Towards Indigenous Marine Management: A Case Study of Yelloweye Rockfish on the Central Coast of British Columbia

by

Lauren Eckert
B.Sc., University Notre Dame, 2014

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

in the School of Environmental Studies

Towards Indigenous Marine Management: A Case Study of Yelloweye Rockfish on the Central Coast of British Columbia

by

Lauren Eckert
B.Sc., University of Notre Dame, 2014

Supervisory Committee

Dr. Natalie C. Ban, Supervisor
School of Environmental Studies

Dr. Nancy Turner, Departmental Member
School of Environmental Studies

Dr. Alejandro Frid, Additional Member
School of Environmental Studies

Abstract

Coastal Indigenous Peoples worldwide have relied on fish and other marine resources for millennia, and continue to do so despite recent degradation of ocean systems. Their traditional ecological knowledge, comprised of experiences, observations, beliefs, and lifeways, is relevant for modern marine management and conservation. This thesis explores the utility of traditional and local ecological knowledge for extending an understanding of changes over time for places or periods in which scientific data are unavailable.

This thesis had three goals: 1) undertake research that is collaborative and inclusive, and that addresses priorities established by participating First Nations; 2) contribute to fisheries management and conservation recommendations by focusing on a species of cultural importance and exploring the applications of traditional and local ecological knowledge to species-level understandings; and 3) contribute a marine social-ecological case study that investigates the use of traditional and local ecological knowledge to understand change over time and provides appropriate context. Two main objectives allowed me to accomplish my goals: 1) demonstrate the application of traditional and local ecological knowledge to establish historical baselines that extend farther back in time than scientific surveys, and investigate reasons for changes, and 2) investigate the utility of a social-ecological trap framework in assessing impacts to a social-ecological system and identifying ways to escape such a trap.

My case study occurred in collaboration with four First Nations (as many Indigenous Peoples of Canada are called) on the Central Coast of British Columbia, Canada. My methods included semi-structured interviews with knowledge holders to examine traditional and local ecological knowledge of a culturally and economically important species, Yelloweye rockfish (*Sebastes ruberrimus*). In this study, I interviewed First Nations fishers and Elders (n=43), asking about: observed changes to the body sizes (length) and abundance of this species over the last ~60 years, the factors driving these changes, stewardship principles or traditional management strategies, concerns for marine resources, and perceived opportunities for cultural revitalization. I then quantified the interview participants' current and historical estimates of size and abundance, compared interview data to current biological survey data, and qualitatively analyzed responses

regarding stewardship, culture, perceived threats, and cultural solutions. I utilized the framework of a social-ecological trap to analyze responses about stewardship, traditional stories or management, and threats to culture, selecting illustrative quotes to contextualize the lived experiences of participants.

Overwhelmingly, respondents had observed a decrease in Yelloweye rockfish body sizes since the 1980s. Median historical length observed by participants was nearly twice the modern length. Participants reported substantial decrease in Yelloweye rockfish abundance since the 1980s, and most stated that this change was evident in the early 2000s. Sizes of modern Yelloweye rockfish estimated by participants resembled measurements from ecological data recorded concurrently at the study region. Thus, my study extends baseline historical data of Yelloweye rockfish reliably by about 50 years. Questions about traditional stories and culture revealed the presence of a social-ecological trap created and reinforced by the interplay between species decline and colonization (e.g. the residential schooling system). When asked about traditional management or stewardship practices, only one participant could remember specific traditional stories about Yelloweye rockfish, though all participants expressed adherence to the stewardship principles of taking only what is needed and respecting all life. Though participants expressed concern about the muting of traditional ecological knowledge, culture, and language, they also highlighted key ways towards revitalization and Indigenous resurgence. The ubiquitous presence of stewardship principles suggests there are ways beyond the social trap: participants described on-going cultural revitalization efforts, recovery of depleted species and ecosystems, and the reassertion of Indigenous management rights as ways to overcome problems inherent to the social-ecological trap.

My research adds to a growing body of literature that supports the use of traditional and local ecological knowledge in marine management and conservation science. Adding to this literature, my work suggests the significant value of traditional and local ecological knowledge for filling gaps in historical scientific data or in data-poor regions, and highlights the importance of appropriately contextualizing Indigenous knowledge. To overcome the social-ecological trap of knowledge loss and to achieve informed marine management, reassertion of Indigenous

management rights and application of traditional management strategies to modern fisheries management is vital.

Table of Contents

List of Tables

Chapter 2

List of Figures

Chapter 2

Chapter 3

Acknowledgements

With utmost gratitude and humility, I thank the Kitasoo/Xai'xais, Wuikinuxv, Heiltsuk, and Nuxalk Nations who motivated, supported, and enlivened this work with their knowledge and energy. I thank all those who participated in the study and whose observations, contributions, and willingness to offer their time and knowledge constitute our data. I am also grateful to the Tallio family for contributing anecdotes from their proprietary Q'umukwa story. Special thanks are extended to the stewardship directors and marine managers who were critical to the formation and success of this project: Danielle Shaw, Mike Reid, Harvey Humchitt, Megan Moody, Peter Siwallace, Douglass Neasloss, and Barry Edgar. The Central Coast Indigenous Resource Alliance and the Guardian Watchmen within each community also made this work possible.

I am grateful to my advisor, Natalie Ban, whose inexhaustible guidance, patience, excellence, and support are represented in every aspect of my work. I am immensely thankful to my committee member Alejandro Frid for his inspiration, leadership, constant counsel, collaborative spirit, and for allowing me opportunities to experience the marine waters and species that my work aims to conserve. To Nancy Turner, whose legacy of Ethnobotanical research first directed my attention to the University of Victoria, I owe thanks for supportive advice, critical edits, and all of her foundational life's work.

I additionally wish to acknowledge the financial support provided by The Marine Environmental Observation Prediction and Response Network (MEOPAR), the Social Sciences and Humanities Research Council (SSHRC), National Sciences and Engineering Research Council (NSERC), The National Geographic Society, and OceanCanada.

Finally, I recognize my friends, family, colleagues, and my partner, who together made my work feasible and supported me throughout the journey. Thank you for sustaining my spirit of adventure and stability throughout this project.

Dedication

My work is dedicated to the individuals and communities who shared their stories, homes, and harvests with me. It is also dedicated to those generations yet to come. May we collectively embrace the Indigenous commitment to future generations, and leave you a world of wonder, vibrancy, and diversity.

Chapter 1: Introduction

1.1 Introduction

This study explores and applies traditional and local ecological knowledge of Indigenous communities of British Columbia (BC), Canada to increase understanding about historical changes to Yelloweye rockfish (*Sebastes ruberrimus*) – a focal species that is economically, culturally, and ecologically valuable in the region and federally listed as "special concern" (COSEWIC 2008).

This study – undertaken in partnership with four Indigenous communities of Canada's West Coast – explores the application of traditional and local ecological knowledge to fisheries management by examining themes related to marine historical ecology, Indigenous marine management, and social-ecological systems. Marine historical ecology emerged as a means of incorporating non-traditional (e.g. local knowledge, archival data, photographs) and historical data sources into marine ecological assessments to better inform conservation goals in an ocean increasingly modified by human action (Lotze and McClenachan 2013, Kittinger et al. 2015). To date, relatively few studies have used traditional or local ecological knowledge as a primary data source to extend temporal baselines and inform marine management (Drew 2005, McClenachan et al. 2012, Narchi et al. 2014). Studies concerning Indigenous marine management are aimed at understanding how traditional management by Indigenous Peoples operated, and how their practices can be implemented to the benefit of contemporary marine conservation (Johannes 1978, 2002, Johannes and Yeeting 2000, Berkes 2004). This project explores the critical importance of Indigenous knowledge for use in marine management plans, and uses a social-ecological systems framework (one which recognizes the interconnectedness of social and ecological systems) (Berkes et al. 2000a) to analyze and highlight ways Indigenous Peoples may overcome, or are overcoming, threats to the continuation of this knowledge.

This introductory chapter situates my study within the interdisciplinary literature on traditional management practices, and illustrates how it fills particular academic gaps. First, I discuss the

brief and relevant history of marine historical ecology, the studies of traditional ecological knowledge, and social-ecological systems theory. Next, I summarize Indigenous knowledge as it applies to marine management, and briefly review the impacts of Western colonization on Indigenous Peoples and their knowledge systems. I then explain "social-ecological traps", a term pertaining to situations in which interactions between social and ecological factors lead to an undesirable system state. I discuss their development, and describe how I utilized them as a lens through which to analyze key themes in my research. Finally, I provide an overview of thesis goals, methodology, and structure.

1.2 Marine Historical Ecology and Traditional Ecological Knowledge

Globally, marine systems are degrading as a result of overfishing, pollution, climate change, and other stressors (Pauly et al. 1998, Myers and Worm 2003, Worm et al. 2006). Overfishing is leading to stock collapses or endangerment of many marine species of key economic, ecological, and cultural concern (Pauly et al. 1998, Jackson et al. 2001, Myers and Worm 2003, Worm et al. 2006). Despite goals to better manage key fish species and thus prevent their extirpation, many fisheries management attempts fall short. Limited data to assess the current and historical status of marine systems and species is a common problem in fisheries management efforts (Johannes 1998a, McClenachan et al. 2012). Even in those regions where data are actively collected, data baselines often do not extend beyond 20-40 years.

