management decisions on data that we have collected" (Chase 1993b:A-3). In fact, this statement is not accurate. Much of ADFG management is built upon British Columbia science. These are the kind of comments that need to be critiqued more thoroughly as they reflect the political ecology of controlling science and limiting data in a way that is in fact antithetical to the process of science itself, and obviously to citizen science (Thornton, personal communication 2011).

Ironically, the scientific evidence on which fisheries managers rely is itself based on incomplete and anecdotal information. The following comment was reported in a March 20, 1993 article in the Ketchikan Daily News:

> According to information possessed by Fish and Game, the Kah Shakes stock comes from Canadian waters in Dixon Entrance, said Phil Doherty, Fish and

> Game commercial fisheries area management biologist. That information is based on tagged recovery and *personal observation*, he said (emphasis added) (Chase 1993c:A-1).

Similarly, and more to the point, in a March 6-7, 1993, *Ketchikan Daily News* article, ADFG Deputy Commissioner Charles Meacham "acknowledged that in the past, abundance was measured with hydroacoustics, which were difficult to quantify and often unreliable. The direct *observation* of herring spawn by Fish and Game biologists who dive in the spawning area 'provides a far more reliable indicator of abundance'" (emphasis added). To which Herring Coalition co-founder Andy Rauwolf aptly replies:

> Since the department places such high value on observation, 'why has your department continually ignored the mounting concerns of hundreds of fishermen and thousands of coastal residents, along with several resolutions by Native organizations over the last 12 years who have sent you first-hand reports regarding the decline in our herring stocks?

In an editorial published in the *Ketchikan Daily News*, Rauwolf (2003) states most clearly:

> What kind of credibility can you give to a bureaucracy which openly admits that its understanding of the herring is very 'feeble,' and two weeks later states that it is going to increase quotas [the Kah Shakes/Cat Island quota was raised from 5000 tons to 6000 tons] due to the 'healthy condition of herring stocks'?

This is a question that members of the Herring Coalition posed to the courts in 1993 when they requested that the commercial sac roe fishery at Kah Shakes be closed until further research could be done to clarify the number and management of herring stocks present in the Revillagigedo Channel.

Ultimately, the courts dismissed the case citing the fifty-seven affidavits collected from local residents and presented by the Herring Action Group as "anecdotal" and unscientific (Rauwolf 2008). The true irony of this outcome is that participatory management structures were created as a foundation of the Alaska Constitution in response to a long, hard battle against the "shackles of federal control and corporate colonialism" (Arnold 2008:94) posed by industrial fish traps that monopolized the market in the early 1900s.

Participatory Fishery Management Structures in Alaska

From 1889 until 1939 federal regulation of the fisheries in the territory of Alaska were carried out by agents within the Department of Commerce and Labor and the Fish and Wildlife Service within the Department of the Interior once that division was created. "For its first fifty years, in other words, federal fisheries management in Alaska was directed by agencies whose primary responsibility was to promote and foster economic growth and development, not to restrict it…" (Arnold 2008:79). Many Alaskans at that time were concerned that the local salmon fish trap operators had created a vertical monopoly of the resource and many small producers were forced to steal fish from the traps to make a living.

The struggle to regain local control of the local fishing resources began in the 1910s. "It was a battle that pitted fisheries managers and bureaucrats, armed with scientific expertise and legal authority, against common fishermen, armed with only their

practical and traditional knowledge of their trade" (Arnold 2008:105). In 1912, a second Organic Act provided Alaska with a territorial legislature (Arnold 2008), but it was not until 1959, with Alaskan statehood, that commercial fisheries within the territory were officially transferred from federal to state control (now the ADFG).

When the state was formed, special legislation was included in the Alaska Constitution to open up the resources for the citizens including Article VIII, Section 2 that provides for "utilization, development, and conservation of all natural resources belonging to the State, including land and waters, for the maximum benefit of its people, Section 3 that states that "Wherever occurring in their natural state, fish, wildlife, and waters are reserved to the people for common use" and Section Four that states that "replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses" and finally Section 15 that dictates that, "No exclusive right or special privilege of fishery shall be created or authorized in the natural waters of the State" (Harrison 2011). The purpose of these provisions in the Alaskan Constitution was to ensure that resource use, including fishing rights, remain with the local residents of Alaska. To specifically address this goal, a Citizen Board structure was created that continues to function today.

Currently, the ADFG operates under the Board of Fisheries. The Board of Fisheries consists of seven members serving three years, who are appointed by the governor and confirmed by the legislature (Garza 1996) "on the basis of interest in public affairs, good judgment, knowledge, and ability in the field of action of the board, with a

view to providing diversity of interest and points of view in the membership" (BOF 2008 webpage). The purpose of the Board of Fisheries is to both conserve and yet develop not just the herring fishery but also all fisheries within the state. These Board members act as a panel of judges in charge of scrutinizing proposed regulation changes that are presented by during multiple yearly meetings.

Figure 11: Advisory Committees by Region
http://www.adfg.alaska.gov/index.cfm?adfg=process.acregion

Calls for proposals are sent out to Alaskan communities as an opportunity for concerned community members (commercial/sport/subsistence fishermen, local residents) to suggest changes to current fishery regulations. The Alaska Department of Fish and Game is also required to follow the proposal process to recommend changes to regulations. "Each year, during a specific window of time, the state calls for fisheries management proposals to be submitted to the Board of Fisheries for consideration. Regions and fisheries are rotated so that they are only up for consideration every third year" (Garza 1996:14) (see Figure 10). For example, proposals submitted for review for

the 2009/2010 fishing season included the following species with variable gear restrictions (set gillnets, subsistence drift gillnets, beach seine, purse seine, longline, pounds, pots, flies, reels), and management specifications (threshold, quota, opening/closing times, allocation percentages) in commercial, sport, and subsistence fisheries: sablefish, salmon, spiny dogfish, thornyhead rockfish, groundfish, cod, and winter pike. The Board then "uses the biological and socioeconomic information provided by the Alaska Department of Fish and Game, public comment received from people outside of the state, and guidance from the Alaska Department of Public Safety and Alaska Department of Law" (BOF 2008) to approve those changes to the regulations that are considered appropriate. According to Garza:

> The goal of the Board process is to ensure adequate public participation. It can take close to 100 days for the Board of Fisheries to consider several hundred proposals submitted each year. Residents who come to testify may spend days at the meeting before they are called to testify. This whole process is lengthy, costly and political" (1996: 15).

The Board encourages individual and Advisory committee, public testimony, written or verbal, at these public meetings either supporting or opposing proposals (BOF 2008:ii).

Advisory committees are regional committees designed to increase community participation in fisheries management and present a means by which concerned residents and fishermen can provide recommendations to the Board of Fish. There are currently 81 Advisory Committees throughout the state of Alaska. The Ketchikan Advisory Committee, which also includes representatives from Saxman, meets multiple times a year and is an open public forum in which anyone in the community is invited to attend

and express concerns and suggest changes to current fishery management processes or practices (creation of fisheries, changes of resource allocation between users, changes in fishing regulations). If the Committee determines by majority vote, that a proposed regulation should be considered further, a formal proposal is completed for review by the Board of Fisheries.

The premise on which these Advisory meeting are bases is one of participatory management. The creation of this participatory structure was intended to allow stakeholders with a meaningful interest and understanding of local conditions, (local residents, commercial fishermen, subsistence users, etc) to voice concerns and challenge current management regulations to coincide with information brought to light by this LEK, so as not to repeat the sequence of events that caused salmon runs to decline throughout the twentieth century. David F. Arnold chronicles the history of the salmon fisheries in Alaska, detailing the political and economic wars waged between fisheries managers convinced that they were operating conservative salmon fisheries, and the local fishermen whose observations ran counter to these claims:

> Fisheries managers believed that since 1924, 'the pink salmon resources of southeastern Alaska were not only restored to the original state of abundance but increased beyond this point through the controlled management of the Bureau of Fisheries.' But fishermen were not so sure. They experienced seasonal fluctuations and saw firsthand the impact of depletion on local streams. They often questioned the rationality of regulations that seemingly did not improve runs, but apparently worked in the opposite direction (Arnold 2008:107).

The proceedings leading up to the closure of the commercial sac roe herring fishery at Kah Shakes is eerily reminiscent of these political and economic struggles first experienced by LEK holders in the 1900s.

In fact, the participatory management structure established as part of Alaska statehood legislature is theoretically sound and does seem to offer opportunities for integration of LEK through the course of Advisory Committee Meetings. Unfortunately, the Board of Fisheries has again become consumed by political and economic interest groups. The formation and legal action pursued by the Herring Coalition is evidence of this.

The Herring Coalition filed a proposal with the Ketchikan Advisory Committee in 1993. That same year, the Herring Coalition, with assistance from the Metlakatla Indian Community, presented this formal proposal to the Board of Fisheries requesting that the expanded boundary at Kah Shakes and Cat Island be returned to its original configuration in order to preserve what the Herring Coalition and its members perceived as a declining number of herring in and around Ketchikan. The Board, in consultation with the ADFG fisheries biologists who expanded the boundary in the first place, declined the motion presented by the Herring Coalition to reinstate the original boundary, a conundrum regarded by Andy Rauwolf, co-founder of the Herring Coalition as, “foxes guarding the henhouse” (Rauwolf 2008). In an attempt to overcome these political barriers, the Herring Coalition and the Metlakatla Indian Community pursued legal action against the State of Alaska, the Board of Fisheries and the ADFG, again requesting that the fishery at

Kah Shakes be closed. As detailed elsewhere in this thesis, the lawsuit was discontinued in 1995 due to financial difficulties.

I find it both distressing and alarming that despite the participatory management structures on which the State of Alaska was founded are so enmeshed by political and economic interests that they are rendered useless to the LEK holders and stakeholders for whom they were created. A new emphasis should be placed on the value and integration of citizen science (Fortmann 2008). I argue in the next section that GIS may assist with the validation and integration of LEK, translating objective data into maps that transcend cultural, linguistic and politically charged barriers of communication.

Using GIS to Integrate LEK

Fisheries managers have, in the past, been reluctant to incorporate fishers' local ecological knowledge (LEK) into current management paradigms. Fishers' knowledge has often been described using terms such as unscientific, anecdotal, pre-scientific, natural history, inductive (Johannes and Neis 2007), and applicable only to local situations (Ames 2005). Scientists find the usefulness of LEK to be limited because it is inherently difficult to translate its qualitative nature into quantitative form (Baelde 2008:392).

> Traditionally, many fisheries scientists have brushed fishers' information aside because it is so difficult to integrate into the world of high-tech, statistics-based research. Even when fishers' subjective observations can be confirmed, they lack the reproducibility and precision of carefully controlled experiments (Ames 2007:358).

Some have argued that even when fishers' subjective observations can be confirmed, they often lack the reproducibility and precision of carefully controlled experiments (Ames 2007:358), but it is not impossible[12] and in fact, some studies, including that by Neis et al (1999) "suggest that fishers' perceptions of how abundant a species was in the past are likely to be more accurate than has commonly been thought" (Sáenz-Arroyo et al. 2005). One example of this is a study by Nies et al. (1999) regarding the perceptions of the cod fishery in the Canadian north Atlantic. The researchers found that both fishing data and fishers' perception indentified a 90% decline in catch-per-unit-effort Despite the inherent difficulties of validating LEK using scientific methodology, fishers' knowledge and LEK can and has allowed fisheries biologists to subject current management schemes to rigorous scientific testing, either reifying or falsifying hypotheses as part of the scientific process. GIS is a tool that can facilitate this method.

Geographic information systems (GIS) are powerful relational databases (Longley et al. 2005) with the ability to store, display and analyze data that links information about space, time and a distinctive property or attribute (Allen et al. 1990; Longley et al. 2005, Wheatley and Gillings 2002; http://www.esri.com/, November 21, 2008). Fisheries management is nothing if it is not data-intensive. Herring are acting and moving throughout the ocean in relation to not only their own life-cycle stages and annual migration routes. These life-stages and migration behaviors are greatly influenced by

[12] See Haggan et al. (2007) for further discussion of Ames' use of sidescan sonar to validate the location of cod and haddock spawning grounds.

ecological (food sources, predation, ocean floor substrate) and climactic factors (wave action, water salinity and temperature). GIS is an "information system … [that] help[s] us to manage what we know, by making it easy to organize and store, access and retrieve, manipulate and synthesize, and apply [enormous datasets of] knowledge to the solution of problems" (Longley et al. 2005:11). GIS is software that allows researchers to centralize many forms of data (qualitative/LEK and quantitative) and to analyze it in spatially significant ways in order to decipher and predict environmental processes of change like the one presented in the multiple narratives describing the ecological event at Kah Shakes (Robbins 2003, McCusker and Weiner 2003).

Validating LEK

GIS software allows multiple forms of data (managerial, scientific and anecdotal) to be displayed side-by-side, or rather, one on top of the other. Overlaying the LEK with data presented as scientific evidence by ADFG illustrates how much more information could be added to the current management paradigm if LEK were introduced and then subject to validation as biological data. At this time, due to restricted funding and commercial importance, herring research is only conducted during the spawning season and only within arbitrary management stock boundaries. LEK becomes a valuable resource that broadens the knowledge of herring movement and behavior through the oceanscape. The methodology needs refinement, but when used with the proper precautions (refer back to Limitations of the Data), the possibilities become endless.

While specific information regarding Kah Shakes was collected and is displayed below, the results of these discourse data overlay is most distinctive when viewed for the entire region of southeast Alaska. Let me explain and then show how this project can be accomplished.

GIS makes it possible to convert qualitative observations (comments made during interview processes, text-based historical documents, etc.) into qualitative data, a language that scientists and fisheries managers can comprehend and then analyze. During the focus group interview with the eight members of the Herring Coalition and during each of the eleven individual interviews with commercial, sport, and subsistence harvesters, both Native and non-Native, that were conducted as part of this project, I provided maps on which participants were asked to identify and then mark, using pen or pencil, herring spawning areas. I then took these notations back to the lab, and integrated these markings into the GIS program drawing polygons to intersect the coastline on a previously downloaded base map of southeast Alaska. Once I had transferred all of the interview data into the program and all polygons and intersections were completed, I used a function of the GIS software to calculate the total length of coastline that had been identified as present and past spawning areas. I followed a similar process with a JPEG file that had been provided by ADFG indentifying known spawning locations, finally calculating the total length of coastline that was identified as spawning areas. The results are presented in Figures 12 and 13.

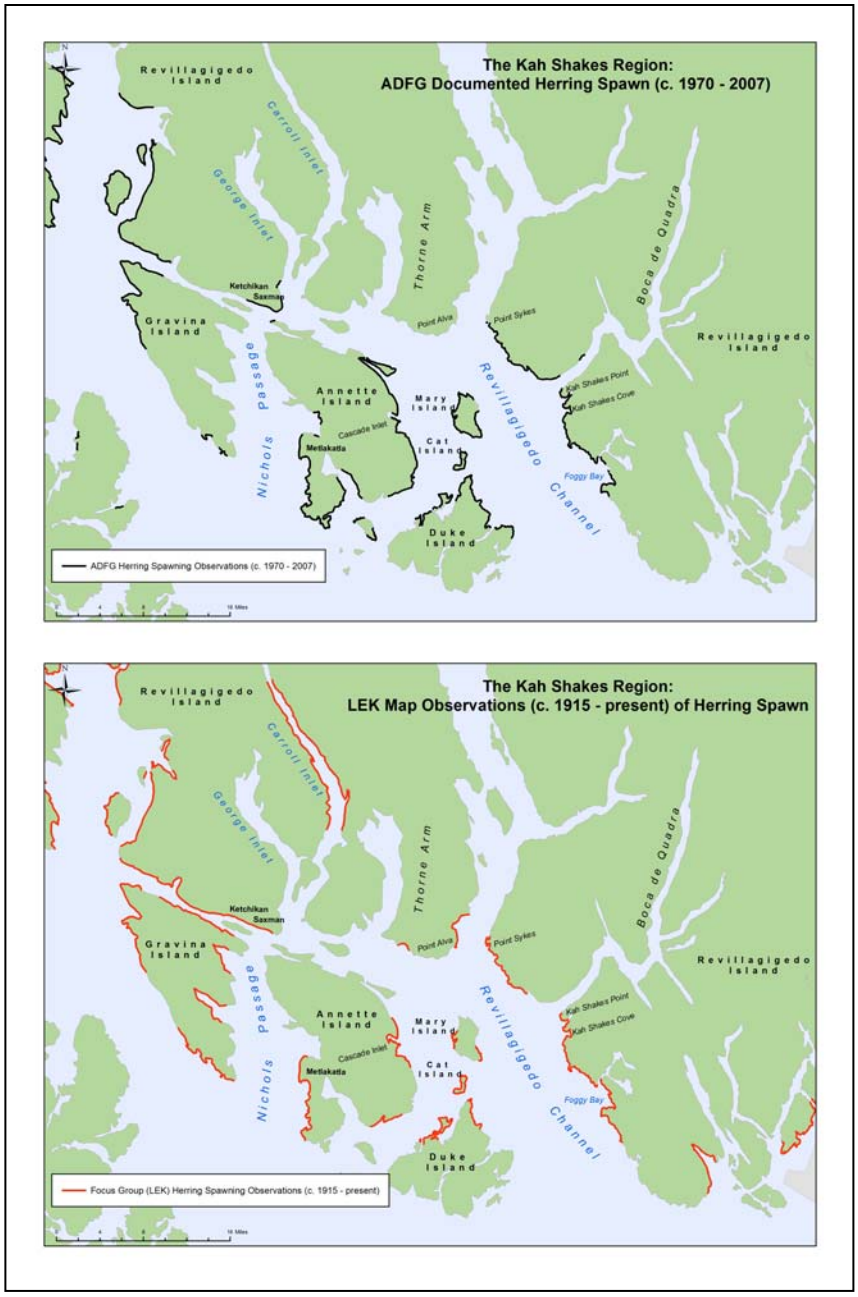

Figure 12: LEK Observations (c. 1915 – present) of Herring Spawn in relation to Alaska Department of Fish and Game Management Areas (c. 1970 – 2007)

The results of this data modeling require some discussion. First, it should be noted that in Figure 12, which illustrates the Kah Shakes LEK in conjunction with spawning

areas documented by ADFG, many of these areas coincide, but there is a considerable amount of coastline identified by the LEK as herring spawning areas that are not identified as such by ADFG. These are areas that informants identified as herring spawning areas that ADFG has either no knowledge of or no interest in because these areas fall outside of management boundaries.

The opposite should also be noted. ADFG records show areas of herring spawning activity where the LEK data does not. The most interesting area where this is shown to be true is around Annette Island. While I have mentioned previously that members of the Annette Island community were under-sampled during this analysis and may explain the lack of LEK identifying herring activity around Annette Island, I can offer no explanation as to why ADFG should have such detailed records of herring activity in an area over which they have no managerial control.

A second source of discussion is the time frames that are illustrated on these maps do not coincide. Future analyses of the data should compare the managerial and LEK data on similar time scales. For example, create both maps with only data from 1976 to the present. Some of the variance seen here could be attributed to temporal variance that might indicate the influence of climatic or biotic factors. However, these caveats of the data only bolsters my conclusion that additional research is required to fully understand the discrepancies between herring observations found in both discourses.

A similar conclusion can be drawn when these same two datasets are viewed and compared at a larger spatial scale, for the entire region of southeast Alaska (see Figure

13). The total miles of spawn documented by LEK informants during this project, as well as during the larger Herring Synthesis Project was 2,759 miles of coastline. Contrast this to the 1,118 miles of spawn monitored by ADFG. Using GIS modeling techniques to compare management and LEK data, it becomes visually and strikingly apparent that neither management nor LEK discourses possess a complete picture of herring migration and movement across the landscape. Because these two discourses approach herring with different purpose (managing versus harvesting), at different stages of the herring lifecycle, and at different times of the year the final goal should be the combination of these multiple knowledge sources to create a more holistic and accurate environmental discourse of herring biology and behavior: a clarification of the environmental discourse that will, in turn, create more sustainable fishing practices not at Kah Shakes, but for those areas still subject to commercial harvest throughout the region of southeast Alaska.