The inquiry of historical ecology can help to fill data gaps. Historical ecology is broadly defined and diversely applied (Szabó 2015). It arose from the intellectual strands of forest history, paleoecology, landscape history, archaeology, and others (Szabó 2015). John Grainger (1940) first coined the term "historical ecology" in the 1940s when he utilized archival data to understand changes to fungus populations (Grainger 1940, Szabó 2015). Since then, historical ecology has been widely applied to inform management and extend data baselines beyond pre-existing scientific limitations. It is frequently used as a tool in conservation ecology (Kittinger et al. 2015), and utilizes diverse methodologies, ranging from natural to social sciences. For example, Deevey (1969), combined radiocarbon dating methods and results of field ecology studies to better understand the historical interplay between plant succession and early humans

(Deevey 1969). Covington et al. (1997) relied upon dendrochronology and *in situ* ecological experiments to postulate post-settlement changes to Ponderosa Pine forests, and recommend restoration procedures (Covington et al. 1997). Veblen and Lorenz (1986) used historical photographs and repeat photography, alongside dendrochronological methods, to analyze long-term disturbance and recovery patterns in montane forests (Veblen and Lorenz 1986). Many recent studies have used non-traditional data sources (e.g., archival documents, historical photographs, human observation, and Indigenous Peoples' knowledge) to create historical references that inform restoration and conservation goal-setting (Swetnam et al. 1999, McClenachan 2009, Meyer and Crumley 2011, Al-Abdulrazzak et al. 2012, McClenachan et al. 2012).

Principles of historical ecology have only been applied to marine environments in the last 20-30 years; Daniel Pauly's 1995 article, "*Anecdotes and the shifting baseline syndrome of fisheries*" (Pauly 1995) was one of the first to argue for the need to apply historical ecology to fisheries management. In this paper, Pauly suggested that scientific data baselines are frequently too short to conceptualize long-term ecosystem or population-level change; thus, we need data sources which elicit to what extent ecosystems have been impacted to effectively manage and set conservation goals (Pauly 1995). Since then, many studies in marine ecology have used historical ecology methods to extend baselines and inform management in regions that are temporally or spatially data-poor. For example, McClenahan (2009) used historical photographs to track previously undocumented changes to trophy fish size in the Florida Keys (McClenachan 2009). Studies in Brazil, USA, Southeast Asia, the Philippines, and Canada (amongst others) have documented the value of local fishers' knowledge to inform species management (Johannes 2000, Beaudreau and Levin 2014, Kittinger et al. 2015). In Washington (USA), fishers' local ecological knowledge was aggregated to increase understanding of historical changes to rockfish species (*Sebastes* spp.); when analyzed, local knowledge was comparable to data from scientific surveys (Beaudreau and Levin 2014). In addition to fishers' local knowledge, Indigenous Peoples' knowledge in the form of traditional ecological knowledge has been explored to allow scientists and managers new insights into species-level changes in data-poor regions, or for the selection of sustainable management methods (Johannes 1998a, Berkes et al. 2000b, Menzies and Butler 2007b, Espinoza-Tenorio et al. 2013). For instance, in the Philippines, traditional

ecological knowledge of Indigenous Peoples elicited new information on changes to fin fish populations (namely species extirpations) previously unknown to science (Lavides et al. 2009). Thus, historical information is now recognized as critical to marine management and ecology to fill temporal (Pauly 1995) and spatial gaps in scientific data (Johannes 1998).

Many regions, for which little scientific data are available, have been stewarded by Indigenous coastal communities for millennia (Drew 2005, Berkes 2012a). Due to their long-term reliance on marine resources and environments, Indigenous Peoples possess traditional ecological knowledge, which allows them to harvest key resources in a sustainable manner (Berkes et al. 2000b, Berkes and Turner 2006, Berkes 2012a). Traditional ecological knowledge is defined as "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 2012a)." Traditional ecological knowledge represents information collected through processes of observation, experience, and trial and error. Localized communities rely on knowledge transmission for cultural and physical subsistence (Berkes and Turner 2006, Turner and Berkes 2006, Berkes 2012b).

The study of traditional ecological knowledge takes its roots in ethnoecology, and has evolved over the last 60 years. Recognition of the detail-oriented, generationally-passed observations utilized by Indigenous Peoples is described by Conklin (Conklin 1957, Nazarea 1999). The term "traditional ecological knowledge" or "traditional environmental knowledge" did not take shape for several decades; at its onset, some ecologists argued against its application or value for management. Increased recognition of the complex stewardship, agricultural, and resource management strategies relied upon by Indigenous Peoples resulted in increased appreciation for its practical applications to management (Posey 1985, Gadgil et al. 1993). In the last three decades, traditional ecological knowledge has been acknowledged for its ability to overcome gaps in scientific data, contribute methods to conservation and management techniques and better prioritize protected areas. (Berkes et al. 2000b, Huntington 2000, Johannes 2000, Turner et al. 2000, Berkes 2004, 2012a, Drew 2005). Further, use of traditional ecological knowledge has

the potential to forward socially inclusive and collaborative resource management (Moller et al. 2004, Thornton et al. 2010).

Because it represents lifetimes and generations of information regarding species and environments, traditional ecological knowledge is relevant to marine historical ecology; but few studies in the field have used it (McClenachan et al. 2012, Narchi et al. 2014). Though much work in the last three decades has focused on applying traditional systems of marine management (such as customary marine tenure) to modern marine management and conservation efforts (Johannes 2000, Johannes and Yeeting 2000, Aswani and Hamilton 2004, Haggan et al. 2007, Menzies and Butler 2007b, Hallwass et al. 2013), fewer explore traditional ecological knowledge. Amalgamating the multi-generational and lifetime observations of coastal Indigenous Peoples may allow scientists to fill data gaps in remote locations where little sampling has occurred, or on larger temporal scales than available from scientific studies.

In this thesis, I use both the terms "traditional ecological knowledge" and "local ecological knowledge". Local ecological knowledge is constituted by a lifetime of observations about a particular ecosystem and the species that inhabit it. Local ecological knowledge and traditional ecological knowledge interact (Berkes and Turner 2006); the accumulation of local ecological knowledge, and its transitions towards social institutions, cultural internalization, and worldview result in the inter-generational establishment of traditional ecological knowledge (Berkes et al. 2000b, Berkes and Turner 2006). Many Indigenous Peoples possess both traditional and local ecological knowledge; Indigenous fishers who have relied on local resources over their entire lifetime may possess both the traditional ecological knowledge passed to them from their family and community, and local ecological knowledge accumulated over a lifetime of interaction with local ecosystems and harvested species. Thus, the knowledge represented in this thesis is referred to as "traditional ecological knowledge and local ecological knowledge" and represents knowledge from Indigenous individuals that is constituted by both.

1.3 Indigenous Peoples and Marine Management

Despite global degradation of marine environments, many Indigenous Peoples continue to rely heavily on marine resources. Indigenous Peoples, communities, and cultures possess a unique and important perspective on marine species declines; over millennia, they have developed sophisticated stewardship and management practices to sustain key resources (Berkes and Turner 2006, Berkes 2012a). For instance, in the Pacific Islands, Indigenous communities utilized complex management strategies for sustaining local resources that included temporal and spatial closures, cultural taboos, and proprietary management through customary marine tenure (a system in which one individual or family was charged with stewarding a certain area) (Johannes 1978, 2002). For example, in British Columbia, Canada, Indigenous leaders known as "hereditary chiefs" historically held proprietary ownership rights and management responsibility over salmon stocks and other key resources in specific areas (Haggan and Brown 2002). Along Canada's Western coastline, Indigenous Peoples selectively harvested salmon by using technology (e.g., fish traps, fish weirs) to select fish size, gender, and abundance; they also manipulated waterways through which migrating fish species passed to maximize harvest (Turner et al. 2000).

Indigenous Peoples of the world have faced the resounding impacts of colonization (Brave Heart and DeBruyn 1998, Environics Research Group 2008, United Nations Declaration 2008, Turner et al. 2013b). Genocide, involuntary expulsion from native lands, familial separation, and forced cultural assimilation are hallmarks of Western colonization which have resulted in dramatic population decreases and negative impacts to culture and lifeways amongst the world's Indigenous Peoples (United Nations Declaration 2008). These impacts, combined with increasing ecological degradation to local environments and species of critical importance, have disrupted traditional ecological knowledge of many Indigenous Peoples. Indigenous knowledge is place-based and inter-generationally passed, and thus requires time to adapt to ecosystem-level changes for knowledge transmission and cultural continuity (Berkes 2012a). Thus, rapid environmental degradation or loss of local species abundance further degrades cultures and

lifeways already profoundly impacted by colonization. Recognizing and seeking to repair this degradation traditional ecological knowledge within Indigenous communities is vital; not only is traditional ecological knowledge recognized by scientists and conservationists as a valuable source of information for improved management (Berkes 2004, 2012a, Drew 2005), but upholding and reviving this knowledge and Indigenous cultures is directly linked with supporting inherent Indigenous rights. The deterioration of traditional ecological knowledge and culture, caused by the interactions of colonialism and environmental degradation (Turner et al. 2008), fits into the multidisciplinary study of social-ecological traps.

1.4 Social-ecological Systems and Social-ecological Traps

Social-ecological systems theory is a multidisciplinary area of inquiry that recognizes the interconnectedness of social and ecological systems, and the myriad interactions and feedbacks that occur within and between them (Berkes et al. 2000a). First formalized in 2000, the theory characterizes social-ecological systems as complex and dynamic. Framing systems in this way allows researchers to consider multifaceted interactions that impact key issues (Berkes et al. 2000a). Understanding social factors (e.g. socio-economic status, local customs, etc.) is important for success in conservation planning (Ban et al. 2013). Social-ecological systems thinking has been applied to marine systems, for example to analyze the role socio-economic or human compliance factors play in the efficacy of marine reserves (Pollnac et al. 2010).

Social traps, first described in 1973, are situations in which individuals or groups of people "get started in some direction or some set of relationships that later prove to be unpleasant or lethal and that they see no easy way to back out or to avoid (Platt 1973)." These "traps" are well researched and applied in the field of psychology. Platt provides several examples of social traps, including Hardin's "Tragedy of the Commons" (Hardin 1968), in which a group of individuals competing for an open-access resource will be driven to extirpate it at their own expense. Social-ecological traps combine social trap theory with the theoretical framework of social-ecological systems thinking, and are defined as "situations when feedbacks between social and ecological systems lead toward an undesirable state that may be difficult or impossible to reverse (Cinner 2011)." Social-ecological traps have been applied to marine research, but not extensively.

Steneck et al. (2011) recognized evidence of a "gilded trap" in the Maine lobster fishery; in Maine, lucrative financial incentives drive communities and individuals to harvest lobster with little attention to the environmental or economic ramifications of extirpation (Steneck et al. 2011). Cinner (2011) recognized and analyzed a social-ecological trap within reef fisheries of the western Indian Ocean. Here, poverty and a lack of governing institutions interact to drive local depletions in resources of importance, thus increasing poverty and spiraling communities further into the trap (Cinner 2011).

Despite the application of social-ecological traps to frame issues within marine conservation, few, if any, studies have used the framework of a social-ecological trap to acknowledge and address knowledge loss in Indigenous cultures due to environmental depletion. Because Indigenous communities worldwide seek to move beyond the impacts of colonization, revitalize their culture, and reassert their marine and terrestrial management rights, I use the framework of a social-ecological trap to analyze cultural and knowledge losses faced by Indigenous Peoples. Increased understanding of the mechanisms and feedbacks which snare Indigenous communities in a "knowledge and culture loss trap" may also suggest opportunities to move beyond the trap.

1.5 Study Goals

I engaged in a collaborative project with four Indigenous Nations on the Central Coast of BC, Canada. These four First Nations, as some Aboriginal groups of Canada are called, identified a species of cultural concern (Yelloweye rockfish), which is the focal species of this thesis.

My thesis has three main goals:

1) Undertake research that is collaborative and inclusive, and addresses priorities established by participating First Nations.

2) Contribute to fisheries management and conservation recommendations by focusing on a species of cultural importance and exploring the applications of traditional and local ecological knowledge to species-level understandings.

3) Contribute a marine social-ecological case study that investigates extending data baselines using traditional and local ecological knowledge and provides appropriate context.

The following main objectives were at the core of my study:

1) Demonstrate the application of traditional and local ecological knowledge to establish historical baselines that extend farther back in time than scientific surveys, and investigate reasons for changes.

2) Investigate the utility of a social-ecological trap framework for assessing impacts to a social-ecological system and identifying ways to escape such a trap.

Generally, this thesis aims to overcome gaps in the literature. These include: 1) the application of traditional ecological knowledge to studies in marine historical ecology, to extend data baselines in marine environments; and 2) the use of a social-ecological trap framework to analyze and help to address Indigenous knowledge loss.

1.6 Case Study: First Nations of the Central Coast of British Columbia, Canada

The Central Coast of BC represents a complex and dynamic social-ecological system. It is a productive temperate marine system, with oceanographic conditions ranging from exposed offshore islands to sheltered fjords and inlets. The oceanic study area borders Canada's "Great Bear Rainforest"; this large, intact temperate rainforest classically heralded as Canada's "ecological treasure," has received attention from environmentalists, biologists, extractive and industrial companies (e.g. forestry, fisheries, etc.), First Nations, and provincial and federal government alike and is formally protected through the collaborative Great Bear Rainforest Agreement (2006) (Price et al. 2009, Dempsey 2011). Despite the collective and collaborative efforts to preserve the temperate rainforest, less attention has been paid to the Pacific waters

bordering it. Key marine species in the area (e.g. salmon, rockfish, halibut, etc.) are harvested by commercial fishers, recreational fishers, and First Nations fishers.

Within the region, complex and diverse First Nations (Heiltsuk, Kitasoo/Xai'xais, Wuikinuxv, and Nuxalk) have stewarded key marine resources since time immemorial (Turner et al. 2000) and continue to rely on them for cultural and physical subsistence. Despite geographic proximity and shared resources, these four Nations remain culturally and linguistically distinct; the Heiltsuk are members of the Wakashan language family, the Kitasoo/Xai'xais are members of the Tsimshianic and Wakashan language families, respectively, the Wuikinuxv the Wakashan language family (though their spoken language is distinct from that utilized by the Heiltsuk or Xai'xais), and the Nuxalk are members of the Salishin (or Salish) language family (First Peoples' Cultural Council (FPCC) 2014). Today, though these Nations live contemporary lives that interweave Indigenous culture and modern technology, they still rely on local resources and place-based traditional ecological knowledge to sustain their worldviews, lifeways, and unique cultures (Central Coast First Nations 2010).

Central Coast First Nations have collectively faced the negative impacts of colonization (Environics Research Group 2008). Populations in all four communities were devastated by the spread of settler-borne smallpox in the 1700s and 1800s (Hackett 2005). What followed the epidemic was an onslaught of cultural repression forwarded by laws restricting culture (via the Indian Act), displacement or confinement to reserves, and, perhaps most saliently, the implementation of the residential school system in BC (Smith et al. 2005, Environics Research Group 2008, de Leeuw 2009). These policies utilized by the federal and provincial governments of Canada functioned intentionally to destroy cultural, spiritual, and ceremonial aspects of First Nations lifeways, and thus unravel the fabric of knowledge transmission and traditional ecological knowledge. Residential schooling forcibly isolated children from families, traditional land, and opportunities for intergenerational learning (Smith et al. 2005, Turner and Turner 2008, Turner and Spalding 2013). Despite Canada's recent attempts at reconciliation with First Nations (Environics Research Group 2008), the profound impacts of colonization remain (Smith et al. 2005, Turner and Turner 2008, Turner et al. 2013b), and are at times furthered by modern agendas of externally-driven resource management, research, or policies (Turner et al. 2013b).

Today, Coastal First Nations are striving to reassert Indigenous management rights and revive their culture in spite of a long history of colonization. To this end, these Nations have combined forces via the Central Coast Indigenous Resource Alliance (CCIRA) (CCIRA 2016). CCIRA facilitates the shared belief of its member First Nations that resources should be managed sustainability and holistically for the well-being of future generations. The non-profit organization, established in 2010 by the Nuxalk, Wuikinuxv, Kitasoo/Xai'xais and Heiltsuk First Nations, engages in research that recognizes the interconnectedness of human and social systems, and combines independently collected scientific data with traditional ecological knowledge and culture to generate management plans and recommendations (CCIRA 2016). My project was initiated in collaboration with CCIRA after the four Central Coast First Nations identified Yelloweye rockfish as a species of ecological and cultural concern. The Nations had employed scientific techniques to identify the health and status of local rockfish populations (Frid et al. 2016, McGreer and Frid *in press*); previously, there were claims from experienced local fishers and Elders that Yelloweye rockfish abundance had decreased dramatically in recent decades. The Nations recognized that little scientific or social data collection documents historical harvest of Yelloweye rockfish, beyond temporally and spatially limited fisheries dependent surveys. Thus, they aim to better understand traditional ecological knowledge surrounding Yelloweye rockfish in stride with their ecological assessments.

1.7 Yelloweye Rockfish

Yelloweye rockfish (commonly, "red snapper") are a species of commercial, recreational, and cultural importance. They are valued by Central Coast First Nations, who have harvested rockfish for at least 1800 years (McKechnie 2007). Because of their multi-generational relationship with rockfish, Coastal First Nations possess traditional ecological knowledge that may be valuable to contemporary management of this species. Today, First Nations retain federally-recognized rights to fish for food, social, and ceremonial (FSC) purposes; all four member Nations still rely on Yelloweye rockfish as a source of fresh protein available year-round.