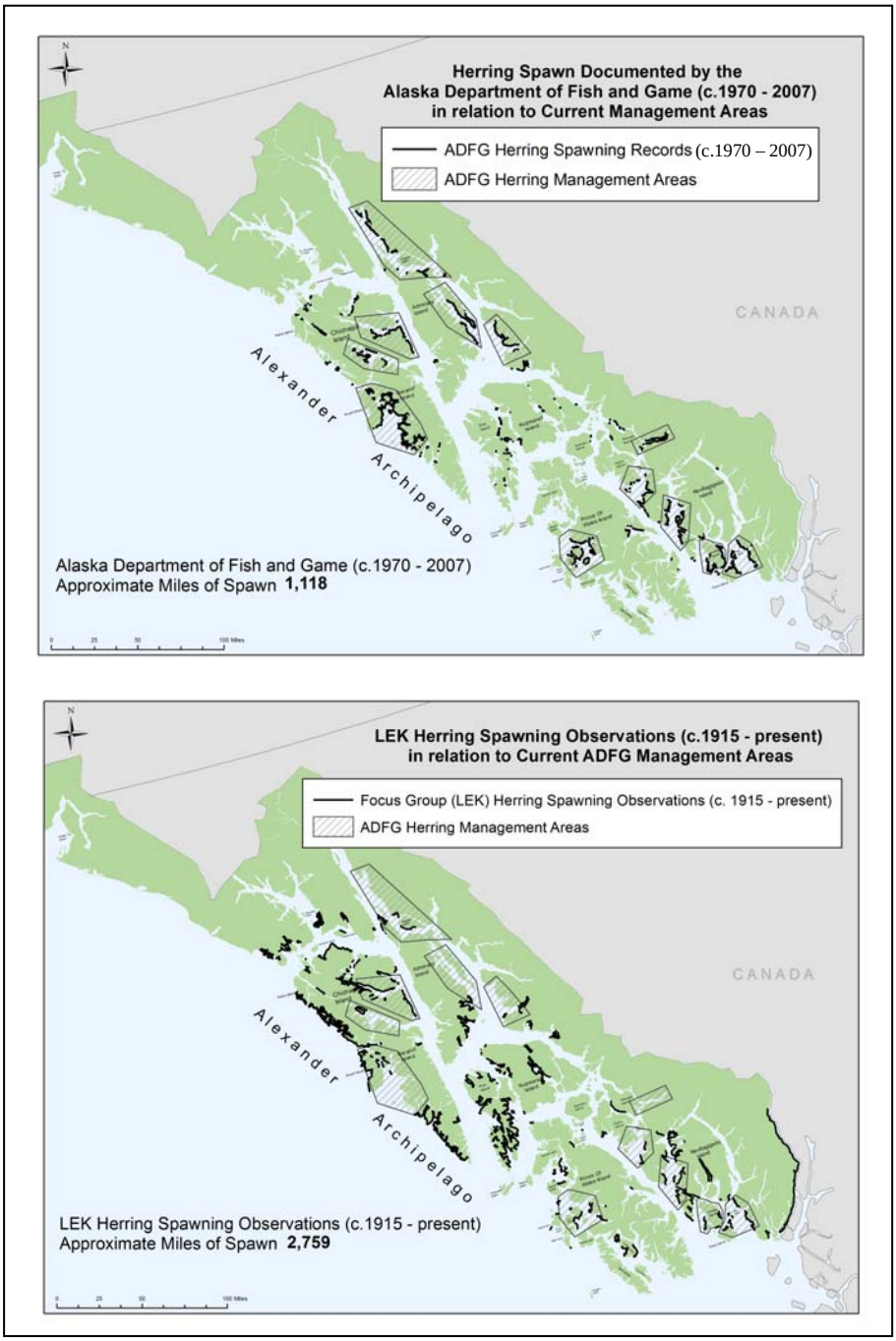

Figure 13: Approximate Miles of Spawn Comparisons Between LEK Map Observations (c. 1915 – present) of Herring Spawn and Herring Spawn Documented by Alaska Department of Fish and Game (c. 1970 – 2007).

Modeling Interrelated Ecological and Environmental Processes

LEK may provide the means to expand the body of knowledge on which current fisheries management in Ketchikan and southeast Alaska currently operates. Unlike ADFG, which monitors the herring only during the spawning season when they are commercially viable, local residents and fishermen, including salmon fishermen, are observing herring year round, at all stages of growth, at different locations along their migratory routes, unhindered by arbitrary management boundaries. GIS has the capabilities to integrate this ecological and environmental data making it possible to model the behavior and movement of multiple, interconnected species and climatic changes simultaneously, facilitating a more holistic management paradigm called "parametric management."

LEK and managerial knowledge systems often operate on different scales. While LEK is very often multispecies (predator-prey relationships for example), a local- or small-scale observation over large expanses of time, the scientific body of knowledge upon which fisheries management relies is often single species, large-scale, and state wide, with very shallow time depth.

> Thus, because fishers and scientists tend to observe the fishery ecosystem at different spatial and temporal scales, their observations are often complimentary. Fishers' knowledge may permit scientific observations to be better targeted, and more insightful, while survey data can provide the detail that leads to a more rigorous interpretation of fishers' knowledge (Williams and Bax 2007:373).

The current division of herring into management stocks maintains a very narrow focus on herring as a commodity rather than a key species in environmental interactions. The

integration of local ecological observations of herring behavior into the current fisheries management paradigm would facilitate a form of management based upon the fish as a species that interacts, reacts and acts upon other species (Acheson and Wilson 2008).

LEK is often multispecies, meaning informants' observations were not just of herring, but of herring interacting as one component of a dynamic ecosystem. For example, many informants commented on the importance of predator-prey relationships and the effects that declining herring populations have had on birds (ducks, seagulls, eagles, etc.), sea lions, whales and other fish (salmon in particular) that inhabit the same ecosystem(s). Everything is connected, as the residents of Ketchikan are acutely aware. Jonathan Dewitt, a commercial fisherman and carpenter who has lived in Ketchikan for thirty-five years (as of 1993), made the following observation: "It was pretty dead out there, no seagulls, no herring, and no fish" (Dewitt 1993). Many of the local residents of Ketchikan have been observing herring for many years, in some cases decades before Alaska even became a state with its own department of fish and game. They have witnessed the multiple climatic and biological interactions in which herring play important roles.

Integrating herring into an ecosystem or parametric based management scheme may show interdependencies between species and how fluctuations/alterations in one environmental component (animal and/or plant populations) can indicate trouble for another. For example, Hamilton et al., describe how the decline of capelin, a food fish for cod may have assisted in the early detection of a decline and the ultimate collapse of

cod in Newfoundland. “[Capelin] are food for larger fish. Capelin themselves feed on zooplankton, so declining capelin signal trouble at the heart of the food web” (Hamilton et al. 2004:203). According to many LEK bearers, herring may serve a similar function at Kah Shakes and other marine ecosystems where they spawn or mass.

Many salmon fishermen expressed concern that salmon that depend on herring as a food source may decrease in abundance as a result of diminishing herring populations. Some salmon fishermen noted the lack of herring in the stomachs of the salmon they caught. Elizabeth Chambers has lived in Ketchikan for forty years and grew up on the waterfront. She commented that “the salmon that we caught did not have any herring in their stomachs and … that this was indeed disturbing” (Chambers 1993). Similar to the decline of capelin in Newfoundland, the lack of herring in the stomachs of salmon may be an early indication that herring populations are in trouble.

Scientists are just now coming to understand the herring-salmon predator-prey relationship that salmon fishermen have been aware of for centuries. Gary Freitag, a Marine Advisory Program Agent and professor at the University of Alaska Southeast has been working and studying salmon since 1978. Although he is skeptical that all salmon populations are as reliant upon herring populations as comments made by local residents would suggest, he recognizes a relationship between herring and Chinook salmon populations. The availability of herring as a source of energy may allow the salmon to travel further upstream during spawning endeavors:

> Herring are probably utilized by the Chinook salmon.... Those guys will suffer if there’s a lack of herring in the area. The other species like coho, pink salmon,

> chum salmon, they'll probably all take the incidental herring, coho more than the others, but.... It's probably not going to cause life or death if they don't have herring at that point and the reason being, the only thing those fish are doing is trying to put on the additional extra fat and weight reserves so that they can go up the river and spawn (Frietag 2008).

The full extent of the herring-salmon predator-prey relationship is not fully understood. Expanding the current single stock herring fisheries management paradigm into an ecosystem or parametric approach may shed light on interspecies relationships, how the fluctuations of one species may affect another.

GIS offers the means by which both herring and salmon populations can be modeled together to reveal the dynamic ecological relationship between these species and many other living and non-living components that comprise an ecosystem. LEK, when incorporated and validated can broaden ecological knowledge both outward in space, past arbitrary management boundaries, and backward in time.

In this chapter, I have shown that integration of management and LEK discourses will result in a clarification of the environmental discourse, the natural history, biology and behavior of herring. I performed a comparison of the managerial and LEK discourses to determine points of coincident data and found that very little coincident data exists. ADFG has been hesitant to consult or recognize LEK as useable data within the management paradigm despite a historical precedence to do so. Unfortunately, the participatory structures, as they exist today, have become saturated with political and economic influences and have rendered the framework ineffective. I argue that LEK is an invaluable data source that will expand our understanding of herring biology and

behavior outward in space, beyond the current management boundaries, and backward in time, beyond the limitations of ADFG documentation. I have shown how GIS can be used to validate and integrate LEK and translate objective data into maps that transcend cultural, linguistic and politically charged barriers of communication. It is my hope that a more systematic mapping of the LEK and management data using GIS software will facilitate a more productive dialogue between these two discourses based on mutually intelligible data. GIS software is highly capable of storing and modeling both LEK data that is often multispecies and site-specific, and management data that is single-species and larger scale. GIS provides the means to both compare and combine many forms of data to create a more accurate environmental discourse on which more sustainable fisheries management practices can be derived.

In the next chapter, I look at stock definition and definitions of baselines, where the management and LEK discourses of the environmental change at Kah Shakes are conflicting, and explain how reconciliation of these areas of dissidence are imperative for the integration of management and LEK data.

CHAPTER FIVE: RECONCILIATION OF DISCOURSES

As discussed in prior chapters, I have defined two discourses (management and LEK) that describe the event at Kah Shakes in 1991. The ADFG insists that the herring are healthy and have simply moved their spawning grounds to Annette Island for the time being. Annette Island biologists, the Herring Coalition and local residents disagree with this assessment, maintaining that the herring at Kah Shakes and those in the waters surrounding Ketchikan are declining and point to the disappearance of herring at Kah Shakes as the result of commercial overharvesting of herring sac roe condoned by improper management techniques. Using the methodology outlined by political ecology, it would be easy to configure a power struggle between the management and LEK discourses but the management discourse itself is not uniform. Both ADFG and Annette Island employ fisheries biologists who manage each respective commercial fishery using scientific data. What constitutes “scientific” is more complicated than one might assume.

Using discourse analysis, it soon becomes clear that the struggle is of a different sort, a valuation of anecdotal versus scientific evidence. However, scientific data is itself often based on structured observation (Berkes 1999). I argue that if subject to systematic analysis, LEK can expand the knowledge base on which current fisheries management in Alaska relies. In the previous chapter, I determined that very little coincident data exists between the three discourses I identified in Chapter Three. Here I examine how LEK can offer the means to expand our knowledge of herring biology and behavior both outward in space by calling into question arbitrary stock management boundaries, and backward in time by rectifying the current "pristine" measures of herring biomass that management bodies attempts to maintain.

The resolution of dissident discourse, or more specifically in the case of Kah Shakes, the rifts between the two human-created discourses (management and LEK) will clarify the environmental discourse, creating a more accurate database regarding herring natural history, biology and behavior. "Paying particular attention to areas of agreement and disagreement between scientific and fishers' knowledge can contribute significantly to improved understanding and to advancing the knowledge of both groups" (Johannes and Neis 2004: 44). Because so little coincident data exists between discourses, fisheries management needs to become an interdisciplinary project. The reconciliation of these dissident data is the key to a more holistic herring management paradigm. In this chapter I provide suggestions for reconciliation, and I show how GIS can be used as a tool in this process.

Dissident Data: Identification of the Kah Shakes/ Revillagigedo/Annette Island Herring Stock(s)

One of the main arguments presented by the Herring Coalition in the 1993 lawsuit was that the herring that arrived to spawn at Cat and Dog Islands during the 1991 sac roe fishery were of a "mixed stock" that included fish that under past environmental conditions would have spawned either along the shoreline of Kah Shakes or at Annette Island. However, in 1991, due to an alteration in climatic conditions, namely a northeasterly wind and turbulent waters, herring failed to spawn at both Annette Island and Kah Shakes Cove and suddenly began to appear and prepare to spawn along the shores Cat and Dog Island. This observation is consistent throughout all discourses and as discussed in Chapter Four is considered coincident data.

The data are not united in where these herring originate. Both ADFG and Annette fisheries biologists responsible for monitoring sac roe harvesting conditions observed small spawning aggregates at Annette Island and at Kah Shakes but while ADFG insists that fish from all three locations originate from one stock, members of the Herring Coalition and the Metlakatla Community maintain that fish that spawned at Kah Shakes and those that spawned at Annette Island belong to two distinct stocks. This disagreement regarding stock definition within the management discourse at Kah Shakes is situated in a long running debate within the scientific community regarding the division of the species

into stocks and calls into question the accuracy of ADFG management areas that are purportedly located where single stock have been identified.

The definition of a herring stock has long been contested and continues to be debated. “Because herring are migratory and disperse and mix at different times of year under different conditions, it is difficult to distinguish between stocks” (Thornton et al. 2010:127). Efforts to identify Pacific herring stocks began in the 1930s using tagging techniques. It was hypothesized that herring that returned to the same spawning area each spring were of the same stock.

Rounsefell and Dahlgren (1935) completed the first tagging studies of Pacific herring in the 1930s. The following was printed in the Ketchikan Alaska Chronicle on July 7, 1932 and presumably describes these initial efforts in Ketchikan:

> The Heron, bureau of fisheries boat, called in port on her way to Chatham straits [sic] where the three men aboard will commence tagging of herring to determine the numbers of the fish and learn something of their history … Five reduction plants have already installed 500 volt magnets [that will assist in the recovery of tags].

Using feeding locales, vertebral counts, growth rates and the results of these tagging studies, they determined that Sitka, Craig and Auke Bay each hosted a different stock. Later work by Skud (1963) disputed their determinations and found that the Sitka and Craig stocks are subject to intermixing during the summer months and could not be considered separate stocks. In 1977, a tagging study conducted by Carlson confirmed the presence of an Auke Bay stock and “generated evidence that the Ketchikan spawning

stock was isolated and did not migrate to mix with the other stocks" (Carlson 1980:64)[13]. Additional research by Carlson (1984) identified five major stocks of herring based on the location of their wintering grounds: 1) Sitka, 2) Auke Bay, 3) Craig/Hydaburg, 4) Deer Island-Etolin Island (near Wrangell), and 5) Ketchikan. The basis of stock identification, whether it is most accurately defined by spawning site fidelity, vertebral counts, growth rates, and/or wintering grounds continues to be contested and the definition of herring "stock" has been repeatedly redefined.

The definition of stock continues to be debated in fisheries science and management.[14] In 1984, Carlson commented that "a stock is whatever anyone wishes to define it as the term has been so overused that it lacks a unique meaning in fishery science" (5). In 1943, Dahlgren and Kolloen defined stocks as:

> Individual bodies of fish which do not mingle with adjacent groups, but which remain as distinct stocks with feeding and spawning grounds separate from the others and with different migration patterns. The verity of these assertions has

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[13] Whether this designation of a "Ketchikan spawning stock" refers to just Kah Shakes or the entire Revilla Channel is unclear.

[14] Early stock designations were based upon vertebral counts, spatial temporal distribution, behavioral and biological characteristics (Carlson 1980, Skud 1963), allele frequency (Grant 1979), and tagging experiments (Rounsefell and Dahlgren 1935, Dahlgren and Kolloen 1943, Carlson 1977). More recently in Alaska, otolith analysis (Meuret-Woody 2007), and fatty acid signature are methods of stock identification being examined by the Herring Stock ID Project supported by the Alaska Department of Fish and Game, the National Marine Fisheries Service-Auke Bay Lab, and the University of Alaska-Fairbanks (www.herringstockid.info). As new technologies are introduced into the field of biology, the question of herring stock identification continues to be revisited.

> been established by the statistical analysis of biometrical data (racial analysis) and by extensive tagging programs (Dahlgren and Kolloen 1943).

In 1980, Hourston was the first to define a stock in relation to an economically influenced management strategy as, “an aggregation of fish which is capable of supporting a geographically distinct roe fishery” (1980:80). Carlson defined a stock based on spawning and wintering site fidelity: “A group of herring that maintain their identity by utilizing certain spawning and wintering grounds within the same geographic area from year to year and have negligible exchange with other similarly defined stocks” (1984:6). Brown et al. offered the following definition: “A geographic unit of herring spawning and recruitment that responds to environmental forcing in unison” (2001:335).

Most recently, on April 2, 2007, the definition of a herring stock again became a source of discussion in southeast Alaska when the Sierra Club of Juneau submitted a petition to list the Lynn Canal *Stock* of Pacific Herring as a Threatened Or Endangered Species (Federal Register 72(174):51619-51621, emphasis added). The petition initiated a review of the scientific evidence and elicited public comment on the subject. As part of this determination, a distinction was made between migratory and resident stocks. Migratory stocks were defined as herring that are "long-lived and make extensive summer feeding migrations" (ADFG 2008:7) and resident stocks were defined as those stocks that "make comparatively very short feeding migrations (or no migrations at all)" (7). The identification of herring stocks throughout southeast Alaska have undergone periodic changes as more knowledge has been attained regarding non-linear equilibrium

models, herring physiology, biology and behavioral patterns including feeding, spawning site fidelity and migration patterns.

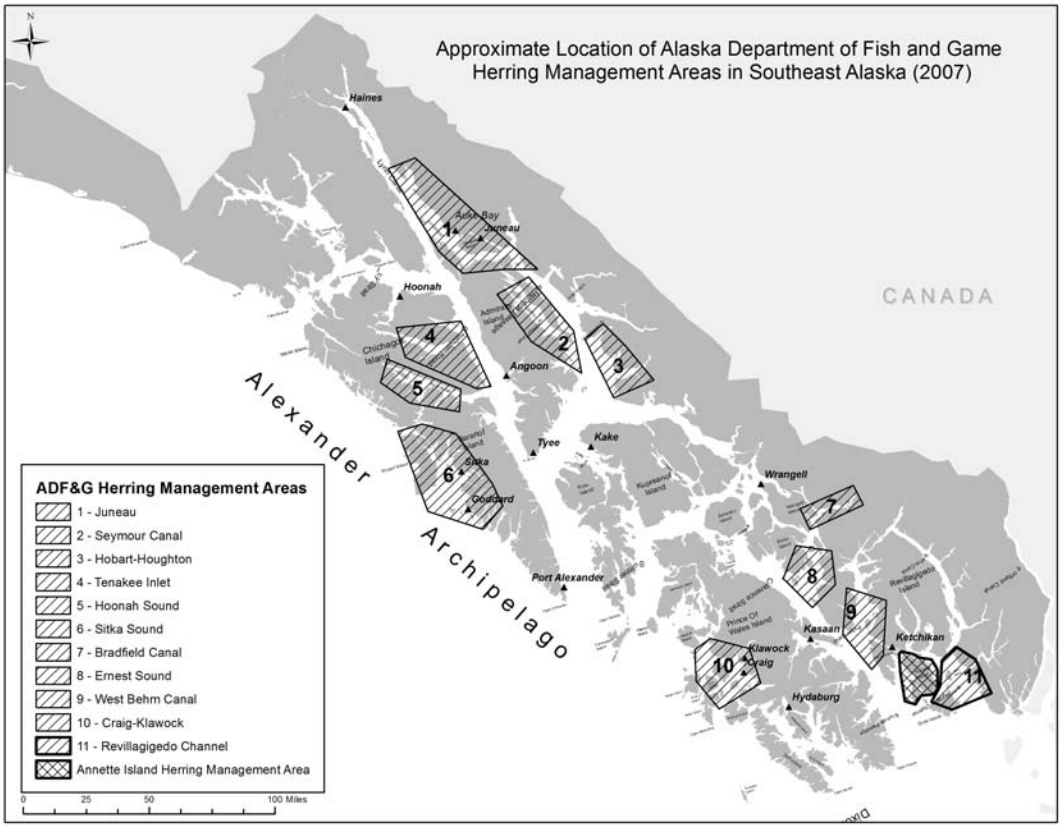

Figure 14: Approximate Locations of Alaska Department of Fish and Game Herring Management Areas in Southeast Alaska

Many Ketchikan residents question whether ADFG stock management areas reflect these changing definitions. Stock assessments have been conducted "each fall by the Alaska Department of Fish and Game at nine spawning areas in southeastern Alaska for most years since 1980" (Dressel et al. 2006:1). However, ADFG fails to differentiate between migratory and resident stocks as part of current management practices. Rather, ADFG recognized only a "management stock," defined in Section 16.05.940.(16) as "a

species, subspecies, geographic grouping or other category of fish manageable as a unit." Based on this definition, ADFG has divided southeast Alaska into eleven management areas (see Figure 12). The Kah Shakes herring management boundary was first established 1976 (see Figure 5), presumably based upon the tagging studies performed by Skud (1963) and Carlson (1984) as described above. However, stock admixture in the waters surrounding Ketchikan that may result as a function of overlapping migration routes is still a hotly debated subject despite previous scientific determinations.