Yelloweye rockfish are especially vulnerable to extirpation due to their slow life-history traits. They have been aged to 121 years (Department of Fisheries and Oceans Canada 2015), and their age at 50% maturity on the Central Coast of BC is estimated at 17.5 years and 15.2 for males and females, respectively (McGreer and Frid *in press*). Additionally, as for most fish of the genus, Yelloweye rockfish fecundity increases with size and age of female fish. Recreational and commercial fishers frequently target large fish; population-level productivity can be drastically reduced by this removal of the larger and more fecund individuals (Birkeland and Dayton 2005, Hixon et al. 2014). Further, Yelloweye rockfish are commonly found at or below depths of 100 m (Love et al. 2002). When fish are brought rapidly to the surface by fishers, their air bladder expands, causing often-fatal internal damage and limiting success of releasing the fish as bycatch (Jarvis and Lowe 2008).

Yelloweye rockfish are listed as a species of "Special Concern" under the Species At Risk Act (SARA) (COSEWIC 2008) in Canada. The Department of Fisheries and Oceans Canada (DFO) has responded to widespread stock depletions by implementing several management strategies (Department of Fisheries and Oceans Canada 2016). Total Allowable Catch (TAC) limits are applied to recreational fishers harvesting rockfish, and for commercial fishers harvesting quota or non-quota species (Department of Fisheries and Oceans Canada 2016). At-sea observance or electric monitoring of rockfish bycatch is compulsory. As an additional step to manage and conserve rockfish, including Yelloweye rockfish, DFO has implemented Rockfish Conservation Areas (RCAs). RCAs were established between 2004 and 2007, and are designed as harvest refugia for rockfish; in these designated areas, hook-and-line, longline, and trawl gear are prohibited (Haggarty 2013). However, the efficacy of RCAs has been called into question, particularly due to lack of compliance (Lancaster et al. 2015, 2017).

Fishery-independent data regarding the abundance or size of Yelloweye rockfish on BC's Central Coast is non-existent before 2003. This lack of data limits current management attempts, leaving a temporally limited and skewed data baselines, and highlights the need for incorporating the traditional and local ecological knowledge and historical management methods of First Nations into current research and management attempts.

1.8 Study Methodology

Accomplishing my goals and objectives fundamentally required co-creation of the research and its protocols with the four participating First Nations. After interest in the project was expressed by the Central Coast First Nations, I attained approval from the Human Ethics Board at the University of Victoria. In collaboration with each Nation, I developed a research protocol which defined our working relationship and project goals. Because much of the content of this project was developed to attain the goals of the First Nations, my research methodology was responsive and interdisciplinary. Generally, I relied on a social science approach (interview-based data collection and analysis) (Lichtman 2013) to collect data about biological parameters of Yelloweye rockfish, as well as key qualitative cultural themes. Interview methods and a combination of qualitative and quantitative analysis are typical in studies where traditional or local ecological knowledge is used (Johannes and Yeeting 2000, Murray et al. 2006, Beaudreau and Levin 2014).

I established a multi-step research process which facilitated the collection of data in an inclusive and dynamic way. After establishing a research protocol with each Nation, I hosted a workshop in each community to introduce the project and receive preliminary feedback. After these introductory workshops, I engaged in semi-structured interviews (Huntington 2000) with selected participants. The interview questionnaire followed a "vessel-based" approach. This approach is relatively recent in the social sciences; it was initially utilized by Murray (2007) while capturing local knowledge of fishers who had witnessed the collapse of Atlantic cod (Murray et al. 2007). The method frames questions about changes to a particular species over time by asking participants to chronologically walk through the vessels they have fished on throughout their lives, thus setting their answers in a reliable window of time (e.g. the period in which one vessel was active). Because one key critique of the use of traditional and local ecological knowledge in resource management is that applying rigor to anecdotal evidence is challenging, this method was particularly important for collecting reliable historical data from First Nations participants. My questionnaire also included general questions about traditional harvesting and stewardship, concerns for Yelloweye rockfish and key resources, insights into improving marine management, and others (Appendix A). I audio-recorded and transcribed all

interviews. The research process concluded with return trips to each community, during which findings were presented at workshops. Finally, I analyzed interviews using a combination of qualitative and quantitative techniques.

Concurrent with, and preceding, the collection of data through semi-structured interviews, CCIRA lead ecologist and project collaborator Alejandro Frid collected biological data on rockfish (*Sebastes* spp.) in traditional territories of the four involved Nations. His methods, detailed elsewhere, included hook and line sampling (Frid et al. 2016).

1.9 Personal Relation to the Work

Undertaking this thesis required an honest and ongoing exploration of my positionality to the work. As a North American of European descent and unearned privilege, I recognize that my inherited history is one marked by the violent onslaught of colonization against Indigenous Peoples. Throughout the work, I aimed to grow in my propensity to understand and forward a decolonizing methodology (Smith 1999). However, as a "cultural outsider" I may not ever fully understand the lived experience of First Nations participants, their connection to land and resources, or the sophistications of traditional ecological knowledge, ceremony, or culture. Thus, it has been my hope to position myself as an intermediary between the First Nations I worked with and the fisheries managers they wish to reach. To do so, I combined my Western scientific perspective with their invaluable traditional ecological knowledge and integrated both to compile information participating First Nations may use to reaffirm inherent Indigenous marine management rights. I recognize and attest that the data, the stories, and thus the results represented in this thesis are proprietary to the Heiltsuk, Kitasoo/Xai'xais, Wuikinuxv, and Nuxalk Nations. I am humbled by the wealth of information possessed by the member Nations, and grateful for the generosity and passion with which participants shared their culture, knowledge, and homes.

1.10 Thesis Structure

My thesis addresses both the use of traditional ecological knowledge in extending baseline data and the social-ecological complexities of that knowledge, and traps and opportunities it may face

in marine conservation. Thus, the body chapters of the thesis (Ch. 2,3) are intended as self-contained manuscripts for publication in peer-reviewed journals.

Chapter 1, this chapter, serves as a general introduction to thesis content. It sets the thesis within the fields of marine historical ecology, Indigenous management, and social-ecological systems theory and briefly outlines what literature gaps my project seeks to fill. It also provides an overview of the goals, case study, and methodologies for the thesis. Finally, it provides an overview of thesis structure.

Chapter 2 analyzes the application of traditional and local ecological knowledge to extend data baselines for Yelloweye rockfish. I used a "vessel-based" approach to conduct semi-structured interviews with 42 First Nations participants. In this chapter, rendered data were qualitatively and quantitatively analyzed, and compared to ecological data, to extend the data baseline for Yelloweye rockfish and propose management implications.

Chapter 3 explores a theme that arose throughout the project - the social-ecological trap of Indigenous knowledge loss. This chapter seeks to better understand what interacting factors in the social-ecological system lead to the erosion of Indigenous knowledge and, through interviews with 43 knowledgeable participants, discover ways to circumvent the trap.

Chapter 4 concludes my thesis by summarizing the key results of my research, and how my results accomplish my stated project goals. This chapter closes the thesis by discussing study limitations, key "take-aways", offering marine management suggestions derived from the project, and suggesting future research.

Chapter 2: Diving Back in Time: Extending Historical Baselines for Yelloweye Rockfish with Indigenous Knowledge

2.1 Introduction

Many culturally and commercially important fish species are declining globally (Pauly et al. 1998, Myers and Worm 2003), yet data limitations often obscure the extent of declines. Unconventional data sources, such as traditional and local knowledge, historical photographs, and archival materials, are increasingly used to estimate baselines for data poor species, particularly fish (Pitcher 2004, Lotze and Worm 2009, McClenachan 2009, McClenachan et al. 2012, Beaudreau and Levin 2014). Historical baselines are crucial; without them, recovery targets and fisheries polices fail to recognize the population and ecosystem characteristics that preceded large-scale exploitation (Pauly 1995, Dowling et al. 2008, Lotze and Worm 2009, McClenachan et al. 2012, 2015).

Traditional and local ecological knowledge are increasingly recognized for their capacity to complement and extend ecological data and improve fisheries management (Huntington 2000, Drew 2005, Haggan et al. 2007, Mellado et al. 2014). Local ecological knowledge represents a lifetime of accumulated ecological observations, while traditional ecological knowledge is composed of similar observations, passed generationally, and woven into the framework of Indigenous Peoples' culture, practices, and beliefs (Berkes et al. 2000b, Berkes 2012a). Both can provide long-term ecological information (i.e. 20-80 years for local ecological knowledge, centuries for traditional ecological knowledge) complementary to scientific data (Johannes 1998a, Haggan et al. 2007, Beaudreau and Levin 2014, Service et al. 2014). Despite advances in the field of marine historical ecology and growing recognition of the value of unconventional data sources in conservation sciences (Lotze and Worm 2009, McClenachan et al. 2012, 2015), traditional ecological knowledge and local ecological knowledge remain underutilized in marine conservation and fisheries management (Johannes 2000, Drew 2005, McClenachan et al. 2012).

Because of their geographical, cultural, and subsistence ties to marine resources and coastal ecosystems, Indigenous and local communities possess valuable knowledge about species that are scientifically data-poor. Globally, myriad studies support the notion that traditional ecological knowledge and local ecological knowledge from fishers and Indigenous knowledge holders can expand baselines and inform conservation goals (Johannes 2000, Valbo-Jørgensen and Poulsen 2000, Drew 2005, Haggan et al. 2007, Martin et al. 2007). For example, in the Western Solomon Islands, traditional ecological knowledge identified recent population changes of Bumphead Parrotfish (*Bolbometopon muricatumand*) and highlighted historical conservation strategies for this species (Aswani and Hamilton 2004). In the Brazilian Amazon, local fishermen identified changes in the relative abundance of several fish species after the construction of a local dam; their assessment was consistent with scientific surveys conducted shortly after (Hallwass et al. 2013). Similar examples have been documented in Samoa, Fiji, Cook Islands, Palau, and other locations (Johannes 2002). Beyond their capacity to extend historical or current population-level data, the use of traditional ecological knowledge and local ecological knowledge engages local communities with the development of management strategies. Community support for conservation plans is commonly cited as important for the long-term success of management plans. Strategies which engage and incorporate traditional ecological knowledge or local ecological knowledge, or community involvement in general, produce higher rates of local support (King and Faasili 1999, Johannes 2002, Turner 2003, Aswani and Hamilton 2004, Drew 2005, Ban et al. 2013).

Many Indigenous communities recognize that the formal documentation of traditional ecological knowledge and local ecological knowledge can provide important insights for marine conservation and fisheries management. For example, archaeological evidence indicates that First Nations of coastal British Columbia (BC), Canada, have harvested rockfish (*Sebastes* spp.) consistently for at least 1800 years (McKechnie 2007). In recent decades, however, Indigenous fishers from the Kitasoo/Xai'xais, Heiltsuk, Nuxalk, and Wuikinuxv First Nations of BC's Central Coast have been observing declines of rockfish, which they attribute primarily to overexploitation by commercial and recreational fishers. These First Nations are particularly concerned about Yelloweye rockfish (*Sebastes ruberrimus*), an important cultural and economic resource, and commissioned this study to complement information from ecological surveys (Frid et al. 2016). Their primary interest was in using traditional ecological knowledge and local

ecological knowledge to understand change over time in the sizes and abundance of Yelloweye rockfish at traditional fishing sites, thereby informing restoration targets.

Yelloweye and other rockfishes are targeted by commercial, recreational and Indigenous fishers alike. They are vulnerable to overfishing because of their slow life-history traits. Many rockfish species are long-lived (Yelloweye rockfish have been aged to 121 years (Department of Fisheries and Oceans Canada 2015), take about 1.5 decades to mature (Love et al. 2002, Mangel et al. 2007, Yamanaka and Logan 2010, McGreer and Frid *in press*) and form localized populations in structurally complex rocky reefs (Love et al. 2002). Many rockfish species, including Yelloweye, are commonly found at depths of 100 m or deeper (Love et al. 2002). When brought to the surface by fishers, most species suffer internal damage due to air bladder expansion, which limits options to release bycatch (Jarvis and Lowe 2008). Additionally, as is the case for other groundfish, fecundity increases with size or age (Dick et al. 2017). Fishers tend to remove larger individuals, thereby reducing population productivity (Birkeland and Dayton 2005, Hixon et al. 2014). In Canada, Yelloweye rockfish are listed as a species of "special concern" under the Species At Risk Act (SARA) (COSEWIC 2008). In BC, modeling of Yelloweye rockfish populations estimated their present biomass to be at 18% of 1918 levels (Department of Fisheries and Oceans Canada 2015).

Indigenous Peoples have developed complex resource management strategies through generations of trial-and-error and resource dependence embedded in stories, ceremonies, institutions, beliefs, and harvesting practices (Berkes et al. 2000b, Berkes 2004, 2012a). Many of these management strategies continue, or there is an interest in revitalizing them. In BC, traditional adaptive management strategies are well-documented for a number of marine food resources, such as salmon, eulachon, and herring (Snively and Corsiglia 1997, Turner et al. 2000, Menzies and Butler 2007a, Heaslip 2008, Thornton et al. 2010). Despite the impacts of industrialization and colonization, communities still harvest local ocean resources for food and cultural well-being. The local and traditional knowledge of First Nation individuals could improve understanding of recent changes in rockfish populations, and inform management, including spatial management such as marine protected areas.

The goal of this research was to use the Central Coast of BC, Canada, as a case study to illustrate the application of traditional ecological knowledge and local ecological knowledge to establish

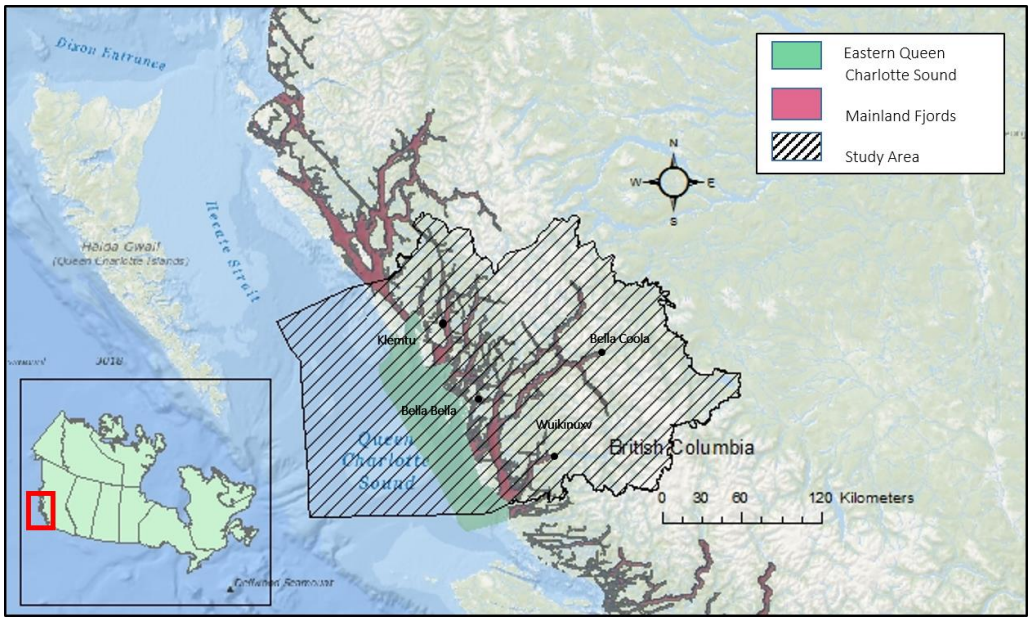
historical baselines that extend farther back in time than scientific surveys. The objectives were to **1)** use interviews to estimate relative changes in Yelloweye rockfish size and abundance since the 1950s, **2)** identify factors perceived to have caused these changes (e.g. commercial fishing, environmental shifts, etc.), and **3)** compare modern traditional ecological knowledge and local ecological knowledge observations with recent scientific surveys of rockfish by the Central Coast First Nations (Frid et al. 2016) and Fisheries and Oceans Canada (DFO).

2.2 Methods

Study Site

Research was conducted on the Central Coast of BC, Canada, in partnership with four First Nation communities (populations range from 80-1500 individuals) (Figure 2.1). The region is characterized by both exposed offshore islands and sheltered fjords and inlets.

Figure 2.1. Map of study region. Bella Bella is home to the Heiltsuk Nation, Bella Coola to the Nuxalk Nation, Wuikinuxv to the Wuikinuxv Nation, and Klemtu to the Kitasoo/Xai'xais Nation. The Eastern Queen Charlotte Sound and Mainland Fjord upper ocean subregions are identified. The Study Area represents is represented as the combined traditional territories of the four Nations.



Research Process

Research agreements and protocols were developed with each of the four First Nations that had identified the need for this study. Where feasible, the research began in each community with a workshop open to all community members to introduce the project and its goals, and to solicit interest in interview participation. In one community, the workshop occurred after interviews had begun. After the workshops, semi-structured interviews were carried out. After transcription and analyses of interviews, findings were publicly reported in each community, follow-up interviews were conducted, and data were shared per research agreements.

Semi-structured Interviews

Participants had 20 to 70 years of experience fishing or preparing catch, including targeting Yelloweye rockfish. They either self-identified their interest to be interviewed during community workshops, or were recommended by resource stewardship directors from their community. Subsequently, a snowball sampling method (Huntington 2000) was utilized. In this sampling method, several key participants were initially identified, and in turn these individuals identified other potential participants from their acquaintances. Interviews typically lasted 1-3 hours, and were audio recorded and transcribed.