Many Ketchikan residents are critical of the stock assessment performed and scientific evidence presented by ADFG to rationalize the boundary change at Kah Shakes in 1991. As Ralph Guthrie passionately explains:

> Well what the Fish and Game says, [that the herring moved to Annette Island] and this is where you can look at it and if you ask them this question, you know, they say it's all one stock of herring in Southeast Alaska. Well, that's bullshit. You know, that's just pure bullshit. And a good example is down on the Foggy Bay shore [within the Kah Shakes ADFG commercial fishery jurisdiction]. They [ADFG permitted fishermen] fished there for 15 years and all the sudden there was no fish on Foggy Bay … So what the Fish and Game says is, "Well, the herring moved over to Cat Island (Guthrie 2008).

When ADFG asserted that the herring that spawned at Kah Shakes, Cat Island, and Annette Island were of one stock, the Revillagigedo Channel Stock, this definition ran counter to the LEK that identified two distinct stocks in the channel: one that traditionally spawned at Kah Shakes and one that traditionally spawned at Annette Island. When herring began to spawn at Cat and Dog Islands in 1991, this was considered to be a

mixture of the two stocks by both the LEK and scientific evidence presented by Annette Island fisheries biologists (coincident data).

Both Hap Leon, the fisheries biologist for Annette Island who monitored the event (management discourse) and members of the Herring Coalition (LEK discourse) believe that some of the herring that arrived at Cat Island during the 1991 sac roe season originated from Annette Island, a separate stock than the one that traditionally spawned at Kah Shakes. The major concern here is that if the herring that spawned at Cat Island represented an admixture of herring from Kah Shakes and Annette Island, the expansion of the ADFG management boundaries to include not only Kah Shakes waters, but also the shores of Cat and Dog Islands, caused the ADFG harvest threshold to become falsely inflated: that the threshold and therefore the quota calculated for the Kah Shakes sac roe harvest included Annette Island fish.

Andy Rauwolf, co-founder of the Herring Coalition, describes the resultant overlapping fishing strategies as ‘double-dipping’ and credits the Kah Shakes boundary change with the ultimate collapse of the Kah Shakes herring sac roe fishery. The following is an excerpt from an article written by Andy Rauwolf, Lawrence ‘Snapper’ Carson and John Harrington, published in SitNews in 2006 that describes the Herring Coalition’s concerns:

> During the last half of March, 1991, ADF&G saw what they said were "large schools of herring" in deep water off Kah Shakes. On March 28th, Kah Shakes was placed on a 12 hour notice. On April 4th, three miles of spawn were observed thirteen miles west on Cat Island. On April 5th and 6th, the department monitored more spawn at Cat Island but couldn't find as many schools of herring as they

> thought they had seen on their depth finders earlier at Kah Shakes. The department kept the gillnet fleet appraised of the spawning on Cat Island. "There were many opinions expressed that the area should be opened for them."
>
> ADF&G scheduled this fishery for 10:45 AM on April 8th at Cat Island. Prior to the start of the fishery, Annette Island biologists came on board ADF&G's vessel to protest the fishery and explain that they had tracked these herring from Annette Island. ADF&G ignored this protest and opened the fishery. At that moment, ADF&G violated three of its own rules. They conducted a sac roe fishery outside of the designated legal boundary with no data or history of the area, they opened a fishery in which two separate agencies could be targeting the same stock of herring and they allowed a fishery on a mixed-stock which is a spawning biomass originating from more than one discrete stock.

Herring returned to spawn at Annette Island and Kah Shakes (though very few) the following commercial fishing season in the spring of 1992. Again, herring arrived at Cat and Dog Islands to spawn, but this time, within the expanded ADFG management area, these fish were included in pre-season biomass estimates on which harvest levels were calculated. By combining fish from these two areas, the threshold was met, and again, state permitted commercial fishermen were allowed to harvest at Cat and Dog Islands in addition to the traditional spawning areas at Kah Shakes. If the fish at Cat and Dog Islands were indeed a mixed stock as the Herring Coalition and Annette Island fisheries biologists assert, then fish from Annette Island that traveled to Cat and Dog Islands may have falsely inflated pre-season biomass estimates and therefore increased the harvest quota to unsustainable levels. These observations by the Herring Coalition and Annette Island fisheries biologists question the wisdom of ADFG fisheries management that allowed the Annette Island permitted fishers and then State permitted fishers to harvest sac roe from the same herring stock.

The ADFG argued that the herring that arrived to spawn at Cat Island during the 1991 sac roe season were composed of only one stock of herring, that the fish at Annette Island and Kah Shakes comprised one population of fish, the Revillagigedo Channel stock. The herring from Kah Shakes, seeking calmer waters in which to spawn, traversed the Revillagigedo Channel and settled around Cat Island. For this reason, ADFG found it acceptable to expand the Kah Shakes fishery boundary to include Cat and Dog Islands. Scott Walker, fisheries biologist for ADFG explained it this way:

> So we fished in Kah Shakes. The fish moved to, they moved east to Cat, Dog and Mary Island. We moved with them. We had a commercial fishery. Annette Island felt that we were catching their fish and so they sued us. So it was about a two-year process. They sued us. The judge decided that those were indeed State fish, or they were indeed one stock of fish; that we weren't just catching Annette Island's fish which were a separate stock. So we were catching fish from the Revilla Stock and—which was perfectly legal for us to do. And not solely based—we were not just catching stock that solely lived in Annette Island waters.
>
> So ever since that, instead of really calling that Kah Shakes or Kah Shakes/Cat Island Stock, we just call it the Revilla Channel Stock (Walker 2008).

However, upon further examination, it becomes clear that the migratory behavior and possibility of stock admixture of herring in the Revillagigedo Channel and herring throughout southeast Alaska is not fully known or understood by ADFG:

> We know the Craig stock winters in Boca de Fines and Ursa Channel and Buccareli Bay and Meares Passage because we've done hydro acoustic surveys of this over the years past and we have a winter bait fishery … So now we know that these fish move in and the sea lions follow them in. You know, I guess this is something a little bit less known. We don't know for sure that some of these don't even come over clear around over to Kah Shakes. Or some of these may even go clear up to Sitka, which our tagging evidence does suggest a few of these might.

> So we don't know what percentage, or even who knows, even goes up to other places (Walker 2008).

After the final closure in 1991, ADFG continued to monitor spawning activity at both Kah Shakes and Cat Island, collecting age, weight and length (AWL) data from both test fisheries and commercial catch. These data were compared to similar data collected from the Annette Island herring that had been collected by an Annette Island Reserve biologist. Statistical comparisons were made by ADFG to determine if the fish at Cat Island were more similar to those at Annette, or those at Kah Shakes. Age-structured analysis (ASA) was also performed on the abundance of fish at Annette and at Kah Shakes to determine if year-class-specific declines could be identified. From these statistical calculations, it was found that there were significantly higher numbers of age-2 herring at Annette Island, and significantly more age-3 fish at Cat Island than from Annette Island, and significantly more age-3 fish at Kah Shakes than at either Cat Island or Annette Island. According to the 1991 Board of Fisheries Briefing Document prepared by ADFG fisheries biologists, "The differing age compositions do not necessarily indicate different stocks" (ADFG 1991: 10). However, ADFG cannot fully conclude that the herring at Cat Island were of the same management stock as those that had spawned at Kah Shakes in previous years. As stated by ADFG, "The differing age compositions do not necessarily indicate different stocks. Differences in sampling and ageing techniques between Annette Island and Cat Island/Kah Shakes,[sic] may confound the interpretation

of age composition analyses" (ADFG 1991:10). It is this level of uncertainty in the scientific evidence that concerned members of the Herring Coalition[15].

Despite many years of scientific investigation by fisheries biologists and annual monitoring by ADFG fisheries biologists, the numbers of stocks present in the Revillagigedo Channel (including Kah Shakes) and the manner in which these fish move throughout the channel remains unclear. This uncertainty is most plainly illustrated in the variable titles used to describe the management stock in the Revillagigedo Channel. When commercial sac roe fishing began at Kah Shakes in 1976, the management stock in the channel was identified as the "Kah Shakes stock." After the boundary change in 1990, the herring became known as the "Kah Shakes/Cat Island stock." Now, to add to clerical confusion and presumably to allow for any further boundary expansions in the future, the management stock is referred to as the "Revilla Channel stock." Walker reiterates: "So ever since that [boundary change], instead of really calling that Kah Shakes or Kah Shakes/Cat Island Stock, we just call it the Revilla Channel Stock" (2008). While it seems to be an argument of semantics, it illustrates the arbitrariness of current

[15] It should also be noted that the accuracy of the ASA model used by ADFG to "estimate abundance, survival rates and maturation rates needed to forecast the biomass of mature herring" (ADFG 2010) and to produce statistical analyses of age composition as an interpretation of stock differentiation at Kah Shakes has recently been called into question at the Sitka Sound commercial herring sac roe fishery. In the Sitka Sound Herring Fishery Announcement published by ADFG on December 16, 2011, "Based on a recent review of the department's herring scale aging methodologies, the department has discovered inconsistencies in methods in aging herring using scales" (ADFG 2010). The ADFG is in the process of revising past ASA data and replacing the current age composition method with a "biomass accounting model." This adds further questions of accuracy to the age composition analysis conducted using ASA methodology and the resultant single stock definition at Kah Shakes in 1991.

management stock boundaries and a lack of knowledge of biological or ecological systems.

I conclude from this analysis of the dissident data that ADFG management stocks do not coincide with the spawning and migration behavior observed by the Annette Fisheries biologists, members of the Herring Coalition and many local Ketchikan residents. I have addressed two levels of conflict that must be reconciled to arrive at a biologically accurate identification of stocks, the political control of scientific classification and the current lack of knowledge regarding herring characteristics that best define a stock. As discussed previously in this chapter, scientific definitions of stocks often change as new technologies and new knowledge of herring behavior and biology are introduced. I have shown that integrating LEK into this process of validation offers another means to expand the knowledge of herring behavior both spatially and temporally. The use of GIS software will help facilitate this introduction of LEK into the scientific method by expanding the knowledge of herring biology and behavior beyond the current arbitrary ADFG management boundaries that may lead to a more biologically accurate definition of stock in relation to the movement of herring throughout its life cycle from ocean to coastline.

Using GIS to Question Stock Definition

The utility of GIS is not only that it can store, process and analyze immense amounts of data, it can also that it can take layers of information away to allow a closer

examination of previously undetermined underlying factors of environmental change. At Kah Shakes, for example, the overlying conflict is one of fisheries managerial boundaries. When the herring chose to move spawning locations in 1991, they gathered around Cat and Dog Islands, an area that lies between two management areas maintained by ADFG and Annette Island. As soon as ADFG filed an emergency order to expand the commercial fishing area to include Cat and Dog Island, a political battle began adding layers of complexity to what still remains an ecological event. Using GIS allows us to get down to those bare bones again, providing the ability to model culturally constructed management boundaries alongside LEK data at multiple scales and thereafter to introduce new hypotheses of stock definition based on observations of herring movement and spawning sites, both past and present, through the oceanscape.

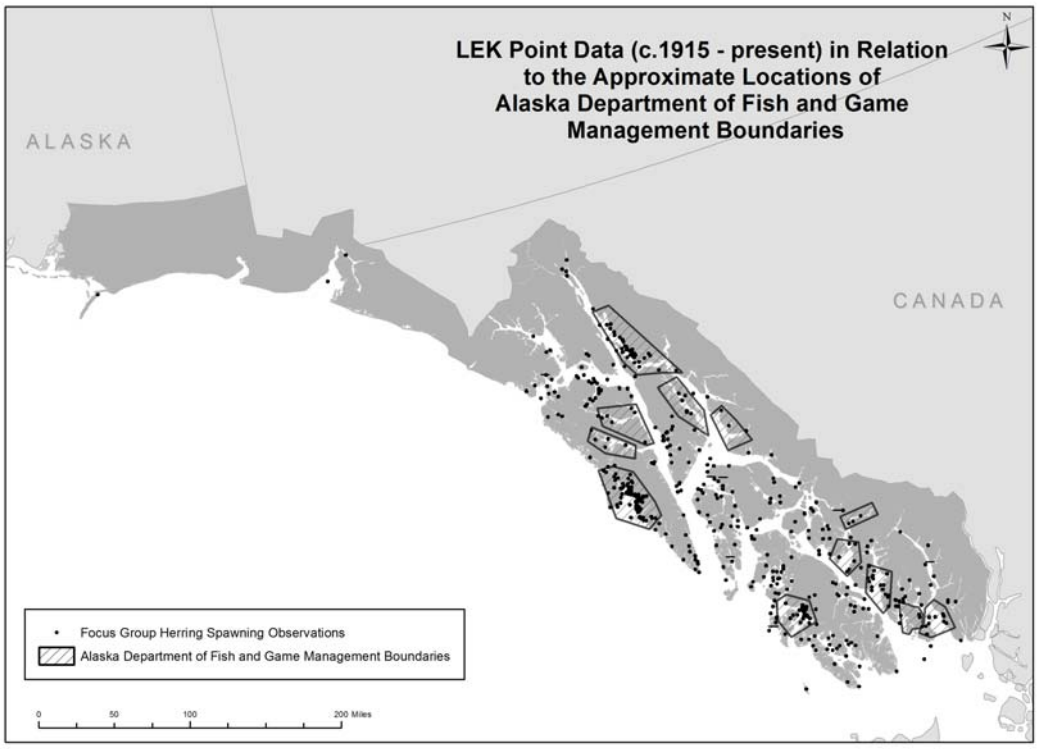

Figure 15: LEK Point Data (c.1915 – present) in Relation to the Approximate Locations of Alaska Department of Fish and Game Management Boundaries (2007).

GIS can be used to show that spawning areas identified by LEK are more extensive than the current ADFG management areas. This incongruence suggests that ADFG's list of spawning areas is not complete. This requires that we, again, take a step back and view the entire region of southeast Alaska, identify those areas defined as management areas, and contrast these with herring spawning and massing areas documented in historical texts and during the interview process.

To do this I first reduced text-based observations of herring spawning areas identified during the comprehensive review of the anthropological and historical

literature, and observations made during the interview process, both where herring have been observed to be in abundance or decline, to point data (for example, Kah Shakes Cove is represented by a point rather than a coastline or polygon) (see Chapter One for a more in-depth discussion of methods and limitations of the data).[16] These observations are shown juxtaposed to the management areas currently defined by ADFG. The result is a visual confirmation that LEK observations are not confined within current herring management boundaries and suggests that scientific inquiry needs to be broadened to include areas not considered commercially significant in order to come to a more complete understanding of herring movement and spawning behavior in the past as well as the present. This, in turn, will allow for a more accurate definition of herring populations or stocks to be formulated.

I have included all areas observed as herring spawn sites though I have included areas of decline *and* abundance. The significance in this method is to include areas that are coincident without excluding areas of dissident observations. Further analysis is required to validate each of these claims. And while they cannot be integrated wholesale into the fisheries management database at this time, it is my hope that the presentation of these LEK observations and this analysis will become a starting point at which interdisciplinary analysis can begin to formulate a more accurate stock definition.

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[16] It should be mentioned that GIS, although it does not include all the cultural context of the point observation, it does recognize LEK as fundamentally emplaced knowledge on par with scientific observations.

Dissident Data: Shifting Baselines and Measures of Decline

Having shown how GIS can systematize LEK by broadening our understanding of herring distribution and stock definition, I now turn to my second example of the usefulness of GIS, namely that current fisheries management is often based on incomplete and temporally shallow knowledge of the very resource it attempts to regulate and conserve (Haggen and Neis 2007). LEK in combination with archival evidence (grey literature, fishing/"naturalist" narratives, fishing vessel logs) has been shown as useful resources for the recalibration of current fisheries management concepts of abundance exposing what Pauly (1995) terms a "shifting baseline" (Arroyo et al. 2005; Johannes and Neis 2007; Brown et al. 2007; Saenz-Arroyo et al. 2006; Ghoti 2003). Roberts explains the effects of shifting baselines as this:

> In my work as a scientist, I find that few people really appreciate how far the oceans have been altered from their preexploitation state, even among professionals like fishery biologists or conservationists. A collective amnesia surrounds changes that happened more than a few decades ago, as hardly anyone reads old books or reports.… The worst part of these "shifting environmental baselines" is that we come to accept the degraded condition of the sea as normal. Those charged with looking after the oceans set themselves unambitious management targets that simply attempt to arrest declines, rather than rebuild to the richer and more productive states that existed in the past (Roberts 2007: xiv-xv).

Fisheries management practices at Kah Shakes are a prime example of this sort of shifting baseline. By the time ADFG began to manage, document and calculate the means to sustain what was considered a "pristine" herring biomass in 1976, the fish had already

been exploited commercially for reduction, canning and winter bait since the 1900s. The reasoning behind this methodology can be found in the history of environmental science when concepts such as “pristine,” virgin biomass, and equilibrium system dynamics were translated into fisheries management practices as calculated maximum sustainable yield (MSY), threshold, quota, and formulaic stock-recruitment models.

Environmental history of the 1970s incorporated ecological definitions such as “pristine” wilderness and ecosystem equilibrium into an ecological managerial discourse of Man as the antithesis to Nature (Neumann 2005). Management was not so much directed toward conservation as preservation of the commons. Hardin’s “tragedy of the commons,” the idea that “resources held in common are vulnerable to overexploitation” (Berkes et al. 1989:91), became popular during this period, and privatization and regulation of common property was viewed by resource managers as the only means of resource protection. Continual research over the following decades has suggested that Man-Nature dynamics are not this simple, “that communities dependent upon common-property resources have adopted various institutional arrangements to manage…resources” (Berkes et al. 1989:91). Management of resources no longer exclusively meant preservation by means of the exclusion of humans. Instead, managers began to recognize, and in some instances, expand upon conservative measures already in place by native resource users.

Alongside these theoretical changes in resource management, it became apparent that conservation methodology premised upon definitions of such concepts as

"deforestation," and "desertification" (Forsyth 2003; Adger, et al., 2001) should be reexamined as part of a historical context that does not presuppose a climatic or homeostatic, linear ecology (Neumann 2005, Acheson and Wilson 1996). The effects of this theoretical paradigm are manifest in the calculated maximum sustainable yield (MSY), measures of abundance, threshold calculations and quota computations that form the basis for herring fisheries management in southeast Alaska. Each of these variables is input into formulaic stock-recruitment models created to maximize economic return while maintaining the same abundance of herring that was present when management first began in the 1970s.

These formulaic stock-recruitment models rely on maintaining system equilibrium by limiting fishing effort through calculated quotas and threshold levels to maintain maximum sustainable yield (MSY). In theory, maintaining an exploitation rate based on the ratio of stock size to MSY allows levels of abundance to remain near the environmental carrying capacity or virgin biomass: the level of abundance that a fish population would reach in the absence of harvesting pressures, where only environmental factors such as food, space and natural predation would limit population growth. MSY calculations attempt to predict at what harvest rate the population will be both sustained and yet provide maximum product for the economic market (Hilborn et al. 2003; Blankenbeckler 1980). The concept of MSY continues to influence fisheries management in the US where "target exploitation rates are tied to the estimated stock size in relation to

virgin biomass" (Hilborn 2003:378). When a stock is estimated to be 40% above the virgin biomass, this is considered a threshold. But what, exactly, is a "virgin biomass"?

The concept of MSY appear to be, and could be, a perfectly valid method by which to conserve commercially harvested fish populations such as herring. The problem then, is not with the formula, but with one of the concepts on which this formula relies: "virgin biomass." Herring have been harvested commercially in southeast Alaska since the late 1800s. "Many people estimate there are presently less than 2% of historic levels of the early to mid-1900s" (Rauwolf et al. 2004:2). ADFG and Annette Island management of herring fisheries began, in earnest, in the late 1970s when sac roe became a lucrative commercial product. Current fisheries management paradigms fail to account for the effect that nearly one hundred years of intensive commercial harvesting has had on the abundance of herring populations in southeast Alaskan waters. Management based on the maintenance of a "virgin biomass" (calculated by ADFG in the late 1970s) is faulty, or at best, unexamined. Both historical documentation and local ecological knowledge present ample evidence that herring abundance has fallen drastically due to extended and intensive commercial herring harvesting. LEK observations can be used to recalibrate perceptions of "pristine" by alluding to these past levels of abundance.

Using LEK to Recalibrate Shifting Baselines

Historic documentation and LEK observations gathered during the interview process suggest that herring populations have been in decline for as many years as they

have been subject to commercial fishing (Thornton et al. 2010). As shown above, the first signs of decline may have been apparent as early as 1939, when herring fishing for reduction plants was temporarily prohibited in 1942 when all herring harvesting throughout southeast Alaska was disallowed for a time. Reduction fishing began again in 1948, but was short lived. Although a decreased market demand for reduction products (fish meal and oil) may have been a factor in these closures, declining herring populations should also be considered as fishermen supplying these plants had to continually increase the distance and time spent searching for herring schools to harvest (Cobb 1906, Huizer 1952). Unregulated bait fishing continued at this time. By the time herring in southeast Alaska became a viable commodity on the commercial sac roe market and subject to fisheries management by ADFG, these fish had already been intensively harvested since the early 1900s. What ADFG considers a pristine biomass, or initial level of abundance, may actually be only a fraction of the original population of herring that once inhabited southeast Alaskan waters. This would mean that ADFG is working to maintain an already depleted herring population—a shifted baseline. As shown by this research and analysis, local ecological knowledge may offer a means by which current fisheries management models can begin to factor in historical levels of abundance and recalibrate current harvest levels to increase sustainable fisheries practice.

Multiple studies find that LEK can be utilized to correct inaccurate management models (Johannes and Nies 2007, Baelde 2007, Mathooko 2005). In an example provided by Johannes and Nies, fishers were able to describe how coral reef fish larvae will

migrate away from rearing grounds toward reefs once they reach a certain level of maturity. “Biologists confirmed the observation 15 years later but until then had been creating and using models to manage these fish based on erroneous data” (Johannes and Nies 2007:46). The authors go on to say that:

> Marine fishers and hunters often know a lot about how the distribution and abundance of marine animals vary from year to year with type of habitat, season, weather, time of day, stage of tidal cycles, lunar phase and other factors. They can also often relate important observations about behaviours of marine animals that contribute to these changing distributions and abundances (Johannes and Neis 2007:47).

LEK can be used to recalibrate the scientific evidence that current fisheries management, and more specifically concepts of “pristine” biomass, are based on. For example, in a study of Gulf groupers (*Mycteroperca jordani*, Serranidae) by Arroyo et al. (2005), information was collected and analyzed from grey literature, naturalists’ observations and LEK provided by interviews conducted with 108 fishermen from three generations, in 11 communities in central Baja California. The authors conclude that “Contrary to what the statistics suggest, it appears that Gulf grouper stocks collapsed in the early 1970s long before modern statistics started being collected” (Arroyo et al. 2005). Similar evidence for herring population decline can be found in the literature as early as 1855, further substantiation that when ADFG began managing and maintaining biomass as a function of commercial sac roe fisheries in the 1970s, the herring population had already been reduced by intensive harvesting techniques (reduction, canning, bait) for over seventy years.

When herring populations in Britain's waters were reduced by overfishing in 1855, John Cleghorn, in a report read before the Statistical Section of the British Association for the Advancement of Science at Liverpool on September 26, 1854, produced a narrative that has become all too familiar to fisheries around the world, including southeast Alaska:

> May we not have drawn over liberally on our shoals of herring? With such appliances may we not have overfished the sea? That a river or lake may be overfished, or that the whales between the tropics and at the poles may have their numbers so thinned that the fishing would cease to pay, will be readily conceded; but nobody here ever dreams of imputing the failures in the herring fishing to our having overdone it. The Commissioners for the British fisheries, in their Report for 1850, hint that overfishing has told on the cod and ling.… [The Commissioners are quoted,] 'By the statements of the fishermen generally, it appears that the boats are almost everywhere obliged to go further from the land than formerly before they find fish; and hence it is assumed either that the fish have changed their runs on account of the fishing that has been carried on, or that the fishing grounds near the shore have been overfished'" (Cleghorn 1855:241).

Intensive fishing in British waters caused herring populations to decline and ultimately collapse in the early 1900s, though warning signs were apparent in 1850.

Evidence for declining herring populations in southeast Alaska can be found in one of the first reports generated for the 1905 fishing season regarding the productivity of the herring reduction fishery at Kootznahoo Inlet in Chatham Strait by John N. Cobb, one of the first authors to record reduction plant catch data for southeast Alaska for the US Bureau of Commercial Fisheries: "For many years the inlet at Kootznahoo, on Chatham Strait, was the favorite resort for herring, but they are much less abundant now, owing, it is claimed, to the constant fishing for them with purse seines, which breaks up the

schools and drives them away" (Cobb 1906:21). As a result, fishermen employed by the herring reduction plant had to expand their search for herring, an indication that herring populations may have been in a state of decline as early as 1905 calling into question the baseline standard established by ADFG in the 1970s as a "pristine" biomass.

A similar question can be asked about the herring populations in the waters surrounding Ketchikan. Observations of herring decline in the waters surrounding Ketchikan have been recorded as early as 1920. The Thursday, February 5th edition of the Ketchikan Weekly ran the following story headline, "Whale Killing Cause Herring Fishing Short." A short excerpt follows:

> Capt. Gunderson of the boat Pirate stated about the lack of herring this winter that this is the poorest winter for herring for many years….
> Capt. Gunderson said that there are great schools of herring out side [sic] but as the whales are being killed off so extensively there is nothing to drive the herring in to the bays where the fishermen can catch them….
>
> It is indeed noticeable that the herring are not coming in as they used to, also that the whales no longer can be seen in Clarance [sic] Straits and these in side [sic] waters as they were ten years ago or less (1920:1).

Seven years later, this headline ran in the Ketchikan Alaska Chronicle on January 27, 1926: "Herring Bait Supply Short is Assertion." The article states that "The bait situation in Southeastern Alaska was described as acute with less than 50 per cent of the necessary bait frozen. The committee [Executive Committee of the Commercial Club of Ketchikan] reported a shortage of herring in the areas now open to fishing" (1926:1). Another headline describing herring shortages appeared in 1938.

The herring shortage in Ketchikan's waters became so problematic in 1938 that frozen bait had to be imported from outside suppliers. An article in the Ketchikan Alaska Chronicle, published on March 4 of that year states that, "In order to supply the demand for frozen herring for bait here until such time as herring can be caught near Ketchikan, the first of several boat loads of frozen herring from the Prince Rupert cold storage was brought in today by the Canadian boat W.R. Lord …. Although two local herring boats have been scouting nearby waters for many weeks, herring have not as yet shown up here." LEK observations support the perspectives presented in these historical texts, that herring have been in decline for decades.

Sonny Deagan, a fisherman and resident of Alaska since the 1950s, confirmed that herring were once harvested for reduction purposes in Chatham Strait:

> In the 30s, 40s and 50s there were herring reduction plants in Port Armstrong, Port Conclusion, Port Lucy Port Herbert, Big Port Walter, Washington Bay, Rowan Bay and these are the ones I can remember off the top of my head. These plants operated for many years and all of the herring were caught right out in Chatam Straights [sic] (Deagan 1993).

Despite the fact the herring plant in Chatham Strait closed in 1916, herring no longer school at this location in sufficient quantities to harvest sac roe or bait, evidence that local residents had begun to make observations of herring decline during the reduction era.

Another often-repeated observation by local residents during the course of this project is that herring have disappeared from the water directly in front of Ketchikan, often referred to as City Float. Arnold Ludwigsen, a retired commercial troller, remembers when, "Herring [bait] fishermen were able to meet their herring needs in the

Revillagigedo Channel right in front of the City [sic] of Ketchikan" (Ludwigsen 1993). Joe R. Hassell has been a Ketchikan resident since 1949. He remembers the abundance of herring around the docks in Ketchikan in the 1950s:

> I recall very vividly the huge, unlimited schools of herring around the docks, log booms, and the boils out in the straits. From a skiff, we used a herring rake to catch herring for bait. It was a grand extension of my earlier years, upon arriving in Ketchikan in 1949, to see that the same conditions existed here, as the abundant salmon fishing and huge herring population was extremely impressive in the Ketchikan area. In the early 50s, we put up our own herring in salt, and froze some as well. The herring were plentiful, and one could select any size desired. There were no problems obtaining as many as one could use, with a hoop-net, from the docks and floats around the entire area. The cold storage put up frozen bait each year, which were caught by seining, in front of town (Hassell 1993).

Today, both commercial and subsistence, herring fishermen, must search elsewhere to locate herring schools.

Multiple photographs exist as testament to this practice and give an indication of past herring abundance (see Figure 14). A similar photograph was published in the Ketchikan Alaska Chronicle on December 5, 1945. The caption reads:

> The herring season is in full swing along Ketchikan's waterfront where nearly every day the seiner Rio Grande, owned by Frank Murphy and operated by him and Herry Selig, can be seen making a set, as pictured here. The ever-present seagulls also welcome the herring season, finding food plentiful in the fishermen's nets.

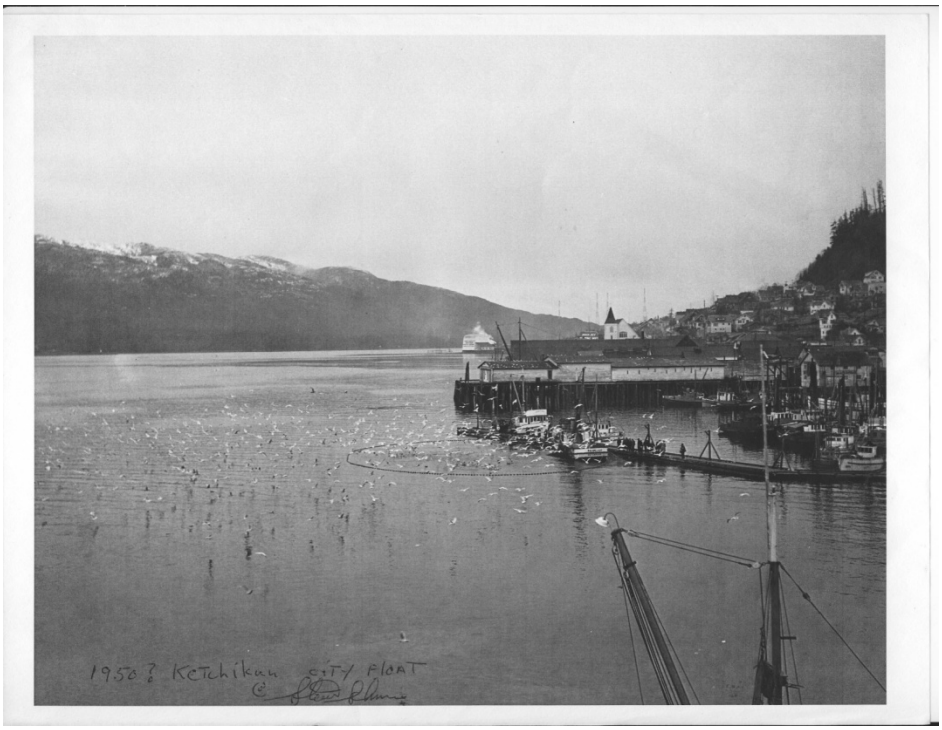

Figure 16: Commercial sac roe fishing at City Float, Ketchikan c. 1950. *Photo courtesy of Steve Schrum.*

This description attests to the abundance of herring once found at City Float in front of Ketchikan. The City Float continued to be utilized by both herring as a spawning location and commercial fishermen as a harvest location as late as 1955. Searching through past publications of The Ketchikan Daily News I found the following excerpt in an article published on February 15th of that year:

> One of the most interesting aspects of herring seining in this area is that when the small fish have their run in the winter, seining operations can be carried on most anywhere along the waterfront. This season, most of the fishing season was done inside of the city float boat harbor.

According to LEK observations by local residents, herring have not been seen at these levels of abundance for many, many years. ADFG documentation, however, reports no

such decline despite further evidence gathered from historical data sources, possibly an indication incompatible equilibrium models between discourses.

During my review of historical documentation found at the Tongass Historical Museum in Ketchikan, I found that concern regarding herring decline in the Ketchikan area was first documented in 1985, in a letter I located in the Herring Coalition archives, written by Dick Borch, President of the Alaska Sports and Wildlife Club and sent to Senators Frank H. Murkowski, Robert H. Ziegler and Ted Stevens, then a member of the Committee on Appropriations in the Senate, and Department of Fish and Game Commissioner, Don Collingsworth. The letter, written March 1, 1985 begins:

> As you are aware, there has been growing concern over the Herring Roe Fishery for several years. Our membership, which has been increasing rapidly, has indicated to its Directors a solid backing in pursuing efforts to end this needless depletion of our herring stocks.
>
> We have had several meetings on this subject, which included not only our members, but other sportsmen, charter groups and commercial seiners, trollers and gillnetters. All groups oppose the continuation of taking herring for roe.

Borch's letter was published in the *New Alaskan* in April of 1985 with commentary by Bob Pickrell. Pickrell's commentary begins:

> We have a perspective that is unique to a specific situation. From our vantage point, only several yards from tidewater, we have watched the steady decline over twenty-five years of one of God's special creations – the Herring [sic].
>
> Science is basically the discipline of observation … be it a controlled chemical reaction or tagging salmon. Scientists repeat tests and if the results are observed to be similar or the same over a period of time they arrive at a conclusion or theory. They can then predict with some authority future actions or reactions of the subject studied.
>
> Concerning several hundred acres of waters adjacent to the area where we live and work – we believe we qualify as an expert.

In May of 1986, Pickrell wrote another commentary in The New Alaskan: “It seems like a futile crusade but as the fishing season approaches we again raise a lonely voice to condemn the sac roe herring fishery” (Pickrell 1986). Many local residents continue to voice concern about the effect of the commercial sac roe fisheries on the health of herring populations and the predators that depend on these fish as a food source.

During the course of the interview process, many local residents observed a decline in herring populations in the regions surrounding Ketchikan and beyond. Spawning locations have disappeared, predator populations are suffering and according to some informants, the closure of Kah Shakes/Revillagigedo commercial fishery is a testimony to these declines. Thomas B. Ramiskey, a Ketchikan resident since 1954, describes the decline of herring and the effects this has had on the predator populations in Tongass Narrows:

> Upon arriving in Ketchikan, I believe that what impressed me the most was the life that I observed while being on the water or watching from the beach. Tongass Narrows was really alive not too many years ago! There were thousands of gulls and diving ducks, hundreds of eagles soaring overhead, and herds of sea lions during the winter when great masses of herring flooded the narrows! (Ramiskey 1993).

Sonny Campbell, an Alaskan resident of 32 years and a sport fisherman by profession, remarked on herring massing at Thorne Bay: “I remember thinking at the time, how can there be so many fish in the ocean. I would stand on the dock and watch in awe as this huge blanket of Herring, around the docks and in the bay, moved below me [at Thorne Bay]” (Campbell, 1993). Dan McQueen has lived in SE Alaska since 1981 and in 1993

operated his own saltwater guiding service. In the affidavit he submitted to the courts as a member of the Herring Coalition, he comments that:

> I am worried about the lack of herring and feel that the herring sac roe harvest is to blame. But I'm not a Science Proffesser [sic]. I do have eyes and I don't see any herring as I have stated. I feel this decline is due to the commercial herring sac roe and bait fisheries in SE Alaska (McQueen 1993).

These sentiments are echoed throughout the fifty-seven affidavits submitted as testimony in support of the closure of Kah Shakes by the Herring Coalition in the 1993 injunction and was repeated by many of the interview informants and historical documentation consulted as part of this project.

The management discourse presented by ADFG fisheries biologists runs counter to these LEK assessments of herring decline. ADFG, with support from some local residents and commercial fishermen, is insistent that the herring populations at Kah Shakes are healthy, have not suffered collapse but instead have moved to Annette Island to spawn, out of reach of State jurisdiction. Phil Doherty, the state area management biologist for commercial fishing during the 1990 boundary change was quoted in the *Ketchikan Daily News* ten years later as saying:

> If you actually look at the overall return of herring to that area down there and if you add Kah Shakes, Cat Island and then add on the spawning biomass that happened over on Annette Island, the returning herring to the area was pretty much what the state had forecasted…. It actually wasn't a decline in herring stocks. It was just another movement of fish" (Friedel 2000:1).

David Carlile, ADFG Southeast region biometrician describes the causes of this herring movement: "I don't doubt people now don't see herring where they formally did.…

There is data showing that herring will leave an area or disappear due to natural factors, environmental factors and stock movement" (Chase 1993b:A-3). Scott Walker, current fisheries biologist for ADFG, echoes these sentiments. "I know that probably within my lifetime, those herring will move back out of Annette Island and then we'll have fisheries again. But right now, they have that stock is predominately spawning in Annette Island waters" (Walker 2008). I found very little support for this assessment during the focus group interview, during the individual interview process, or in the historical documentation, but there are some Ketchikan residents including commercial fishermen that agree that the fish population that once spawned at Kah Shakes have simply moved, rather than suffered collapse. Jev Shelton, a commercial gillnet fisherman in Juneau (2007), is in concordance with ADFG personnel, that the fish at Kah Shakes herring population "simply left the area…and spawned near Annette Island and other areas." He does not speculate about the possible return of these fish to Kah Shakes waters in the future.

The Herring Coalition and many more local residents, fishers and non-fishers alike, repeatedly describe declining populations of herring in Ketchikan and the surrounding areas and yet the scientific evidence presented by ADFG disputes these observations. The source of this conflict may be a shifting baseline compounded by a homeostatic perception of herring population dynamics. The MSY, stock-recruitment model that ADFG uses to calculate harvest quotas and threshold levels is based on the concept of system equilibrium using temporally shallow data gathered since the 1970s.

LEK holders may also anticipate herring fluctuations as a function of system equilibrium dynamics. Local residents, including members of the Herring Coalition, perceive measures of decline along a much older time frame, some as early as the 1920s indicating that ADFG is currently managing an already depleted level of herring abundance.

The reconciliation of these dissident discourses with consideration of non-equilibrium models is imperative for effective management of this important resource. Integration of LEK into the current fisheries management could recalibrate measures of what is considered to be a sustainable, possibly decreasing current allowable harvest levels and pinpointing the need for further research to determine if further conservation measures are needed to bring herring levels back up to historic levels to maintain ecosystem health and the economic viability of commercial fisheries. GIS can assist in this integration and recalibration.

Using GIS to Integrate LEK and Account for Shifting Baselines

GIS also has the potential to integrate a temporal component, though these capabilities are largely lacking in GIS software in general at this time. I have provided one example of how this modeling can be accomplished. Skud (1959) provided maps illustrating where he identified herring during three years of researching the variation of herring spawning areas (1953, 1954 and 1955). Using these data, I created scanned images of the Skud maps and georeferenced them onto a map of the southeast Alaska coastline (a technique that can be visualized as laying one map over the other and tracing

the information from one on to the other). The largest circles represent the earliest observations made by Skud in 1953. Each successive observation is represented by a smaller and smaller circle to represent a succession of herring observations over time.

Using this symbology, both the earliest and the latest observations remain visible at all times. In Skud's report, he recorded, in tabular form, whether herring were absent or present during each year of research. I've also integrated this component into the symbology: a white circle represents the absence of herring, while a grey circle represents the presence of herring. Herring, as illustrated by Skud's (1959) scientifically controlled observations, spawn consistently at certain locations as shown by the succession of grey dots in Figure 15. Most of these observations of consistency were made near Craig on Prince of Wales Island. As shown in many more locations, herring may spawn there one year and then disappear for a year, only to reappear at the same location the next. These areas are represented by a mixture of overlain black and grey dots. Most importantly, it reveals just how "spotty" herring spawning behavior really is and how much research needs to be done to clarify the temporal consistency of herring spawning behavior.

The variation of spawning locations illustrated by the Skud map raises an important issue: herring move in unpredictable ways. The situation is similar to that experienced by salmon fisheries managers in the 1900s:

> Without modern methods of determining fish returns and without an approach that considered the entire life cycle of the salmon, however, conservation managers were shooting tin the dark. They were also driven primarily by economic and political imperatives rather than ecological concerns. It is no surprise, therefore, that salmon were uncooperative to the ambitious designs of salmon managers (Arnold 2008:90).