A vessel-based approach (Murray et al. 2007) was used to frame questions about changes in Yelloweye rockfish size (length), depth caught, and abundance. This method guided participants chronologically through the fishing boats they have used throughout their lives, attempting to document each vessel's size, technology, crew composition, etc. The method related answers to the windows of time associated with a given vessel. Questions regarding vessel technology (i.e. boat type, engine size, navigational instruments) were asked to ensure that observed changes in fish population were not driven primarily by changes in boat technology over time. Interviews began with questions about the first boat participants fished on during their youth. The interview then attempted to chronologically reconstruct the participants' life or career experiences fishing, concluding with the participant's estimate of the current typical catch size and abundance of Yelloweye rockfish, and general abundance of rockfish as a genus. For analysis, "typical length catches" reported were interpreted as median length of the typical rockfishes participants caught. Other studies have shown that fishers' memories are quite accurate compared to archival data, and hence are useful to construct baselines (Thurstan et al. 2016). Most participants felt

comfortable providing information only about their earliest and most recent years fishing (henceforth "historical" and "modern" years, respectively); these two points in time were the basis for our analyses. Questions throughout the chronology included: Yelloweye rockfish typical size and abundance, perceived causes of changes to rockfish populations (if changes were observed), depth fished, and changes to participants' fishing strategies. Participants were also asked to identify on nautical charts where they fish (historically and/or currently) for Yelloweye rockfish. Their responses were digitized using ArcGIS © software (ESRI 2015); we[1] did not illustrate fishing locations or other spatial data due to the sensitive nature of such locations to First Nations.

Supportive materials (nautical charts, species ID books, etc.) were utilized where appropriate to facilitate information sharing by participants. We feel confident in participants' ability to identify Yelloweye rockfish not only because we utilized species ID guides throughout interviews, but also because of the imbedded and evidenced cultural importance of this species to Central Coast First Nations. When asked about historical length of Yelloweye rockfish, most participants responded using the length between their two upheld hands. To facilitate these estimates, size references were offered in the form of rockfish-shaped paper cutouts illustrating maximum (91cm), large (75 cm), and early maturity (51 cm) lengths (from (Love et al. 2002)). In the three cases that fishers reported weight rather than length, we converted weight (kg) to total length (cm) using the regression $TL = 40.445 weight^{0.2913}$, which was derived from field specimens (Frid et al. 2016). Yelloweye rockfish size data participants supplied during interviews were linked with the spatial locations they mapped. We assumed that the participant's estimates of historical and modern catch characteristics derived from these locations.

Because some participants did not wish to use sized cut-outs, researchers also used a tape measure to test and confirm their ability to estimate distance between raised hands to within 5 cm.

Analysis

[1] This chapter has been accepted as "Eckert, L., Ban, N.C., Frid, A., and McGreer, M. Diving Back in Time: Extending Historical Baselines for Yelloweye Rockfish with Indigenous Knowledge" and is in press. "We" is used to refer to the collaborative nature of the work. I conceptualized, carried out, analyzed, and wrote the chapter. Co-authors and First Nations partners provided direction, guidance, and editing support.

Interview transcripts were coded into coarse categories (e.g. size, abundance, perceived threats), and finer sub-categories for qualitative analysis using NVivo software (*NVivo qualitative data analysis software; QSR International Pty Ltd. Version 10, 2012*). R-statistical computing software (version 3.1.1) was used to analyze data and graph results. To analyze changes to perceived Yelloweye rockfish size over time, a linear mixed model (LMM) was used (Pinheiro and Bates 2000), with reported typical fish length (interpreted as median length) as the response variable. The predictor variables (fixed effects) were decades, which was a categorical variable with 5 levels (1950, 1960, 1970, 1980, and 2010), and depth (m). These years represent the beginning years for decades (10 year periods), except for the modern decade (2010), which encompassed only 6 years. Because participants provided an estimated fish length for two decades (a historical decade and the modern decade), participant ID was modeled as a random effect. Visual inspection of quantile–quantile plots, residuals vs fitted plots, and correlation values between variables, were used to verify the assumptions of normality, homogeneity, and variable independence, respectively (Pinheiro and Bates, 2000). This analysis excluded three outlying data points from the 2010s in which fishers targeted depths of 300 meters, much deeper than the remaining participants. The three outliers, however, were included in all descriptive statistics and insights derived from them are discussed qualitatively.

Ecological data sources

Two types of recent ecological surveys were compared with the interview data. The first consisted of hook-and-line surveys and sampling of landings by Indigenous subsistence fishers carried out by Central Coast First Nations (CCIRA data). These data encompassed 2006-2007 and 2013-2016, and all of the study region, including sheltered channels and fjords (Frid et al. 2016). The second data source consisted of fishery independent surveys carried out and/or collated by DFO (collected via the Pacific Halibut Commission longline survey and northern and southern Pacific Halibut Management Association longline surveys, and trawl surveys) (Department of Fisheries and Oceans Canada 2015). We restricted our analysis of these data to the geographic scope of the interview data: Pacific Marine Fisheries Commission major areas 5B and 5C, and the upper ocean subregions (BCMCA, 2011): Eastern Queen Charlotte Sound and Mainland Fjord. We note, however, that these data have poor coverage of sheltered fjords and channels (McGreer and Frid *in press*). We also restricted our analyses of DFO data to the years

2010-2015 to best align with modern traditional ecological knowledge and local ecological knowledge data. Given the different biases, sampling methodologies, and sample sizes inherent to each source, we compared interview and ecological survey data only descriptively.

2.3 Results

In total, 42 participants participated in semi-structured interviews between May 2015 and May 2016. Eighty-three percent *(83%, n=42)* of participants were men and 17% women. Fourteen participants identified themselves as Kitasoo/Xai'xais, 14 as Heiltsuk, 7 as Wuikinuxv, and 7 as Nuxalk. Participants ranged in age from 36-88 years, with an average age of 61. Ages were estimated in the case of 12 participants who did not disclose this information. Some participants did not answer all interview questions, and thus sample sizes vary between data types. Participants started fishing (or accompanying older fishers) between the ages of 1 and 18 years old (mean = 9.4 years; *n*=22). Most remain active fishers, except for six Elders who stopped fishing regularly within a decade prior to our interviews. Twenty-four participants had fished commercially at some point of their lives, though none had fished Yelloweye rockfish commercially.

Most respondents (88.5%, *n*=35) observed a decrease in individual Yelloweye rockfish length since the 1980s, while 11.5% did not. For the study area as whole, the median historical length (1950s-1980s) was 84 cm (mean of 85 cm) while the median modern (2000-2015) length was 40 cm (mean of 46 cm). The differences were similar when comparing modern and historicalsizes within the Mainland Fjords and Eastern Queen Charlotte Sound upper ocean subregions. Modern traditional ecological knowledge and local ecological knowledge Yelloweye lengths were similar to those from ecological survey data (Figure 2.2).

Most respondents (97.6%, *n*=42*)* also observed a substantial decrease in abundance of Yelloweye and other rockfishes since the 1950s, with 33% suggesting the change was most evident in the early 2000s, followed by the 1980s (21%) and 1990s (17%).

Participants observed declines in size and abundance despite the fact that all *(n=25)* had improved their boat technology (e.g. more powerful engines, advanced navigation equipment, etc.) over their lifetime, thereby compensating for local resource depletions by expanding the spatial scope and technological accuracy of their fishing effort. Specifically, 79% of participants

(*n*=19) had changed their fishing strategies. Nearly half (47.4%) fished deeper (typically by 10-20 m), further from their community (21.1%) or switched gear from simple hand-lines to modern rods, lures, longlines, etc. (10.5%). The remaining (21%) did not modify their fishing strategy.

In modern years, participants fished at an average depth of 112 m (relative to 59 m historically). This change in average depth, however, was driven by three individuals fishing much deeper than their historical experiences, targeting depths of 300 m to 500 m. Notably, these were the only fishers still catching large Yelloweye rockfish (90 cm or larger). When excluding these outliers from analysis, the linear mixed model revealed a significant decrease in Yelloweye rockfish size in 2010s, compared to the 50s, 60s, 70s, and 80s (Table 2.1; Figure 2.3). Given that the 3 deep-fishing outliers were excluded, the linear mixed model did not find a significant effect of depth on length (Table 2.1; Figure 2.3).

Participants (*n*=36) described the following stressors as major drivers of decreased abundance and length of Yelloweye rockfish and other rockfish species: commercial trawling (42%), the rockfish specific fishery (33%), the longline fishery (25%), non-specified commercial activity (22%), and sports fishing (22%). Participants also cited forestry impacts (6%), earthquakes (8%), and climate change (11%). A quote from one participant illustrates the impact of by-catch fatalities via trawling, the most often cited cause of depletions, “And we get out there, and there’s red snapper [Yelloweye rockfish] floating everywhere. Cod fishermen weren’t taking them.” The discarded Yelloweye rockfish had experienced fatal barotrauma; that is, when brought to the surface at rapid rates, these deep-dwelling fish experience internal damage as air in their swim bladder expands (Jarvis and Lowe 2008).