The same can be said about herring fisheries managers today, a hundred years later. Issues of herring spawning site fidelity and stock locations remain uncertain because there simply is not enough known about herring movement through the oceanscape to make accurate predictions of herring health or commercial sustainability.

Observations of herring decline may be an artifact of homeostatic versions of ecological analyses. Are suggestions that herring populations are in decline, merely noting a level of abundance in the past that, when subject to non-linear analysis, is not required or expected to return to the exact same location, but rather - move? If this is the case, ADFG may be correct when they describe a herring movement away from Kah Shakes, to Cat and Dog Island and then to Annette Island. Perhaps ADFG is correct in their predictions that herring will once again return to Kah Shakes.

The possibility must remain open, but I argue against it. Both fisheries managers and LEK holders identify some degree of herring spawning site fidelity. ADFG management areas are presumably created around these areas of high fidelity and in fact describe herring spawning locations within these areas as “traditional” spawning areas (ADFG 2008). Native resource users assert that historically, there have been some reliable locations where people have had a good, steady supply of herring for years. Kah Shakes was one of these areas (Goldschmidt and Haas 1998:118).

I would also point out that event ecology requires an expansion of this analysis outward in space. If Kah Shakes stood alone as the only commercial sac roe fishery to fail to reach threshold and remain closed to commercial fishing, the possibility of herring

movement to Annette Island may gain more plausibility. However, it should be noted that additional closures at Lynn Canal and the West Behm Canal have also been implemented due to low threshold. If these herring are moving, where have then gone? Fully 90% of commercial sac roe harvest now originates from Sitka Sound. Is it possible that herring have migrated here? I, myself, find this unlikely, but concede that the answer is one best addressed through multidisciplinary analyses that are beyond the scope of this thesis.

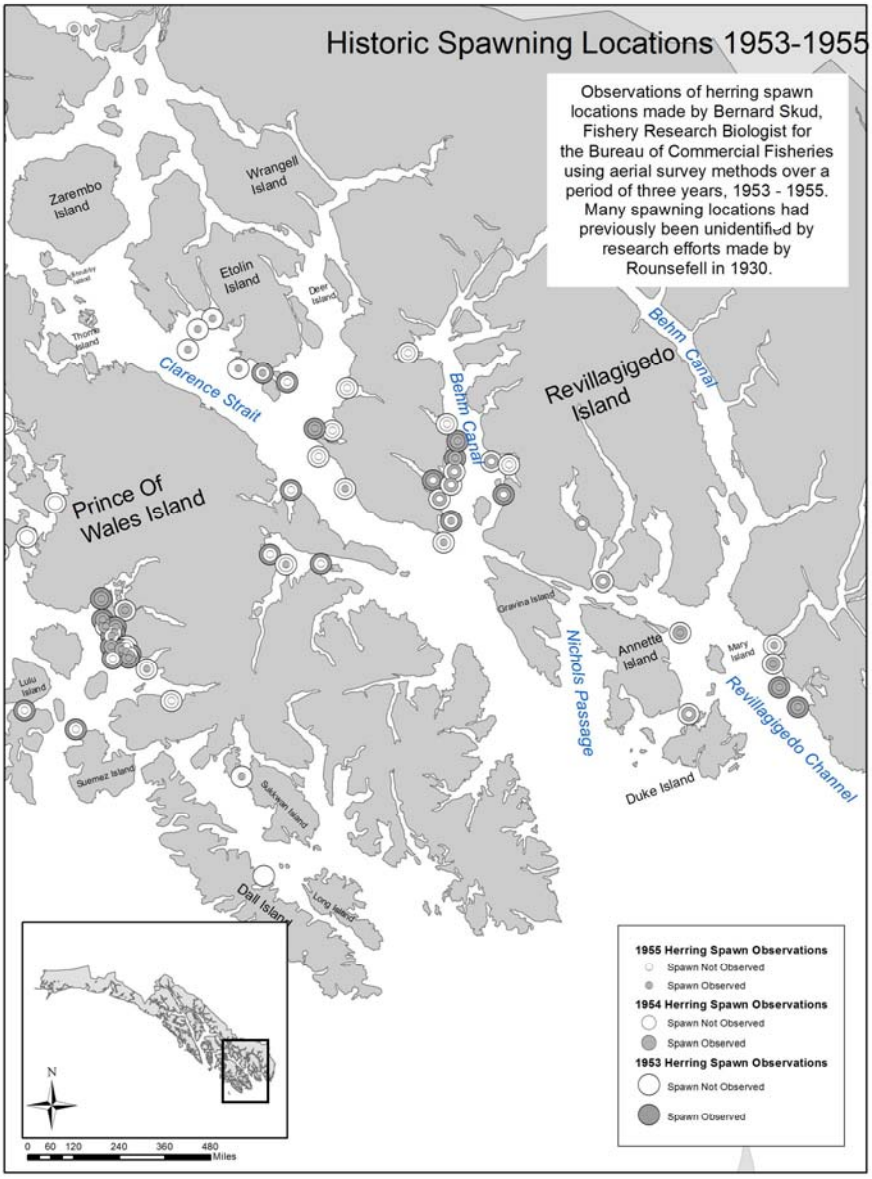

Figure 17: Historic Spawning Locations 1953 – 1955 (from Skud 1959)

The purpose of this example of temporal GIS modeling techniques is to assess the validity of LEK observations that identify past herring spawning locations. As shown in a

previous map, Figure 14, herring have been observed throughout southeast Alaska, many of these locations fall outside of current ADFG management areas. The movement of herring outside of these areas remains unclear. A systematic review of LEK observations may offer an opportunity to fill in these gaps. While direct measures of herring abundance may be impossible, patterns of herring spawn, especially those areas identified as consistent in the past, would allow measures of herring trends to be inferred as the number herring spawning areas either increase, decrease or even remain similar across the oceanscape *and* through time if the LEK can be resolved at some time scale. The results of this analysis will hopefully decrease the effects of a shifting baseline by recalibrating current ADFG conceptualization of a "pristine" biomass causing harvest quotas to change in accordance with these findings.

To summarize this chapter, the disappearance of herring from the traditional herring spawning grounds at Kah Shakes is not disputed. Whether the fish have simply relocated or their disappearance reflects a true population decline is a source of dissidence between the management and LEK discourses, and is a source of contention even between members of the scientific community. Through discourse analysis of the ecological event, it becomes apparent that the struggle is not only for the control of scarce resources, namely herring sac roe, but also for the control of what constitutes scientific evidence. The resolution of these areas of dissidence as they are manifest in the struggle to define herring "stock" and "pristine" biomass and the utilization of GIS as a modeling

tool have the potential to assist in the creation of a more holistic and sustainable herring management paradigm.

Herring stock identification and the very definition of what constitutes a "stock" have been debated within the scientific community since the 1930s and continue to undergo revision as new technologies are introduced and as new knowledge of herring biology, physiology and behavior is established. The dissident data that is present within the management discourse and between the management discourse and LEK discourse at Kah Shakes is a microcosm of this larger conflict. Many local residents, the Herring Coalition and Annette Island fisheries biologists consider the disappearance of herring from Kah Shakes to be the result of inaccurate stock definition by ADFG. The dissidence between these discourses indicates that there is a lack of knowledge regarding the characteristics that best define a herring stock. Integrating LEK into the scientific process of stock identification will provide a means of expanding our knowledge of herring to create a more accurate definition of the term "stock." This should be an interdisciplinary process that integrates knowledge from scientific and ethnographic sources to reveal a more holistic definition that includes the following factors: historical ecology, life-cycle, genetics, migratory routes and multispecies interactions. GIS software possesses the capabilities to model these myriad factors to reveal meaningful patterns of herring biology and movement integral to proper stock definition.

Measures of herring abundance are a second source of dissidence between the management and LEK discourses. ADFG maintains that the herring in the Revillagigedo

Channel are healthy and that management measures are, and always have been, conservative. The disappearance of herring at Kah Shakes is due to the natural movement of herring stocks across the oceanscape. LEK observations and historical documentation collected as part of this project disagree with this assessment. Evidence of herring decline in the waters around Ketchikan is documented as community concern in local newspapers as early as the 1920s. The basis of this dissidence is a shifting baseline. LEK offers a means to recalibrate the concept of “pristine” biomass that was first calculated by ADFG in the 1970s to reveal that current management techniques are maintaining already depleted herring populations. GIS, though limited in its ability to model temporal fluctuations of herring behavior at the present time, offers a means to model herring movement through time illustrating not only annual spawning patterns but also patterns that extend back in time that can be used to extrapolate ideas of a past level of herring abundance.

CONCLUSION

As I write these closing remarks, herring are on their migratory course from the depths of the ocean to Sitka Sound, the location of the largest commercial sac roe fishery in southeast Alaska, one of only three management areas the state continues to open for commercial harvest (the others not having enough herring to support them). A struggle between Native resource users and ADFG personnel possesses some similarities to the conflict at Kah Shakes.

Sitka is the home to the Sitka Tribe of Alaska. In 1996 the Sitka tribal members, concerned that the commercial sac roe fishery was adversely affecting herring populations and their subsistence harvesting, collected affidavits and prepared to file an injunction to close the commercial fishery. Then, the tribe decided to address the issue by filing a proposal for a fishery moratorium to the Board of Fisheries. According to Robi Craig, the proposal was dismissed because the affidavits were determined to be "anecdotal" (Thornton et al. 2010: Appendix D). Since that time, Sitka Tribe subsistence

harvests have continued to decline overall as commercial sac roe harvest quotas continue to rise. The Tribe argues in some cases they have not been able to meet their subsistence needs.

The 2011 Sitka Sound commercial sac roe fishery forecast, published electronically by ADFG fisheries biologists on December 16, 2010, predicts that 97,499 tons of mature herring will arrive to spawn this spring. According to ADFG guideline harvest quota calculations, state permitted commercial fishermen will be allowed to harvest 19,490 tons of herring. “Sitka Sound herring stock is at the highest levels seen since the department began monitoring the stock in 1964” (ADFG 2010). This, in turn, means that the amount of fish permitted for harvest is at the highest level ever.

In sharp contrast is the status of the Kah Shakes fishery. In 2009, no herring spawn was observed by ADFG at Kah Shakes or Cat Island. The commercial fishery remains closed. Similar situations exist at Auke Bay and Lynn Canal, the empty waters echoing rumors of collapse. As commercial fishermen prepare for a record harvest at Sitka Sound, Sitka tribal members nervously watch these developments wonder whether this year’s projected record harvest will be the last.

Conclusions and Recommendations

In this thesis, I have determined that the conflict at Kah Shakes is the product a dynamic interplay between culture, power *and* ecology best analyzed using event ecology (Vayda and Walters 1999, 2009) enhanced with discourse theory. Many local residents of

Ketchikan describe the herring stock at Kah Shakes as “collapsed” but ADFG fisheries managers maintain that the herring population is “healthy.” Because ecological events are framed and maintained within cultural models of the way the world works, and the power to describe environmental change is constantly negotiated through discursive actions, I have provided a thorough analysis of the ecological and political factors contributing to the creation of this conflict. To accomplish this, I Identified and then compared the management and LEK discourses revealing points of coincident and dissident data that must then be integrated and reconciled respectively, in order to clarify the environmental discourse.

My identification of coincident data between management and LEK discourses exposed the spatial and temporal gaps in the knowledge of herring behavior and biology on which current management techniques are based. I argued throughout this thesis that LEK observations are a useful data source that should be consulted when addressing these areas of uncertainty. In fact, LEK is the only data source that exists that can expand the knowledge of herring beyond the current management boundaries to include multispecies interactions throughout the herring lifecycle, and backward in time to present historical measures of abundance. Again, I posit that integration of this LEK into the current fisheries management paradigm and valuation of citizen science is integral to a clarification of the environmental discourse, the natural history of herring biology and movement.

My identification of the dissident data between the management and LEK discourses exposed specific areas of ecological uncertainty that must be reconciled before clarification of the environmental discourse can be achieved through participatory management frameworks that value citizen science. I analyzed two of these areas of dissidence between and within the LEK and management discourses surrounding the environmental change at Kah Shakes, stock definition and measures of abundance. Although I do not offer a revised definition of stock or propose a new baseline as part of this thesis, I do show that both of these points of dissidence will be clarified using LEK to enhance discussions of herring spawning site fidelity and migratory movement through the oceanscape throughout time that address issues of shifting baselines, concepts of "pristine" biomass calculations, and non-linear equilibrium models. I followed this with evidence that integration of the coincident data and reconciliation of the dissident data will produce a better informed and more sustainable management scheme not just in relation to commercial herring sac roe fisheries in southeast Alaska, but in resource management in general. GIS software will assist in this process.

I have shown that GIS software is a tool to be used to increase the intelligibility of LEK to fisheries managers by converting largely qualitative LEK data into quantitative datasets that can then be made comparable to management datasets. GIS has the capability to reframe multiple datasets, spatially and temporally, to arrive at new hypothesis of herring behavior and migration. The software also has the storage capacity to model multiple ecological and climatic components to better illustrate multispecies

interactions that may be affecting herring populations throughout the herring lifecycle and across the oceanscape.

The conflict at Kah Shakes is a prime, but not unique example of the political struggles being fought throughout southeast Alaska and elsewhere to integrate LEK and management data. As I discussed in Chapter Two, the conflict at Kah Shakes cannot be described using traditional ecological theory of conflict over scarce resources. When ADFG filed an emergency order in 1991 to expand the management boundary of the Kah Shakes commercial herring sac roe fishery to allow commercial fishermen to harvest at Cat and Dog Island, many Ketchikan residents, both Native and non-Native, including commercial fishermen, joined together to protest the expansion. That commercial fishermen would willingly join the Herring Coalition in legal action to close a fishery, the basis of their livelihood, was significant in that observations of herring decline cross traditional political and discursive boundaries.

In Chapter Three, I addressed this issue by employing a methodology called event ecology outlined by Vayda and Walters (1999). My critique of event ecology is that every event is composed of multiple narratives or discourses, which frame its causes and boundaries. Therefore, event ecology must begin with discourse analysis. Using discourse analysis, I identified three discourses present in the Kah Shakes conflict (which I labeled as management, local ecological knowledge and environmental) and showed how these discourses can be used as comparative units to identify both coincident and dissident data, and explained that the reconciliation of the dissident data in combination

with the coincident data will result in a clarification of the environmental discourse that will, in turn, lead to better informed fishery management techniques.

In Chapter Four, I made it clear that the coincident data of the Kah Shakes discourses is sparse and that integration of management and LEK discourses will result in a clarification of the environmental discourse, the natural history, biology and behavior of herring. Dismissal of LEK as mere anecdote by ADFG is erroneous. Despite a historical precedence to include LEK holders as equal participants in the formation and revision of management regulations, the current participatory management structure has become ineffective due to political and economic influences. GIS software may be a useful interface on which to address the intersection of LEK and management data. LEK observations are multispecies and small-scale. Management data is often single species and large-scale. GIS has the capability to model this LEK and management data side-by-side that may result in the validation of LEK observations, introduction of new hypothesis and challenge current perceptions of herring biology and behavior. It can also be used to model many interrelated ecological and environmental processes creating a more holistic and integrated perspective for fisheries and other resource managers.

In Chapter Five, I conducted an examination of the dissident discourse, addressing the conflicts surrounding stock definition and measures of decline. First, I concluded that ADFG management stocks do not coincide with the stock behavior observed by the Annette Island fisheries biologists, members of the Herring Coalition and many local Ketchikan residents. LEK, when integrated into the scientific process, may

offer the means to expand the knowledge of herring behavior beyond arbitrary stock management boundaries in a way that will provide a more accurate method for stock identification. Second, I concluded that the "pristine" biomass baseline on which ADFG base their conservative harvest quota calculations, represents a mere fraction of past herring levels, a phenomenon known as a shifting baseline. LEK is useful in the recalibration of these shifted baselines of herring abundance by expanding the ecological knowledge of herring backwards in time, identifying past spawning, massing and harvest locations. GIS has the potential to become a useful tool in this endeavor in the future but lacks the capabilities and sufficient comparable data to model temporally significant data at this time.

Vayda and Walters' (1999) event ecology worked well for the analysis of ecological change by opening up initial inquiry to multiple levels of conflict without presupposing a political struggle, but without a means to address the issue of how events are created and contested during dialogue, it cannot be used alone. Discourse theory compliments the methodology very well. Utilizing a combination of event ecology and discourse theory to analyze the event and discourses surrounding the disappearance of herring at Kah Shakes allowed me to disentangle the myriad sources of conflict without losing sight of environmental factors such as the many uncertainties regarding herring behavior and biology including herring migration patterns, the degree of fidelity herring exhibit to traditional spawning sites, and the role of multispecies interactions throughout the herring lifecycle, but especially those that occur during the juvenile stage. Some of

the dissident data is a direct result of these uncertainties. It is important to note that even though members of both the managerial and LEK discourses assert that they "know" what happened to the herring, in the end, there still exists a certain level of ambiguity regarding the status of these fish that will not be resolved until the environmental discourse is clarified. Event ecology allowed me to bring the issue of an incomplete environmental discourse to the forefront.

That said, while Vayda and Walters (1999) assert that event ecology is a methodology developed to refocus political ecological analyses on the "ecology" rather than presupposing political struggles over scarce resources, the results of my analysis suggest that events are framed within environmental and cultural parameters and ongoing socio-political struggles: issues of narrative politics (collective memory) on top of culturally constructed boundaries (management and stock boundaries) on top of control of what constitutes scientific data. Perhaps the reason it is easy to lose sight of the ecology is because events, at least those with conflicting interpretations, are largely political struggles after all.

Despite this assessment, the importance of LEK as a component of resource management is becoming quite apparent in this and other case studies. Not only is it a meaningful data source that can be used to expand our knowledge of herring outward in space, beyond fisheries management boundaries, and backward in time, beyond the baseline measures of biomass calculated by ADFG in the 1970s, it is also be subject to an economically prudent method of data gathering. As it has been explained, ADFG lacks

sufficient funding to conduct the research required to expand the knowledge of herring beyond the current management boundaries and beyond the spawning period but denying dissident data simply because one does not collect it is both untenable and irresponsible (Thornton, personal communication 2011).

LEK bearers possess a wealth of knowledge that is arguably at least as reliable as flying and certainly just as verifiable. Not only this, it is the only source of data about the relatively distant past. But this information needs to be contextualized as LEK is differentiated according to individual interactions with herring. For example, trollers are more familiar with herring as a food source for the salmon they harvest. Natives have extensive knowledge of herring spawning areas because it is a key resource in their annual seasonal round. Winter bait fishers possess knowledge regarding herring behavior outside the spawning season when the fish are schooling in the open ocean. Pilots have an aerial perspective of herring massing and spawning behaviors from the air. Even ADFG dive surveyors have a unique, underwater vantage point of herring spawning behavior. Projects to integrate management and LEK data should take advantage of these expertises to both clarify the environmental discourse and provide a more accurate picture of herring natural history of behavior and biology.

In reality, there are processes in place that allow for community participation in the creation or modification of commercial fishery regulation. However, although herring management in southeast Alaska appears democratic and may make an effort to be (Advisory Committees, Board of Fisheries meetings, etc), many fishermen and local

residents are unhappy with the system and are skeptical of ADFG conservative management claims and calculations. The true question posed here is whether fisheries managers and board members are willing to foster relationships with LEK holders on equal terms as concerned stakeholders in the sustainability of the commercial herring fisheries? One would assume this collaboration would be welcome in light of the historical precedence of citizen science (Fortmann 2008) on which fisheries management in southeast Alaska was constructed. But recent developments, including the dismissal of LEK during the 1993 Board of Fisheries meeting, and the identification of LEK as "anecdotal" filed by the Herring Coalition in that same year, would suggest that fisheries management in southeast Alaska has moved away from citizen science, a move that will prove unfavorable to both the herring and for everything and for everyone who depends upon them. GIS software offers a new way in which management personnel and LEK holders can communicate and store validated ecological and environmental data, a data source on which everyone can draw upon as equal investors not the survival of not just the herring, but in the environment as a whole.

Future research should explore additional modeling techniques and data collection capabilities of GIS software. A GIS platform has the potential to foster a community-based library of ecological knowledge not restricted to herring data, and not restricted to the scientific community (Fabian 2007). This community data center could house data not just on herring, but all ecological components (salmon, birds, sea lions, ocean

substrate). It could also be expanded to include climate data (water temperature, wind speed, etc.) as it becomes available.

Constructing an open database again raises the question of how LEK can or should be validated and then integrated into management discourses. LEK, when input into a GIS program, is not then immediately transformed into scientific data. As with all new information, it must be subject to the rigors of scientific method. Unfortunately, the very nature of LEK makes traditional testing methods very difficult, but that does not mean that the effort is wasted. Quite the opposite. LEK should be used to challenge scientific hypotheses, again, and again, and again. But first the management community must recognize the utility of not only LEK as information, but of LEK holders as integral partners in the management of resources and their socioecological habitats. This can be accomplished in certain areas, especially in southeast Alaska, through a return to state citizen science model and reinvigoration of participatory management structures with a robust LEK and GIS program for basic herring research as well as potential restoration, empowering local Ketchikan residents in the decision making processes of management and regulation of fisheries.

Environmental stewardship cannot be restricted to an individual or an agency. It must be a social and ecological project in a meaningful socioecological system. Political conflict at Kah Shakes has created communication barriers between the many people involved and discourses have become dissident. The underlying source of dissidence is a lack of knowledge regarding herring behavior and the ecological variables that effect

herring development and movement. GIS may help increase communication between the many stakeholders by making it possible to analyze management data alongside LEK data, expanding our knowledge of herring behavior and movement across the oceanscape and through time to help create more accurate measures of abundance and to offer the opportunity to increase the accuracy of biological stock definitions. The reconciliation of these data will ultimately result in more accurate management models and recalibrated harvest quotas that conserve both biodiversity and productivity – measures that are needed with urgency.

REFERENCES

Acheson, James M.
2005 Developing Rules to Manage Fisheries: A Cross-Cultural Perspective. *In* Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity. E. A. Norse and L. B. Crowder, eds. Pp. 351-361. Washington, D.C.: Island Press

Acheson, James M.
1981 Anthropology of Fishing. Annual Review of Anthropology 10:275-316

Acheson, James M., and James A. Wilson
1996 Order Out of Chaos: The Case for Parametric Fisheries Management. American Anthropologist 98(3):579-594

Adger, W. Neil, Tor A. Benjaminsen, Katrina Brown, and Hanne Svarstad
2001 Advancing a Political Ecology of Global Environmental Discourses. Development & Change 32(4)

Alaska Department of Fish and Game (ADFG)
2010 Southeast Alaska Sac Roe Herring Fishery Management Plan. Regional Information Report No. 1J10-03: 1-26.

2008 Southeast Alaska Sac Roe Herring Fishery Management Plan. Regional Information Report No. 1J08-09: 1-26.

2007a Herring Fisheries in Alaska: *Statewide Home* . Electronic document, http://www.cf.adfg.state.ak.us/geninfo/finfish/herring/herrhome.php, accessed 11/1, 2007

2007b Herring Fishery News Releases: *Area Openings / Updates / Announcements*, Electronic document, http://www.cf.adfg.state.ak.us/geninfo/finfish/herring/herring_news.php, accessed 8/20, 2007.

2007c Pacific Herring Listing; Public Comment C009. 1514-12-a-02-g:1-45.

2007d Sitka Sound Subsistence Herring Roe Fishery 2002, 2003 and 2006. :1-25.

2007e Technical Paper Search Results: Herring. Electronic document, http://www.subsistence.adfg.state.ak.us/geninfo/publctns/techsearch.cfm, accessed 11/15, 2007.

2007d Re: Lynn Canal Herring. Electronic document, http://www.sf.adfg.state.ak.us/statewide/PDFs/Lynn%20Canal%20herring%20FR%20comments%20(final%20to%20NMFS%2012-10-2007).pdf, accessed 12/9/2010.

1998 Southeast Alaska Sac Roe Herring Fishery Management Plan. Regional Information Report No. 1J08-09: 1-26.

1997 Herring Fisheries, Southeast Alaska - Yakutat Region 1995/96. (January):1-26

1996a Southeast Alaska Sac Roe Herring Fishery 1996 Management Plan. (March):1-2-11 .

1994a Preliminary Summary of 1994 Alaska Herring Roe Fisheries. Regional Information Report No. 5J94-20:1-101.

1994b Southeast Alaska/Yakutat Annual Herring Research Report, 1994. Regional Information Report No. 1JP94-27:1-144.

1994c Subsistence Resource use Patterns in Southeast Alaska: Summaries of 30 Communities - Sitka. (June):1-58.

1993/94 Return Kah Shaes to pre-1991 Boundaries. Technical Report, 342. Ketchikan: Board of Fisheries Briefing Document.

1992 Kah Shakes/Cat Island Herring Sac Roe Fishery Set Gillnet. Technical Report, Ketchikan: Division of Commercial Fisheries.

1991 Kah Shakes Sac Roe Gill Net Fishing Area. Technical Report, Agenda Change. Ketchikan: Board of Fisheries Briefing Document.

1988 Southeast Alaska Herring Roe Fishery. Technical Report, Management Plan. 1-15.

1985 Pacific Herring: *Clupea Pallasi*. 333-344.

1979 Management Plan, Herring Roe Fishery 1979. Technical Report. Southeaster Region: Alaska Department of Fish and Game.

Alaska Department of Fish and Game, and Ketchikan Area Herring Action Group
2006 Proposal 94, Page 68. 5 AAC 27.150. Waters Closed to Herring Fishing in Southeastern Alaska. Staff Comments on Subsistence, Personal use Sport, Guided Sport, and Commercial Finfish Regulatory Proposals for the Southeast and Yakutat Management Areas(Alaska Board of Fisheries Meeting, Ketchikan, Alaska, January 22-February 1):38-42.

Alaska Fisheries Board, and Alaska Department of Fisheries
1952 1952 Annual Report. 4:65-80

Aldenderfer, Mark S., and Herbert D. G. Maschner
1996 Anthropology, Space, and Geographic Information Systems. New York: Oxford University Press

Alderdice, D. F., and A. S. Hourston
1985 Factors Influencing Development and Survival of Pacific Herring (*Clupea harengus pallasi*) Eggs and Larvae to Beginning of Exogenous Feeding. Canadian Journal of Fisheries and Aquatic Sciences 42(Supplement):56-68.

Alderdice, D. F., and F. P. J. Velsen
1978 Effects of Short-Term Storage of Gametes on Fertilization of Pacific Herring Eggs. Helgolaender Wissenschaftliche Meeresuntersuchungen 31(4):485-498.

1971 Some Effects of Salinity and Temperature on Early Development of Pacific Herring (*Clupea pallasi*). Journal Canadian Fisheries Research Board 28(10):1545-1562.

Allen, June
2004 A Biography of Alaska's Herring: A Little Fish of Huge Importance. Electronic document, http://www.sitnews.net/JuneAllen/Herring/031404_herring.html, accessed September 2007, 2007.

Ames, Ted
2007 Putting Fishers' Knowledge to Work: Reconstructing the Gulf of Maine Cod Spawning Grounds on the Basis of Local Ecological Knowledge. In Fishers' Knowledge in Fisheries Science and Management, N. Haggan, B. Neis, and I.G. Baird (eds), pp. 353-363. Coastal Management Sourcebooks 4: UNESCO Publishing.

2006 Commercial Fisheries. Fishers Knowledge in Fisheries Science and Management 17:349-354

Ames, Kenneth M., and Herbert D. G. Maschner
1999 Peoples of the Northwest Coast: Their Archaeology and Prehistory. London: Thames and Hudson Ltd.

Anderson AB, and Darell A. Posey
1989 Management of a Tropical Scrub Savanna by the Gorotire Kayapo of Brazil. *In* Resource Management of Amazonia: Indigenous and Folk Strategies. DA Posey and W. Balee, eds. Pp. 159-173. Bronx, New Yoirk: The New York Botanical Garden.

Arctander, Jno W.
1909 The Apostle of Alaska : The Story of William Duncan, of Metlakahtla. 2nd ed. New York: Revell

Arnold, David F.
2008 The Fishermen's Frontier: People and Salmon in Southeast Alaska. Seattle, Washington: University of Washington Press.

Aswani, S.
2006 Incorporating fishermen's Local Knowledge and Behavior into Geographical Information Systems (GIS) for Designing Marine Protected Areas in Oceania. Human Organization 65(1):81

Aswani, S., and R. Hamilton
2004 Integrating Indigenous Ecological Knowledge and Customary Sea Tenure with Marine and Social Science for Conservation of Bumphead Parrotfish (*Bolbometopon Muricatum*) in the Roviana Lagoon, Solomon Islands. Environmental Conservation 31(1):69-83.

Baelde, Pascale
2007 Using Fishers' Knowledge Goes Beyond Filling Gaps in Scientific Knowledge: Analysis of Australian Experiences *in* Fishers' Knowledge in Fisheries Science Management. Nigel Haggan, Barbara Neis and Ian G. Baird. eds. Pp. 381-400. Paris: UNESCO.

Bailey, Geoff
2007 Time Perspectives, Palimpsests and the Archaeology of Time. Journal of Anthropological Archaeology 26(2):198-223

Bakhtin, Mikhail M.
1981 [1935] Discourse and the Novel. *In* The Dialogic Imagination. Michael Holoquist, ed. Pp. 259-422. Austin: University of Texas Press.

Barbier, Edward B., Evamaria W. Koch, Brian R. Silliman, Sally D. Hacker, Eric Wolanski, Jurgenne Primavera, Elise F. Granek, Stephen Polasky, Shankar Aswani, Lori A. Cramer, David M. Stoms, Chris J. Kennedy, David Bael, Carrie V. Kappel, Gerardo M. E. Perillo, and Denise J. Reed
2008 Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values. Science 319(5861):321-323

Bardach, John E., and Regina Miranda Santerre
1981 Climate and the Fish in the Sea. Bioscience 31(3, Living Marine Resources):206-215.

Barnhart, R. A.
1988 Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest) - Pacific Herring. US Fish and Wildlife Service Biological Report. TR EL-82-4 82 (11.79)

Barton, L. H., and V. Westpestad
1980 Distribution, Biology and Stock Assessment of Western Alaska's Herring Stocks. Proceedings of the Alaska Herring Symposium(Alaska Sea Grant Report 80-4):27-53

Beltestad, A. K., and O. A. Misund
1991 On the Danger of Incidental Fishing Mortality in Herring Purse Seining. Alaska Sea Grant College Program Report No. 91-01:617-628.

Bergmann, M., H. Hinz, RE Blyth, MJ Kaiser, SI Rogers, and M. Armstrong
2004 Using Knowledge from Fishers and Fisheries Scientists to Identify Possible Groundfish 'Essential Fish Habitats'. Fisheries Research 66:373-379.

Bergmann, William, Justin Breese, Phil Doherty, Bo Meredith, and Troy Thynes
2006 Southern Southeast Alaska Herring Spawn-on-Kelp Pound Fishery: 2006 Management Plan. (Fisheries Management Report No. 06-10):1-26

Berkes, Fikret
1999 Sacred Ecology: Traditional Ecological Knowledge and Resource Managment. Philadelphia, Pennsylvania: Taylor and Francis.

Berkes, F., and D. Feeny
1989 The Benefits of the Commons. Nature 340(6229):91

Bernard, H. Russel
2002 Research Methods in Anthropology: Qualitative and Quantitative Approaches. 3rd edition. New York: AltaMira Press

Biersack, Aletta, and James B. Greenberg
2006 Reimagining Political Ecology. Durham: Duke University Press

Blankenbeckler, Dennis
1980 Gulf of Alaska Herring Management. Proceedings of the Alaska Herring Symposium(Alaska Sea Grant Report 80-4):55-68

Blaxter, J. H. S., and J. R. Hunter
1982 The Biology of Clupeid Fishes. Advances in Marine Biology 20:1-223.

Boas, Franz, and Henry W. Tate
1916 Tsimshian Mythology. *In* U.S. Bureau of American Ethnology, Thirty-first annual report, 1909-1910. Pp 39-41. Washington.

Bollens, S. M., and A. M. Sanders
2004 Ecology of Larval Herring in the San Fransisco Estuary: Seasonal and Interannual Abundance, Distribution, Diet, and Condition. *In* Early Life History of Fishes in the San Francisco Estuary and Watershed. F. Feyrer, L. R. Brown, R. L. Brown and J. J. Orsi, eds. Pp. 15-36. Bethesda, MD: American Fisheries Society.

Bourdieu, Pierre
1994 Chapter 4: Structures, Habitus, Power: Basis for a Theory of Symbolic Power. *In* Culture/Power/History: A Reader in Contemporary Social Theory. Nicholas B. Dirks, Geoff Eley and Sherry Ortner, eds. Pp. 155-199. Princeton: Princeton University Press.

Bowlen, Scott
1995 Herring Lawsuit Dismissed. Ketchikan Daily News, April 8-9.

1994 Lawsuit Filed: Metlakatla, Herring Coalition Ask Court to Stop Cat Island Fishery, February 15.

Brannian, L. K., and Katherine A. Rowell
1991 Biological and Sampling Considerations when Maximizing Roe Recovery for Alaska's USA Herring Fisheries. Proceedings of the International Herring Symposium Alaska Sea Grant College Program Report No. 91-01:507-520.

Brock, Peggy
2003 Two Indigenous Evangelists: Moses Tjalkabota and Arthur Wellington Clah. Journal of Religious History 27(3):348-366

Brown, Evelyn D.
2001 Survey Design and Methods for Determining Oil Spill Damage to Pacific Herring (Clupea Pallasi) Embryos. Herring: Expectations for a New Millennium University of Alaska Sea Grant Program Report No. 01-04.

Brown, Evelyn D. and Mark G. Carls.

1998. Pacific Herring (Clupea Pallasi) 1, EVOS Trustee Council Restoration Notebook Series. http://www.evostc.state.ak.us/pdf/rnpahe.pdf.

Brown, Evelyn D., Jody Seitz, Brenda L. Norcross, and Henry P. Huntington
2007 Ecology of Herring and Other Forage Fish as Recorded by Resource Users of Prince William Sound and the Outer Kenai Peninsula, Alaska. Electronic document, http://www.adfg.state.ak.us/pubs/afrb/vol9_n2/browv9n2.pdf

Carls, M. G.
2008 Status Review of Pacific Herring (Clupea Pallasii) in Lynn Canal, Alaska. :1-155.

Carlson, Harry Richard
1984 Seasonal Distribution and Environment of Adult Pacific Herring (*Clupea harengus pallasi*) Near Auke Bay, Lynn Canal, Southeastern Alaska. Ph.D. dissertation, Oregon State University.

1980 Herring Research in the Gulf of Alaska: A Historic Overview. Proceedings of the Alaska Herring Symposium Alaska Sea Grant Report 80-4:63-68.

1977 Northwest and Alaska Fisheries Center Processed Report: Results of a Tagging Study of Pacific Herring in Southeastern Alaska in 1960-62 using Radioactive Body Cavity Tags. :1-4.

Chase, Belinda
1993a Herring and Herons: Group Seeks Closure of Kah Shakes, Sitka Fisheries. Ketchikan Daily News, February 25: 1-2

1993b Judge Won't Stop Herring Fisheries. Ketchikan Daily News, March 27-28.

1993c Doling Out the Sac Roe: A Kah Shakes, Cat Island Split? Ketchikan Daily News, March 11.

1993d Kah Shakes Fishery Becoming Controversial. Ketchikan Daily News, March 20.

Cinner, Joshua E., and Shankar Aswani
2007 Integrating Customary Management into Marine Conservation. Biological Conservation 140(3):201-216

Cleghorn, John
1855 On the Causes of the Fluctuations in the Herring Fishery. Journal of the Statistical Society of London 18(3):240-242.

Cobb, J. N.
1906 The Commercial Fisheries of Alaska in 1905. Bureau of Fisheries Document 603:20-23.

Collie, J. S., and A. K. Delong
1999 Multispecies Interactions in the Georges Bank Fish Community. Ecosystem Approaches for Fisheries Management Report 99-01:187-210.

Cooney, R. T., J. R. Allen, M. A. Bishop, D. L. Eslinger, T. Kline, B. Norcross, C. McRoy, J. Milton, J. Olsen, V. Patrick, A. J. Paul, D. Salmon, D. Scheel, G. L. Thomas, S. L. Vaughan, and T. M. Willette
2001 Ecosystem Control of Pink Salmon (*Onorhynchus gorbuscha*) and Pacific Herring (*Clupea pallasi*) Populations in Prince William Sound, Alaska. Fisheries Oceanography 10:1-13.

Dahlgren, Edwin H., and L. N. Kolloen
1943 Fluctuations in the Abundance of the Alaska Herring. The Scientific Monthly 56(6):538-543

Danver, Steven L.
2007 Metlakatla. Journal of the West 46(4):40-47

Dewitt, Jonathan
1993 Affidavit of Jonathan Dewitt. (unpublished ms. on file at Portland State University).

Doherty, Philip S.
1993/94 1993/94 Board of Fisheries Briefing Document: Return Kah Shakes to Pre-1991 Boundaries. Proposal No. 342:1-12.

Doherty, Philip S., Robert C. Larson, D. W. Carlisle, and F. Funk
1991 1991 Board of Fisheries Briefing Document: Kah Shakes Sac Roe Gill Net Fishing Area. Agenda Change:1-31.

Dove, Michael, and Carol Carpenter
2008 Environmental Anthropology : A Historical Reader. Vol. 10. Malden, MA: Blackwell Pub.

edited by Michael R. Dove and Carol Carpenter.; Includes bibliographical references and indexes.; Blackwell anthologies in social and cultural anthropology ; 10.

Dressel, Sheri, Kyle Hebert, Marc Pritchett, and David Carlisle
2006 Southeastern Alaska Herring. Ecosystem Considerations for 2007:1-7.

Duenas, C. E.
1981 Influence of Incubation Salinity and Temperature and Post-Hatching Temperature on Salinity Tolerance of Pacific Herring (*Clupea pallasi valenciennes*) Larvae. MSc Thesis, Department of Zoology, University of British Columbia.

Dulvy, N., and N. Polunin
2004 Using Informal Knowledge to Infer Human-Induced Rarity of a Conspicuous Reef Fish. Animal Conservation 7:365-374

Ecotrust
2007 The Copper River Program. Electronic document, http://www.ecotrust.org/copperriver/, accessed 12/13, 2007

Emmons, George T. and Frederica de Laguna.
1991 *The Tlingit Indians*. Edited with additions by Frederica de Laguna. American Museum of Natural History Anthropological Papers, vol. 70. Seattle: University of Washington Press and the American Museum of Natural History.

Erlandson, Jon M., and Madonna L. Moss
1999 The Systematic use of Radiocarbon Dating in Archaeological Surveys in Coastal and Other Erosional Environments. American Antiquity 64(3):431-443

Escobar, Arturo
1995 Encountering Development : The Making and Unmaking of the Third World. Princeton, N.J.: Princeton University Press

Fabian, Johannes
2007 Memory Against Culture : Arguments and Reminders. Durham: Duke University Press

Feldman, Kerry D.
1981 Anthropology and Public Policy in Alaska: Recent Policy Related to Legal Systems, Native Subsistence, and Commercial Fisheries. Policy Studies Review 1(1):87-110

Fernandez-Armesto, Felipe
2002 Near a Thousand Tables. New York: The Free Press.

Fienup-Riordan, A
1999 *Yaquleget qailunpilariat* (What the Birds do): Yup'ik Eskimo Undersanding of Geese and Those who Study Them. Arctic. 52(1):1-22

Fisheries and Aquaculture Organization of the United Nations
2007 Fisheries and Aquaculture Department, Species Fact Sheets, Clupea pallasii. Electronic document http://www.fao.org/fishery/species/2078/en, accessed 8/20, 2007

Fisheries and Oceans Canada
2007 Pelagic Fish: Marine Ecosystems and Aquaculture Division. Electronic document, http://www.pac.dfo-mpo.gc.ca/sci/herring/default_e.htm, accessed 8/20, 2007

Fladmark, K. R.
1975 A Paleoecological Model for Northwest Coast Prehistory. Ottawa: National Museums of Canada

Food and Agriculture Organization of the United Nations
2007 Species Fact Sheets: *Clupea pallasii (Valenciennes, 1847)* . Electronic document, http://www.fao.org/fi/website/FIRetrieveAction.do?dom=species&fid=2078, accessed 12/6, 2007.

Foucault, Michel
1996 The Order of Things: An Archaeology of the Human Sciences. New York: Vintage Books

Forsyth, Tim
2003 Critical Political Ecology : The Politics of Environmental Science. London ; New York: Routledge

Fortmann, Louise
2008 Participatory Research in Conservation and Rural Livelihoods: Doing Science Together. Honoken, New Jersey:Wiley-Blackwell.