Ninety-one percent of respondents (*n*=32) had noticed the impacts of climate change over their lifetimes, in the form of less snow-pack during milder winters, hotter and drier summers, or an increase in extreme weather events. Though few individuals (11%) attributed changes in climate to abundance decreases in Yelloweye rockfish or other rockfish *spp*., most had noticed changing water temperatures and recognized the impact this could have on groundfish and other marine resources in the foreseeable future. Ninety-six percent of participants (*n*=28) expressed serious concerns for the future of Yelloweye rockfish and of ocean ecosystems in general. These concerns included continued stock depletions due to: commercial, sport, and illegal market fishing (39%), mismanagement by the DFO (32%), and other impacts (24%) (e.g. pipeline

expansion, climate change, pollution, and fish farms). Of those participants that expressed concerns about the future of resources, 28% expressed concern for stock depletions leading to negative impacts to cultural lifeways, traditional diet, or language.

Figure 2.2. Comparison of historical and modern Yelloweye rockfish length, for the study area as a whole and by Oceanographic subregion**.** The size of the boxes is delimited by the first and third quartiles, and the line within each box denotes the median. Outliers are indicated by dots. Panel one compares the 4 sources from all geographic locations of interest in the study; panel 2 shows only those data from Eastern Queen Charlotte Sound, and panel 3 shows only those data from Mainland Fjords. Historic and Modern traditional ecological knowledge(TEK)/local ecological knowledge(LEK) labels represent interview data, CCIRA represents ecological data collected by the Central Coast Indigenous Resource Alliance, and DFO represents the subset of Department of Fisheries and Oceans Canada data we used for comparison.

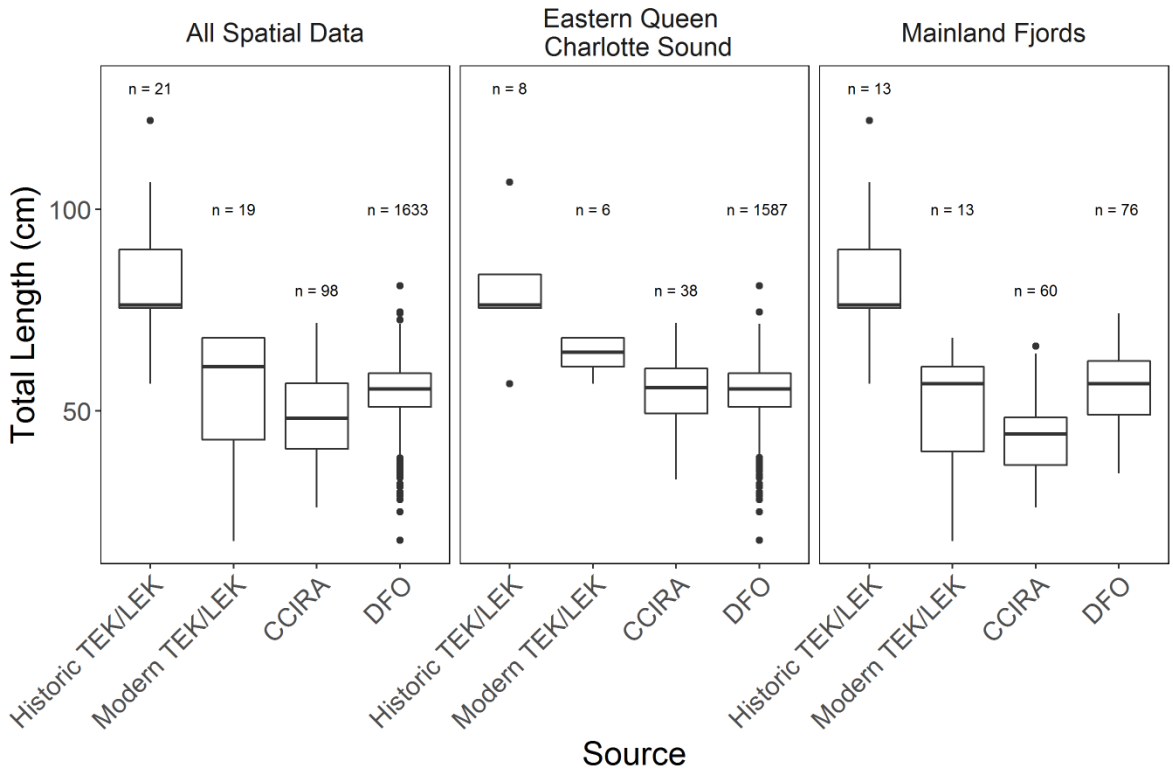
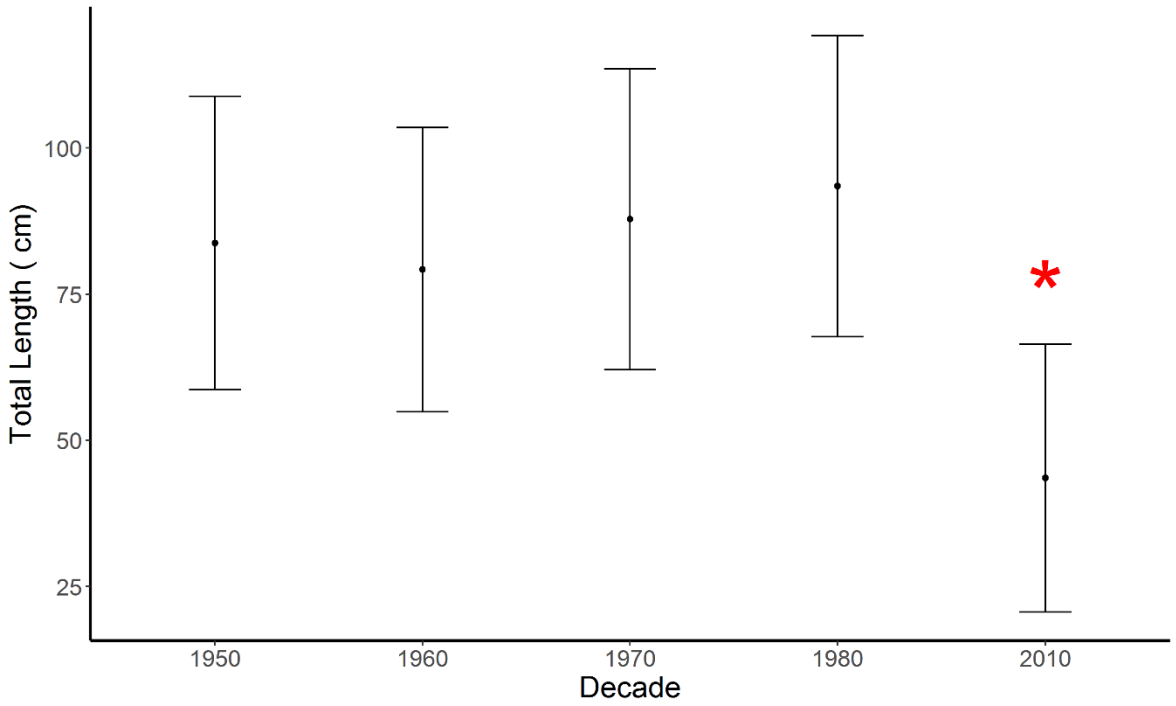


Table 2.1. Relationship between Yelloweye rockfish length and decade. Linear mixed model describing the relationship between Yelloweye rockfish length (cm) and decade (coded as a dummy variable, with 1950 as the reference variable), controlling for depth, and with Participant ID as a random effect.

Predictor	Coefficient	Standard Error	DF	t-value	p-value
Intercept	81.544	13.346	20	6.109	<0.01
1960	-4.428	12.983	13	-0.341	0.74
1970	9.887	13.386	13	0.739	0.47
1980	9.831	13.727	13	0.716	0.49
2010	-40.299	12.225	13	-3.297	<0.01
Depth	0.0241	0.103	13	0.235	0.82

Figure 2.3. Perceived changes to Yelloweye rockfish size (length). Yelloweye rockfish size (length) in relation to decade, where maximum average depth is 150 m. The points are the linear mixed model estimates of Yelloweye length (cm).The bars are the 95% confidence interval. n=25. Participant ID was a treated random effect. The asterisk represents a significant difference.



2.4 Discussion

This study illustrates the utility of traditional ecological knowledge and local ecological knowledge for extending scientific baseline data through interviews, using Yelloweye rockfish size (length) and abundance on BC's Central Coast as a case study. According to interview participants, changes to Yelloweye rockfish size and abundance have been substantial and driven primarily by commercial and recreational fishing pressures. Similar studies have rendered comparable results; work in marine historical ecology that utilizes traditional ecological knowledge or local ecological knowledge has shown its value to extend or generate baseline data, improve spatial resolution of data, identify species abundance trends over time, and others (Worm et al. 2009, Lotze and Worm 2009, Hallwass et al. 2013). For instance, Mallory et al. (2001) revealed that local ecological knowledge of three high Arctic communities indicated abundance decreases in ivory gulls; this decrease was corroborated by ecological surveys shortly thereafter (Mallory et al. 2001). In the Philippines, traditional ecological knowledge of participants near the island of Bohol similarly aided in tracking population declines (and extirpations) of finfish populations for which no ecological data existed, prompting researchers to emphasize the potential value of traditional ecological knowledge for new monitoring methods (Lavides et al. 2009).