Friedel, Darrent
2000 No Kah Shakes Fishery in 2000. Ketchikan Daily News, January 13: 1-2

Funk, F.
2000 Abundance, Biology, and Historical Trends of Pacific Herring, Clupea Pallasi, in Alaskan Waters. Trends in Herring Populations and Trophodynamics:85-93.

1990 Harvest Policy Implications of Yield Per Recruit Models for Pacific Herring in Alaska, USA. Proceedings of the International Herring Symposium Alaska Sea Grant College Program Report No. 91-01:453-462.

Garza, Dolores
1996 The Southeast Alaska Herring Sac-Roe Fishery: A Need for Change? Ph.D. dissertation, University of Deleware.

George, Paul
1999 BC's Herring must be Given the Chance to Recover from Eighty Years of Industrial Overfishing. Wilderness 18(2):1-4

Gezon, Lisa L. and Susan Paulson
2005 Place, Power, Difference: Multiscale Research in the Dawn of the Twenty-first Century. *In* Political Ecology Across Spaces, Scales, and Social Groups. Susan Paulson and Lisa L. Gezon, eds. Pp. 1-16. New Brunswick, NJ: Rutgers University Press.

Glaesel, Heidi
2000 State and Local Resistance to the Expansion of Two Environmentally Harmful Marine Fishing Techniques in Kenya. Society & Natural Resources 13(4):321-338

Gold, Ann Grodzins and Bhoju Ram Gujar
1997 Wild Pigs and Kings: Remembered Landscapes in Rajasthan. American Anthropologist 99(1): 70-84.

Goldschmidt W.R. and T.H. Haas
1998 Haa Aaní Our Land: Tlingit and Haida Land Rights and Use. Seattle Washington: University of Washington Press and Sealaska Heritage Foundation.

Grant, W. Stewart
1984 Biochemical Population Genetics of Atlantic Herring, Clupea Harengus. Copeia 1984(2): 357-364.

Greenpeace, USA
Part Three: Avoiding Boom and Bust Fishery Development-The Need for an Ecosystem-Based Approach to Herring Management: Avoiding Mistakes of the Past. Electronic document, http://www.greenpeaceusa.com/media/publications/herring/herring_part3text.htm, accessed February 2003.

Greenpeace, USA
Profile Three: Accounting for Predator/Prey Relationships-Defining Overfishing in an Ecosystem Context. Electronic document, http://www.greenpeaceusa.com/media/publications/herring/herring_profile3text.htm, accessed February 2003.

Griffin, Frederick J., M. R. Brenner, H. M. Brown, E. H. Smith, C. A. Vines, and G. N. Cherr
2004 Survival of Pacific Herring Larvae is a Function of External Salinity. In Early Life History of Fishes in the San Francisco Estuary and Watershed. F. Feyrer, L. R. Brown, R. L. Brown and J. J. Oris, eds. Pp. 37-48. Bethesday, Maryland: American Fisheries Society.

Grumet, Robert Steven
1975 Changes in Coast Tsimshian Redistributive Activities in the Fort Simpson Region of British Columbia, 1788-1862. Ethnohistory 22(4):295

Haegele, C. W.
1993 Seabird Predation of Pacific Herring, *Clupea pallasi*, Spawn in British Columbia. Canadian Field Naturalist 107:73-82.

Haegele, C. W., and A. S. Hourston
1980 Herring on Canada's Pacific Coast. Ottawa: Campbell Printing

Haegele, C. W., and Jacob F. Schweigert
1991 Egg Loss in Herring Spawns in Georgia Strait, British Columbia, Canada. Proceedings of the International Herring Symposium Alaska Sea Grant College Program Report NO. 91-01:309-322.

1985a Estimation of Egg Numbers in Pacific Herring Spawns on Giant Kelp. North American Journal of Fisheries Management. 5: 65-71.

1985b Distribution and Characteristics of Herring Spawning Grounds and Description of Spawning Behavior. Canadian Journal of Fisheries and Aquatic Sciences 42:39-55.

1989 Egg Loss from Pacific Herring Spawns in Barkley Sound in 1988. Canadian Management Report Fisheries Aquatic Sciences No. 2037.

Haenn, Nora, and Richard R. Wilk
2006 The Environment in Anthropology : A Reader in Ecology, Culture, and Sustainable Living. New York: New York University Press

Haggan, Nigel, Barbara Neis, and Ian G. Baird, eds.
2007 Fishers' Knowledge in Fisheries Science and Management. Paris: UNESCO Publishing.

Haist, V.
1991 An Evaluation of the Precision and Accuracy of British Columbia Canada Herring Stock Forecasts using an Age-Structured Model. Proceedings of the International Herring Symposium Alaska Sea Grant College Program Report No. 90-01:389-402.

Hamilton, R.
2005 Indigenous Ecological Knowledge of the Aggregating and Nocturnal Spawning Behaviour of the Longfin Emperor, Lethrinus Erythropterus. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 18:9-18.

Hamilton, R., and R. Walter
1999 Indigenous Ecological Knowledge and its Role in Fisheries Research Design: A Case Study from the Roviana Lagoon, Western Province, Solomon Islands. Traditional Marine Resource Management and Knowledge Information Bulletin 11:13-21.

Hamilton, Lawrence C., Richard L. Haedrich, and Cynthia M. Duncan
2004 Above and Below the Water: Social/Ecological Transformation in Northwest Newfoundland. Population & Environment 25(6):195-215

Harrison, Gordon
2011 Alaska's Constitution, A Citizen's Guide. Electronic document, http://w3.legis.state.ak.us/docs/pdf/citizens_guide.pdf, accessed 2/16/2011.

Hay, D. E.
2001 Anatomy of a Strong Year Class: Analysis of the 1977 Year Class of Pacific Herring in British Columbia and Alaska. Herring: Expectations for a New Millennium University of Alaska Sea Grant Program Report No. 01-04:171-198.

1991 How Much is Herring Spawn Worth? Potential Economic and Ecological Consequences of Impacts of Herring Spawning Areas. Proceedings of the International Herring Symposium Alaska Sea Grant College Program Report No. 91-01:583-590.

1990 Tidal Influence on Spawning Time of Pacific Herring (*Clupea harengus pallasi*). Canadian Journal Fisheries Aquatic Sciences 47:2390-2401.

1986 Effects of Delayed Spawning on Viability of Eggs and Larvae of Pacific Herring. Transactions of the American Fisheries Society 115(1):155-161.

1985 Reproductive Biology of Pacific Herring (*Clupea harengus pallasi*). Canadian Journal Fisheries Aquatic Sciences 42(supplement 1):111-126.

1984 Stock Assessment of Pacific Herring using Catch and Spawn Data. Proceedings of the Fourth Pacific Coast Herring Workshop Canadian Manuscript Fisheries Aquatic Sciences No. 1700:20.

Hay, D. E., K. D. Cooe, and C. V. Gissing
1986 Experimental Studies of Pacific Herring Gillnets. Fisheries Research 4:191-211.

Hay, D. E., and A. R. Kronlund
1987 Factors Affecting the Distribution, Abundance and Measurement of Pacific Herring (*Clupea harengus pallasi*) Spawn. Canadian Journal of Fisheries and Aquatic Sciences 44(4):1181-1194.

Herring Bait Supply Short in Assertion
1926 Ketchikan Alaska Chronicle, January 27.

Hewes, Gordon Winant
1947 Aboriginal use of Fishery Resources in Northwestern North America.

Higgins, Elmer
1934 Fishery Biology its Scope, Development, and Applications. The Quarterly Review of Biology 9(3):275-291.

Hilborn, Ray, Trevor A. Branch, Billy Ernst, Arni Magnusson, Carolina V. Minte-Vera, Mark D. Scheuerell, and Juan L. Valero
2003 State of the World Fisheries. Annual Review of Environmental Resources 28: 359-399.

Hourston, A. S.
1980 The Biological Aspects of Management of Canada's West Coast Herring Resource. Proceedings of the Alaska Herring Symposium Alaska Sea Grant Report 80-4:69-90.

Huizer, E. J.
1952 History of Alaska Herring Fishery. Annual Report for 1952:65-76

Huntington, Henry P.
2000 Using Traditional Ecological Knowledge in Science: Methods and Applications. Ecological Applications 10(5):1270-1274

Huntingdon, H., and the Communities of Buckland, Elim, Koyuk, Point Lay and Shaktoolik
1999 Traditional Knowledge of the Ecology of Beluga Whales (*Delphinapterus leucas*) in the Eastern Chukchi and Northern Bering Seas, Alaska. Arctic 52(1):49-61.

Johannes, R. E., M. M. R. Freeman, and R. J. Hamilton
2000 Ignore Fishers' Knowledge and Miss the Boat. Fish & Fisheries 1(3):257-271.

Johannes, RE
2002 The Renaissance of Community-Based Marine Resource Management in Oceania. Annual Review of Ecology and Systematics 33:317-340.

1998 The Case for Data-Less Marine Resource Management: Examples from Tropical Nearshore Finfisheries. Trends in Ecology and Evolution 13(6):243-247.

1981 Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia. London: University of California Press.

1978 Traditional Marine Conservation Methods in Oceania and their Demise. Annual Review of Ecology and Systematics 9(1):349-364

Johannes, RE, and B. Neis
2007 The Value of Anecdote. *In* Fishers' Knowledge in Fisheries Science and Management. N. Haggan, B. Neis and I. Baird, eds. Pp. 41-58. Paris: UNESCO.

Johannes, R. E., M. M. R. Freeman, and R. J. Hamilton
2000 Ignore Fishers' Knowledge and Miss the Boat. Fish & Fisheries 1(3):257-271

Johannes, R. E.
2002 Did Indigenous Conservation Ethics Exist? SPC Traditional Marine Resource Management and Knowledge Information Bulletin #14 October (2002):3-7

Jones, R.
2007 Application of Haida Oral History to Pacific Herring Management. *In* Fishers' Knowledge in Fisheries Science and Management. Pp. 103-118.

Keith, D., J. Arqviq, L. Kamookak, and J. Ameralik
2005 Inuit Qaujimaningit Nanurnut: Inuit Knowledge of Polar Bears: A Project of the Gjoa Haven HTO. Calgary: Gjoa Haven HTO and CCI Press.

Ketchikan Alaska Chronicle
1999 The New Ecological Anthropology. American Anthropologist 101(1):23-55.

Kirksey, S. Eben and Stefan Helmreich
2010 The Emergence of Multispecies Ethnography. Cultural Anthropology. 25(4): 545:576.

Kottak, Conrad P.
1932 Tagging Herring is Under Way. July 12.

Kurlansky, Mark
1997 Cod : A Biography of the Fish that Changed the World. New York: Walker and Co.

Lajus, Dmitry L., Yaroslava I. Alekseeva and Julia A. Lajus
2007 Herring Fisheries in the White Sea in the 18th-beginning of the 20th Centuries: Spatial and Temporal Patterns Affecting the Catch Fluctuations. Fisheries Research 87(2-3):255-259.

Landis, Wayne G.
2004 A Regional Retrospective Assessment of the Potential Stressors Causing the

Decline of the Cherry Point Pacific Herring Run. Human and Ecological Risk Assessment 10(2):271-297

Lansing, J. Stephen
1991 Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali. Princeton, New Jersey: Princeton University Press.

Larson, Robert C., and Tim A. Minicucci
1997 Herring Fisheries: Southeast Alaska-Yakutat Region 1995/96. 1J96-28:1-26

Lassuy, D.R.

1989 Species Profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest)—Pacific herring. U.S. Fish and Wildlife Service Biological Report 82 (11.126).

Litle, Kate, Julia K. Parrish, and Jane Dolliver
2006 The Coastal Observation and Seabird Survey Team - Citizens Monitoring Coastal Environmental Health in Alaska. Community-Based Coastal Observing in Alaska, Aleutian Life Forum University of Alaska Sea Grant College Program Report 99-03:21-38.

Lloyd, Denby S.
1996 Relative Effects of Mixed Stock Fisheries on Specific Stocks of Concern: A Simplified Model and Brief Case Study. Alaska Fishery Research Bulletin 3(1):21-31.

Longley, Paul A., Micheal F. Goodchild, David J. Maguire, and David W. Rhind
2005 Geographic Information Systems and Science. Second Edition ed. John Wiley & Sons, Ltd., New Jersey.

Lorrigan, Jack, and Larry Willard
3/31/2003 Concern About Declining Number or Size of Seal. Electronic document, http://www.iser.uaa.alaska.edu/projects/contam/ResourceGuide/seal_num.htm, accessed 11/8/2007, 2007

Malkki, Liisa H.
1995 Purity and Exile: Violence, Memory, and National Cosmology Among Hutu Refugees in Tanzania. Chicago: The University of Chicago Press.

Marine Resources Service,Fishery Resources Division, Fisheries Department, FAO, Rome, Italy

1997 Review of the State of World Fishery Resources: Marine Fisheries. FAO Fisheries Circular No. 920 FIRM/C920:1-4

Marsden, Susan, and Robert Galois
1995 The Tsimshian, the Hudson's Bay Company, and the Geopolitics of the Northwest Coast Fur Trade.. Canadian Geographer 39(2):169

Mathooko, Jude Mutuku
2005 Application of Traditional Ecological Knowledge in the Management and Sustainability of Fisheries in East Africa: A Long-Neglected Strategy? Hydrobiologia 537(1-3):1-6

Maud, Ralph
2000 Transmission Difficulties : Franz Boas and Tsimshian Mythology. Burnaby, B.C.: Talonbooks

Maunder, M. N.
2002 The Relationship between Fishing Methods, Fisheries Management and the Estimation of Maximum Sustainable Yield. Fish and Fisheries (Oxford, England) 3(4):251.

McCusker and Daniel Weiner
2005 GIS Representations of Nature, Political Ecology, and the Study of Land Use and Land Cover in South Africa. *In* Political Ecology: An Integrative Approach to Geography and Environment-Development Studies. Karl S. Zimmerer and Thomas J. Basset, eds. Pp. 201-215. New York: Guilford Press.

Menzies, Charles R., and Caroline F. Butler
2001 Working in the Woods: Tsimshian Resource Workers and the Forest Industry of British Columbia. American Indian Quarterly 25(3):409-430

Meuret-Woody, Heather
2007 Necker Bay Sockeye Salmon: Linking Traditional Ecological Knowledge and Fisheries Science. USFWS Tribal Wildlife Grant 2007-2009 Sitka Tribe of Alaska Project Proposal:1-5.

Meyers, T. R., A. K. Hauck, W. D. Blankenbeckler, and T. Minicucci
1986 First Report of Viral Erythrocytic Necrosis in Alaska, USA, Associated with Epizootic Mortality in Pacific Herring, Clupea Harengus Pallasi (Valenciennes). Journal of Fish Diseases 9(6):479-491

Miller, Jay
1998 Tsimshian Ethno-Ethnohistory: A 'Real' Indigenous Chronology. Ethnohistory 45(4):657

Miller, Tom
1993 Biologist: Herring Fishery One of the Best Ever. Ketchikan Daily News, April 13.

Mobley, C. M.
1984 An Archaeolgical Survey of 15 Timber Harvest Units at Naukati Bay on Prince of Wales Island, Tongass National Forest, Alaska. Ketchikan: Report on file, U. S. Forest Service

Moore, P.
2003 Seals and Fisheries in the Clyde Sea Area (Scotland): Traditional Knowledge Informs Science. Fisheries Research 63:51-61.

Moreno, G., L. Dagorn, G. Sancho, D. Garcia, and D. Itano
2007 Using Local Ecological Knowledge (LEK) to Provide Insight on the Tuna Purse Seine Fleets of the Indian Ocean Useful for Management. Aquatic Living Resources 20:367-376.

Moreno, G., L. Dagorn, G. Sancho, and D. Itano
2007 Fish Behaviour from Fishers' Knowledge: The Case Study of Tropical Tuna Around Drifting Fish Aggregating Devices (DFADs). Canadian Journal of Fisheries and Aquatic Science 11(1):1517-1528.

Morgan, Lael
1979 Alaska's Native People. Vol. 6, no. 3. Anchorage: Alaska Geographic Society

Moss, Madonna L., and Jon M. Erlandson
1998 A Comparative Chronology of Northwest Coast Fishing Features. *In* Hidden Dimensions: The Cultural Significance of Wetland Archaeology. Kathryn Bernick, ed. Pp. 180. Vancouver, B.C.: University of British Columbia Press

Murawski, Steven A.
2000 Definitions of Overfishing from an Ecosystem Perspective. ICES Journal of Marine Science 57: 649–658

Murray, Grant
2006 Lessons Learned from Reconstructing Interactions between Local Ecological Knowledge, Fisheries Science, and Fisheries Management in the Commercial

Fisheries of Newfoundland and Labrador, Canada. Human Ecology (New York, N.Y.) 34(4):549-571

Murray, Grant, Barbara Neis, Craig T. Palmer, and David C. Schneider
2008 Mapping Cod: Fisheries Science, Fish Harvesters' Ecological Knowledge and Cod Migrations in the Northern Gulf of St. Lawrence. Human Ecology: An Interdisciplinary Journal 36(4):581-598

Myers, R. A., and G. Mertz
1998 The Limits of Exploitation: A Precautionary Approach. Ecological Applications 8(1, Supplement: Ecosystem Management for Sustainable Marine Fisheries):S165-S169

Mymrin, N. I., The Communities of Novoe Chaplino, Sireniki, Uelen, and Yanrakinnot, and H. P. Huntington
1999 Traditional Knowledge of the Ecology of Beluga Whales (*delphinapterus leucas*) in the North Bering Sea, Chukotka, Russia. *Arctic* 52(1): 62–70

Neis, B., L. Felt, R. Haedrich, and D. Schneider
1999 An Interdisciplinary Method for Collecting and Integrating Fishers' Ecological Knowledge into Resource Management. *In* Fishing People, Fishing Places. Pp. 217-235. University of Toronto Press.

Neumann, Roderick P.
2005 Making Political Ecology. London; New York: Hodder Arnold; Distributed in the United States of America by Oxford University Press

Noonkwook, George, The Native Village of Savoonga, The Native Village of Gambell, Henry P. Huntington and John C. George
2007 Traditional Knowledge of the Bowhead Whale (Balaena mysticetus) around St. Lawrence Island, Alaska. Arctic. 60(1): 47-54.

North Pacific Research Board
2005 North Pacific Research Board Science Plan. :1-198.

Olson, Julia
2005 Re-Placing the Space of Community: A Story of Cultural Politics, Policies, and Fisheries Management1. Anthropological Quarterly 78(1):247-268

Ortner, Sherry
2006 Power and Projects: Reflections on Agency. *In* Anthropology and Social Theory. Pp. 129-153. Durham, North Carolina: Duke University Press.

Owens, J. B. "Jack"
2007 What Historians Want from GIS. Electronic document, http://www.esri.com/news/arcnews/summer07articles/what-historians-want.html, accessed 2/4, 2008

Paulson, Susan, and Lisa L. Gezon
2005 Political Ecology Across Spaces, Scales, and Social Groups. New Brunswick, NJ: Rutgers University Press.

Pauly, D.
1997 Putting Fisheries Management Back in Places. Reviews in Fish Biology and Fisheries 7:125-127.

1995 Anecdotes and the Shifting Baseline Syndrome of Fisheries. Trends in Ecology & Evolution (Amsterdam) 10(10):430.

Pearson, W. H., R. A. Elston, R. W. Bienert, A. S. Drum, and L. D. Antrim
1999 Why did the Prince William Sound, Alaska, Pacific Herring (*Clupea Pallasi*) Fisheries Collapse in 1993 and 1994? Review of Hypotheses. Can. J. Fish. Aquat. Sci./J. can. Sci. Halieut. Aquat. 56(4):711-737

Peet, Richard, and Michael Watts
1993 Introduction: Development Theory and Environment in an Age of Market Triumphalism. Economic Geography 69(3, Environment and Development, Part 1):227-253.

Pickrell, Bob
1986 Tidelines. New Alaskan, May.

Poizat, G., and E. Baran
1997 Fishermen's Knowledge as Background Information in Tropical Fish Ecology: A Quantitative Comparison with Fish Sampling Results. Environmental Biology of Fishes 50:435-449.

Potts, Deborah
2000 Environmental Myths and Narrative: Case Studies from Zimbabwe. *In* Political Ecology: Science, Myth and Power. Philip Stott and Sian Sullivan, eds. Pp. 45-55.New York: Oxford University Press, Inc

Poulsen, René
2007 An Abundance Estimate of Ling (Molva Molva) and Cod (Gadus Morhua) in

the Skagerrak and the Northeastern North Sea, 1872. Fisheries Research 87(2/3):196-207

Pritchett, Marc
2005 2006 Report to the Alaska Board of Fisheries: Southeast Alaska-Yakutat Herring Fisheries. Fishery Management Report No. 05-67:1-25.

Putsche, Laura
2006 Political Ecology Across Spaces, Scales, and Social Groups. American Anthropologist 108(3):607-608

Rappaport, Roy A., Ellen Messer, and Michael Lambek
2001 Ecology and the Sacred : Engaging the Anthropology of Roy A. Rappaport. Ann Arbor: University of Michigan Press

Rauwolf, Andy
2007 My Turn: Endangered Herring: Why Now, and Why Only the Lynn Canal? Juneau Empire:1

Rauwolf, Andy
2006 An expose on the history and controversy surrounding commercial herring management in Southeast Alaskan fisheries (excluding Sitka Sound). Electronic document, http://www.sitnews.us/0106Viewpoints/011706_andy_rauwolf.html, accessed 8/20, 2007

2003 We Need Help to Protect Herring. Ketchikan Daily News, January 23-24.

Rauwolf, Andy, and John Harrington
2004, February 26 An Urgent Letter to the Governor. Sitnews Viewpoints:1-3.

Rauwolf, Andy, John Harrington, and Lawrence "Snapper" Carson
2004, April 1 An Expose on the History of the Kah Shakes and West Behm Canal Herring Fisheries: The Untold Story of the Crash of the Stocks and Cover-Up Orchestrated by the Alaska Department of Fish and Game. Sitnews History's Viewpoint:1-11.

Reid, Gerald M.
1972 Fishery Facts-2 the Pacific Herring. :1-20

Robbins, Paul
2005 Fixed Categories in a Portable Landscape: The Causes and Consequences of Land Cover Categorization. *In* Political Ecology: An Integrative Approach to

Geography and Environment-Development Studies. Karl S. Zimmerer and Thomas J. Basset, eds. Pp. 118-200. New York: Guilford Press.

2004 Political Ecology: A Critical Introduction. Malden, MA: Blackwell Pub.

Roberts, Callum
2007 The Unnatural History of the Sea. Washington, DC: Island Press/Shearwater Books

Rosenberg, Andrew A.
2003 Managing to the Margins: The Overexploitation of Fisheries. Frontiers in Ecology and the Environment 1(2):102-106

Rosenberg, Andrew A., W. Jeffrey Bolster, Karen E. Alexander, William B. Leavenworth, Andrew B. Cooper, and Matthew G. McKenzie
2004 The History of Ocean Resources: Modeling Cod Biomass using Historical Records. Frontiers in Ecology and the Environment 3(2):84-90

Rounsefell, George A.
1935 Races of Herring, *Clupea pallasii*, in Southeastern Alaska. Bulletin No. 17(Bureau of Fisheries Vol. XLVIII):119-123.

1931. Fluctuations in the Supply of Herring (Clupea pallasii) in Southeastern Alaska. Bulletin United States Bureau of Fisheries 47 :15-56. Washington: U.S. GPO. Rounsfell's 1929 study is also incompletely referenced: 1929 A Racial Study of the Pacific Herring.

1930. Contribution to the biology of the Pacific herring, *Clupea pallasii*, and the condition of the fishery in Alaska. Bulletin of the U.S. Bureau of Commercial Fisheries 45:227-320.

1929 A Racial Study of the Pacific Herring.

Rounsefell, George A., and Edwin Harold Dahlgren
1932 Fluctuations in the Supply of Herring, *Clupea pallasii*, in Prince William Sound, Alaska. Vol. 47 [p.263-291]. Washington: U.S. Govt. print. Off

1935 Races of Herring, *Clupea pallasii*, in Southeastern Alaska. Vol. 48 [p.119-141]. Washington: U.S. Govt. print. off.

Sadovy, Y., and WL Cheung
2003 Near Extinction of a Highly Fecund Fish: The One that nearly Got Away. Fish and Fisheries 4:86-99.

Sáenz-Arroyo, Andrea, and Callum M. Roberts
2008 Consilience in Fisheries Science. Fish & Fisheries 9(3):316-327

Sáenz-Arroyo, Andrea, Callum M. Roberts, Jorge Torre, and Micheline Cariño-Olvera
2005 Using Fishers' Anecdotes, Naturalists' Observations and Grey Literature to Reassess Marine Species at Risk: The Case of the Gulf Grouper in the Gulf of California, Mexico. Fish & Fisheries 6(2):121-133

Sáenz-Arroyo, Andrea, Callum M. Roberts, Jorge Torre, Micheline Cariño-Olvera, and Julie P. Hawkins
2006 The Value of Evidence about Past Abundance: Marine Fauna of the Gulf of California through the Eyes of 16th to 19th Century Travellers. Fish & Fisheries 7(2):128-146

Schroeder, Robert F. and Matthew Kookesh
1990 The Subsistence Harvest of Herring Eggs in Sitka Sound, 1989. Alaska Department of Fish and Game, Division of Subsistence, Technical Report No. 173.

Scoones, I.
1999 New Ecology and the Social Sciences: What Prospects for a Fruitful Engagement? Annual Review of Anthropology 28:479-507

Seattle Times
2004 Two Herring Fisheries to Stay Closed in 2005. Seafood Norway:1-1

Sherzer, Joel, and Richard Bauman
1972 Areal Studies and Culture History: Language as a Key to the Historical Study of Culture Contact. Southwestern Journal of Anthropology 28(2):131-152

Shore, Cris, and Susan Wright
1997 Anthropology of Policy : Critical Perspectives on Governance and Power. London ; New York: Routledge

Silvano, RAM, and A. Begossi
2005 Local Knowledge on a Cosmopolitan Fish: Ethnoecology of Pomatomus Saltatriz (Pomatomidae) in Brazil and Australia. Fisheries Research 71:43-59.

Silvano, RAM, PFL MacCord, RV Lima, and A. Begossi
2006 When does the Fish Spawn? Fishermen's Local Knowledge of Migration and Reproduction of Brazilian Coastal Fishes. Environmental Biology of Fish 76:371-386.

Sinclair, A. F.
1993 Partial Recruitment Considerations in Setting Catch Quotas. Canadian Journal of Fisheries and Aquatic Sciences 50(4):734.

Sinton, Diana Stuart, and Jennifer J. Lund
2007 Understanding Place: GIS and Mapping Across the Cirriculum. Redlands, California: ESRI Press.

Skud, Bernard Einar
1982 Dominance in Fishes: The Relation between Environment and Abundance. Science 216(4542):144-149.

1963 Herring Tagging Experiments in Southeasterm Alaska. United States Fishery Service Fishery Bulletin. 63: 19-32.

1959 *Herring Spawning Surveys in Southeast Alaska*. U.S. Fish and Wildlife Service Special Scientific Report—Fisheries No. 321. Washington, D.C.

Skud, Bernard Einar, Henry M. Sakuda, and Gerald M. Reid
1960 Statistics of the Alaska Herring Fishery, 1878-1956. Washington: U. S. Dept. of the Interior, Fish and Wildlife Service Statistical Digest 48.

Sluyter, Andrew
2005 Blaut's Early Natural/Social Theorization, Cultural Ecology, and Political Ecology. Antipode 37(5):963-980

St. Germain, Sheryl
2000 Ketchikan: Catching Fish. North American Review 285(5):4

Stanley, Richard D. and Jake Rice
2007 Fishers' Knowledge? Why Not Add Their Scientific Skills While You're At It? *in* Fishers' Knowledge in Fisheries Science Management. Nigel Haggan, Barbara Neis and Ian G. Baird. eds. Pp. 401-420. Paris: UNESCO.

Steinbeck, John, Edward Flanders Ricketts, and John Steinbeck
1995 The Log from the Sea of Cortez. New York: Penguin Books

Stevens, Stan, and Terry De Lacy
1997 Conservation through Cultural Survival : Indigenous Peoples and Protected Areas. Washington, DC: Island Press

Stewart, Hilary
1977 Indian Fishing: Early Methods on the Northwest Coast. Seattle: University of Washington Press.

Stott, Philip and Sian Sullivan
2000 Introduction. *In* Political Ecology: Science, Myth and Power. Philip Stott and Sian Sullivan, eds. Pp. 1-11.New York: Oxford University Press, Inc.

Straley, Janice M., Terrance J. Quinn II, and Christine M. Gabriele
2008 Assessment of Mark-Recapture Models to Estimate the Abundance of a Humpback Whale Feeding Aggregation in Southeast Alaska. Journal of Biogeography 36: 427-438.

Sturtevant, William C.
1900 Handbook of North American Indians. Washington: Smithsonian Institution : For sale by the Supt. of Docs., U.S. G.P.O.

Sullivan, Sian
2000 Getting the Science Right, or Introducing Science in the First Place?: Local 'Facts,' Global Discourse – 'Desertification' in North-west Namibia. *In* Political Ecology: Science, Myth and Power. Philip Stott and Sian Sullivan, eds. Pp. 15-44..New York: Oxford University Press, Inc

Swyngedouw, Erik, and Nikolas C. Heynen
2003 Urban Political Ecology, Justice and the Politics of Scale. Antipode 35(5):898-918

Tan-Mullins, May
2007 The State and its Agencies in Coastal Resources Management: The Political Ecology of Fisheries Management in Pattani, Southern Thailand. Singapore Journal of Tropical Geography 28(3):348-361

Thornton, Thomas F.
2008 Being and Place among the Tlingit. Seattle and London: University of Washington Press.

Thornton, Thomas F., Virginia Butler, Fritz Funk, Madonna Moss, Jamie Hebert, Tait Elder

2010 Herring Synthesis: Documenting and Modeling Herring Spawning Areas Within Socio-Ecological Systems Over Time in the Southeastern Gulf of Alaska. Technical Report, 728. North Pacific Research Board.

Townsend, Patricia K.
2000 Environmental Anthropology : From Pigs to Policies. Prospect Heights, Ill: Waveland Press

Turner, Nancy J., Marianne Boelscher Ignace, and Ronald Ignace
2000 Traditional Ecological Knowledge and Wisdom of Aboriginal Peoples in British Columbia. Ecological Applications 10(5):1275-1287.

United States
1997 Draft Environmental Impact Statement... Lab Bay Project Area... Ketchikan Pulp Company, Long-Term Timber Sale Contract... Volume 1... United. S.l.:

Shipping List #: 98-0014-M; Shipping List Date: 11/03/97.

United States Department of Agriculture, Forest Service
1997 Lab Bay Project Area Final Environmental Impact Statement :Ketchikan Pulp Company Long-Term Timber Sale Contract. Vol. 321a-c. Juneau: U.S. Dept. of Agriculture, Forest Service, Alaska Region

United States.Congress.House.Committee on Interior and Insular Affairs
1980 Providing for the Disenrollment of Certain Alaska Natives from the Alaska Native Role and to Allow their Enrollment with the Metlakatla Indian Community :Report (to Accompany H.R. 5108) (Including the Cost Estimate of the Congressional Budget Office). Vol. 96-1405. Washington, D.C.: U.S. G.P.O.

Valbo-Jorgensen, J., and A. Poulsen
2000 Using Local Knowledge as a Research Tool in the Study of River Fish Biology. Environment, Development and Sustainability 2(3-4):253-277.

Vayda, A. P. and Bradley B. Walters
2009 Event Ecology, Causal Historical Analysis and Human-Environment Research. Annals of the Association of American Geographers 99:534-553

1999 Against Political Ecology. Human Ecology (New York, N.Y.) 27(1):167

Vayda, Andrew Peter, and American Museum of Natural History
1969 Environment and Cultural Behavior; Ecological Studies in Cultural

Anthropology. 1st ed. Garden City, N.Y.: Published for American Museum of Natural History by Natural History Press

Victor-Howe, Anne-Marie
2008 Subsistence Harvests and Trade of Pacific Herring Spawn on *Macrocystis* Kelp in Hydaburg, Alaska. Technical Paper No. 225:1-75.

Walker, Peter A.
2007 Political Ecology: Where is the Politics? *In* Pp. 363-369. Sage Publications, Ltd

Walker, Peter A.
2005 Political Ecology: Where is the Ecology? Progress in Human Geography 29(1):73-82

Wertsch, James V.
2008 The Narrative Organization of Collective Memory. Ethos 36(1): 120-135.

Whale Killing Cause Herring Fishing Short
1920 Ketchikan Weekly, February 5.

Wheatley, David, and Mark Gillings
2002 Spatial Technology and Archaeology : The Archaeological Applications of GIS. Taylor & Francis, London ; New York.

White, Geoffrey.
2006 Epilogue: Memory Moments. Ethos 34(2): 325-341.

Whitesell, Edward A.
1996 Local Struggles Over Rain-Forest Conservation in Alaska and Amazonia. Geographical Review 86(3, Latin American Geography):414-436

Williams, Alan and Nicholas Bax
2007 Integrating Fishers' Knowledge with Survey Data to Understand the Structure, Ecology and use of Seascape off South-eastern Australia *in* Fishers' Knowledge in Fisheries Science Management. Nigel Haggan, Barbara Neis and Ian G. Baird. eds. Pp. 365-380. Paris: UNESCO.

Wilson, James A., John French, Peter Kleban, Susan McKay, and Ralph Townsend
1991a Chaotic Dynamics in a Multiple Species Fishery: AModel of Community Predation. Ecological Modelling. 58: 303-322

1991b The Management of Chaotic Fisheries: A Bio-economic Model. *In* Proceedings from Symposium on Multiple Species Fisheries. Michael Sissenwine and Nils Daan, eds. Pp. 287-3000. Copenhagen: International Council for the Exploration of the Sea.

Witteveen, B. H

2003 Abudance and Feeding Ecology of Humpback Whales (*Megaptera novaeangliae*) in Kodiak, Alaska. Masters Thesis, University of Alaska Fairbanks.

Zebdi, Abdelkrim, and J. Collie

1995 Effect if Climate on Herring (Clupea Pallasi) Population Dynamics in the Northeast Pacific Ocean. *In* Climate Change and Northern Fish Populations. R. J. Beamish, Canada Dept. of Fisheries and Oceans and National Research Council Canada, eds. Pp. 277. Canada: NRC Research Press

Zheng, Jie, F. Funk, Gordon H. Kruse, and Alaska Department of Fish and Game

1993 Evaluation of Threshold Management Strategies for Pacific Herring in Alaska. Proceedings of the International Symposium on Management Strategies for Exploited Commercial Fisheries AK-SG-93-02:141-163.

Zimmerer, Karl S., and Thomas J. Bassett

2003 Approaching Political Ecology: Society, Nature, and Scale in Human-Environment Approaches. *In* Political Ecology: An Integrative Approach to Geography and Environment-Development Studies. Karl S. Zimmerer and Thomas J. Basset, eds. Pp. 1-5. New York: Guilford Press

APPENDIX A

Local Ecological Knowledge (LEK) Discourse
Herring Coalition Affidavits, 1993

	Name of Affidavit	Occupation	Years in Southeast Alaska (as of 1993)	Age
1	Terry Wills	Pilot	33	N/A
2	David Werner	Pilot	26	54
3	Herman Ludwigsen	Pilot/Commercial Troller	55	N/A
4	Dennis W. Mann	Fisherman	21	N/A
5	Ben Flee nor	Troller	51	69
6	Cliff Smith	Fisherman	65	N/A
7	Perry C. Coburer	Fisherman	44	N/A
8	Joe R. Hassell	Sport Fisherman/Commercial Troller	44	N/A
9	Matilda Kushnik	Saxman Elder	70	N/A
10	Glenn L. Lervick	Sport Fisherman/Hand Troller	47	52
11	Zelma H. Brand	Fisherman	44	N/A
12	Sonny Campell	Sport Fisherman	32	N/A
13	Elizabeth Chambers	Fisherman	40	N/A
14	Chester V. Thompson	Fisherman	40	N/A
15	Arnold Ludwigsen	Commercial Troller	23	N/A
16	Sylvia Geraghty	N/A	19	N/A
17	Jack M. Mason	Fish Buyer/Merchant	44	N/A
18	Maxine M. Mason	Fish Buyer/Merchant	38	38
19	Jonathan DeWitt	Commercial Troller	54	54
20	Robert C. Lewis	Fisherman	55	N/A
21	Andy Rauwolf	Sport Fisherman	24	N/A
22	Peggy Rauwolf	Sport Fisherman	N/A	N/A
23	Stanley D. Reid	Fisherman	50	N/A
24	Darlene Larson	Commercial Fisherman/Gill Net Deckhand	49	N/A
25	Jack Gucker	Local Resident	68	N/A
26	Jeane Gucker	Local Resident	43	N/A
27	Ray Ford	Gillnet Fisherman	63	63
28	Marvin Jannsen	Fisherman	27	N/A
29	Richard B. Stough	Sport Fisherman/Commercial Fisherman	47	N/A

	Name of Affidavit	Occupation	Years in Southeast Alaska (as of 1993)	Age
30	Robert H. Ziegler, Jr.	Commercial Fisherman/Gill Net Deckhand	42	N/A
31	Thomas B. Ramiskey	Sport Fisherman/Tugboat Operator	39	N/A
32	Dan McQueen	Commercial Troller/Sport Fisherman	12	N/A
33	Dan Roberts	Sport Fisherman	45	N/A
34	Mike Fleenor	Sport Fisherman/Commercial Troller	44	44
35	Lloyd Rinehart	Commercial Fisherman	70	N/A
36	Samuel Carlson	Fisherman/Artist	32	N/A
37	Ruth M. Zieske	Commercial Fisherman/Post Master	50	N/A
38	Laurie Bender	Commercial Fisherman	15	N/A
39	Roman S. Keleske	Commercial Fisherman	44	N/A
40	Rochelle L. Rollenhagen	Fisherman/Land Use Planner	11	N/A
41	Gary Treffry	Commercial Fisherman/Troller	20	N/A
42	Litz Botello	Fisherman	13	N/A
43	John W. Bean	Commercial Fisherman	14	N/A
44	Charles H. Zieske	Commercial Fisherman	44	N/A
45	Terry Kline	Commercial Fisherman	18	N/A
46	Sonny Deegan	Fisherman	35	N/A
47	Jerry Germain	Commercial Fisherman	48	N/A
48	Donald Hernandez	Commercial Fisherman	17	N/A
49	Earnest5 K. Watcom	Survivalist	21	N/A
50	Andrea L. Hernandez	Commercial Fisherman	19	N/A
51	Warren F. Powers	Fisherman	33	N/A
52	Paul C. March	Shipwright/Fisherman	13	N/A
53	Merek E. Mura	Commercial Fisherman	20	N/A
54	Chester V. Thompson	Fisherman	40	N/A
55	Dean Baker	Commercial Fisherman/Troller	50	N/A
56	Norman Alsou	Commercial Troller	62	N/A
57	Chris Chavasse	Fisherman	N/A	N/A

APPENDIX B

Interview Participants Identified by Discourse

	Name of Participant	Occupation/Identification	Interview Date	Age	Discourse
1	Hap Leon	Annette Island fisheries biologist	April 2009	N/A	Management
2	Dustin Winters	Annette Island fisheries biologist	October 2008	N/A	Management
3	Scott Walker	ADFG fisheries biologist	October 2008	N/A	Management
4	Gary Frietag	Professor, University of Alaska Southeast Fisheries Technology Program	October 2008	N/A	Management
5	Matilda Kushnik	Saxman Elder	March 2008	N/A	LEK
6	Merle Hawkins	Native Tlingit, Ketchikan Advisory Council member	October 2008	N/A	LEK
7	Consultant 1	Native Tsimshian, commercial fisherman	October 2008	N/A	LEK
8	Consultant 2	Native Tlingit, subsistence user	October 2008	N/A	LEK
9	Andy Rauwolf	Sport fisherman	October 2008	N/A	LEK
10	Tom Kopeland	Previously employed by ADFG, pilot	March 2008	65	LEK
11	Franklin James, Sr.	Native Tlingit, trader	March 2008	N/A	LEK
12	Ken Kiffer	Commercial fisherman	March 2008	68	LEK
13	Sonner Murphy	Sport fisherman	March 2008	N/A	LEK
14	Martin Perez, Sr.	Native Tlingit, commercial fisherman	April 2009	92	LEK
15	Marvin Charles, Sr	Native Tlingit, subsistence user	March 2008	N/A	LEK
16	Lawrence ‘Snapper’ Carson	Commercial fish tender	March 2008	N/A	LEK
17	Lloyd Gossman	Sport fisherman	March 2008	N/A	LEK
18	Dennis Diamond	Sport and commercial fisherman	March 2008	N/A	LEK
19	Steve Schrum	Pilot	March 2008	N/A	LEK