Though most observations from participants were "local" (experience-based knowledge developed over long-periods of time in one location), they were informed by the knowledge, practice, and belief systems of First Nations culture that characterize the "traditional" knowledge, which has informed Indigenous management for millennia (Turner et al. 2000, Berkes 2012a). The information collected thus lies at the intersection between local and traditional knowledge. The vessel-based approach (Murray et al. 2006) used during interviews, though accompanied by its own hurdles, was an important way to lend temporal accuracy to information provided by participants. In oceans of increasing change, it is imperative to capture and consolidate anecdotes, observations, and stories as a means to look further into the past and understand just how extensive changes have been.

Our interview approach extended both the temporal and spatial resolution of available information. Though the DFO has compiled some information regarding historical Yelloweye rockfish populations, data sources were previously limited to commercial catch data from the

1960's and 1970's, and catch reconstructions (Department of Fisheries and Oceans Canada 2015). Because this historical data is limited to fishery-dependent data driven by external market factors, it was important to establish fishery independent historical baselines. Historical length (1950s-1980s) of Yelloweye rockfish witnessed by participants was about double the modern length. The loss of larger, more fecund Yelloweye rockfish indicates a serious concern for current population health and sustainability (Birkeland and Dayton 2005, Dick et al. 2017), and has been documented on BC's Central Coast from 2003-2015 (McGreer and Frid *in press*). Interviewing fishers with knowledge on the Central Coast of BC indicates that this region appears to be experiencing severe size and abundance declines; their recent observations are supported on both a local and coastwide scale by fishery-independent surveys (Frid et al. 2016, McGreer and Frid *in press*), lending credibility to both modern and historical size estimates by participants in this study. This finding aligns with other studies that have used ecological research to corroborate traditional ecological knowledge or local ecological knowledge (Poizat and Baran 1997, Johannes 1998a, 2000, Mallory et al. 2001, Aswani and Hamilton 2004), or those that have found concurrence between scientific data and fishers' knowledge (Thurstan et al. 2016).

Peak abundance of adult Yelloweye rockfish tends to occur at depths of 90-180 m (Love et al. 2002), which is within the range currently targeted by fishers (mean = 102 m). There is, however, a possibility of depth refuge for the larger size classes of rockfish, as the only participants who still catch large Yelloweye rockfish were three individuals who currently fish substantially deeper (300-500 m) than the typical fishing depth. Their strategy appears to parallel that of large-scale commercial fisheries, which increased their fishing depths to compensate for sequential declines at shallower depths caused by over-exploitation (Morato et al. 2006).

Consistent with other studies (Frid et al. 2016, McGreer and Frid *in press*) our findings suggest that fisheries management for Yelloweye rockfish and other long-lived groundfishes needs to incorporate local and Indigenous knowledge into a more conservative and spatially refined approach to avoid local and regional depletions. Specifically, the four Central Coast First Nations have been working together under the umbrella of the Central Coast Indigenous Resource Alliance (CCIRA) to develop marine use plans and improve fishery management. Their work includes collaborations with provincial and federal governments to develop a marine

protected area (MPA) network in BC (Canada – British Columbia Marine Protected Area Network Strategy. https://www.for.gov.bc.ca/tasb/slrp/pdf/ENG_BC_MPA_LOWRES.pdf. 2014, MaPP 2015). Marine protected areas and other forms of spatial fishery closures can contribute to the conservation and restoration of rockfishes (Parker et al. 2000, Yamanaka and Logan 2010), including Yelloweye rockfish (Frid et al. 2016). Implementing marine use plans co-authored by First Nations (MaPP 2015) and establishing MPAs would facilitate these objectives (Berkeley et al. 2004).

The stories and timing of depletions told by participants reflect the history of groundfish fisheries in BC. The Yelloweye rockfish fishery was unrestricted in the early 1980s until the DFO implemented a license and logbook system (Yamanaka and Logan 2010). The 1990s witnessed the rapid expansion of the fishery and, though the DFO developed total allowable catch (TACs) as part of their management plan, stocks were declining rapidly (Haggarty 2013). According to Yamanaka and Logan (2010), other commercial groundfish fisheries (e.g. trawl, halibut, lingcod etc.) of the 1980s, 1990s, and early 2000s also caused Yelloweye rockfish fatalities as additional targeted allowable catch or as bycatch (Yamanaka and Logan 2010, Haggarty 2013). Many participants echoed experiences in which they had followed commercial groundfish vessels, collecting barotrauma-impacted rockfish thrown overboard en masse. Beyond commercial fishing, the expansion of sports fishing in the last several decades may also be impacting Yelloweye rockfish populations, yet biological and compliance monitoring is limited both temporally and spatially (Cooke and Cowx 2004), a fact which many interview participants lamented. Increased involvement by First Nations in monitoring and management has the potential to improve fisheries management (Danielsen et al., 2009; Gutiérrez, Hilborn, Defeo, 2011).

The declines illustrated in this study are of special concern to First Nations, whose livelihood and culture is embedded in marine harvesting. The Canadian constitution recognizes the Aboriginal right to food, social, and ceremonial (FSC) purposes, and these FSC fisheries are supposed to have priority over commercial and recreational fishing. Yet in reality rockfish declines mean that First Nations fishers are not able to supply for their needs. Because First Nations rely on Yelloweye rockfish – and many other species – for physical and cultural sustenance, conserving Yelloweye rockfish and other species is intrinsically linked with upholding their fishing rights.

The mismatch between large-scale, federal management and the local-scale realities of complex ecosystems and fishing activities is recognized globally (Hilborn et al. 2005). Moving forward, overcoming this mismatch by incorporating the local knowledge, expertise, and management intentions of coastal First Nations alongside federal management has the potential to extend data baselines in data-poor waters and, perhaps most importantly, recognize the constitutional rights of First Nations to local resources.

Several limitations were evident throughout the study. Traditional ecological knowledge and local ecological knowledge are sometimes considered difficult to integrate into scientific management schemes because of their qualitative nature (Gilchrist et al. 2005, Martin et al. 2007). Though this study worked to provide some historical quantitative information about Yelloweye rockfish length, its ecological accuracy is limited. In older, larger rockfish, 2-5 cm differences – 5cm is roughly the resolution of the interview data – can represent substantial age differences. Though our data on length of Yelloweye rockfish is only accurate to within about 5 cm, changes were so large that the interviews nonetheless captured ecologically-significant changes. Additionally, many participants were not willing or able to estimate size measurements, resulting in a small sample size for several questions. Geospatial information was also limited by participants' willingness to share their favorite fishing spots, due to negative previous experiences and concern about public dissemination of secret or sensitive locations. It was sometimes difficult or fatiguing for the participant to trace their entire chronological life history through the format of a vessel-based interview; life stages were often skipped to minimize interview fatigue. Finally, time was a limiting factor in data collection; most interviews lasted 1-3 hours, and therefore sample size was limited by research time and the availability of participants. That said, the approach of capturing information from the first and last vessel participants fished from worked very well. A few knowledgeable fishermen (typically 2-3 per community) were out fishing at the time of our community visits, and therefore unavailable for interviews.

Ultimately, this study expanded insights into changes to Yelloweye rockfish populations in BC. Importantly, it also upholds traditional ecological knowledge and local ecological knowledge of coastal Indigenous Peoples as a valuable source of data that should be integrated into fishery management in Canada and elsewhere, to allow for increased community engagement and as a

means to uphold Indigenous rights. The methods used in this study are repeatable and applicable to case studies globally, and provide a potential approach and justification for integrating traditional ecological knowledge and local ecological knowledge into species management schemes broadly.

Chapter 3: Linking Marine Conservation and Indigenous Cultural Revitalization: Opportunities in Overcoming Social-ecological Traps

3.1 Introduction

Continuity of coastal Indigenous cultures relies on healthy stocks of culturally and nutritionally important marine species (Turner et al. 2013c, Cisneros-Montemayor et al. 2016). Indigenous communities, over thousands of years of experience and culturally-transmitted learning, have developed complex conservation strategies to steward marine resources (Berkes et al. 2000b, Turner and Berkes 2006, Berkes 2012a). For example, globally many Indigenous communities developed customary marine tenures whereby individuals, families, or communities hold stewardship responsibility for particular areas or resources (Johannes 1998b, 2002). In the Pacific, Indigenous coastal communities utilized variations of temporal and spatial closures in combination with cultural taboos to manage marine resources (Johannes 1978, Colding and Folke 2001, Cinner and Aswani 2007). Such practices, passed-down through generations by means of oral stories, ceremonies, art and dance, taboos, and other cultural building blocks, constitute part of the knowledge, practice, and belief complex of Indigenous communities (Berkes 2012a). Traditional ecological knowledge is the academic phrase used to define the knowledge that is transmitted inter-generationally. Indigenous management systems supported by traditional ecological knowledge are largely conservation-oriented (Berkes and Turner 2006, Berkes 2012a). Global and regional threats to marine ecosystems are leading to depletion of many culturally vital ocean resources (Jackson et al. 2001, Worm et al. 2006, Halpern et al. 2009, Bopp et al. 2013), thereby endangering Indigenous cultural continuity and food security.

In the last century, the combined impacts of colonization and degradation of marine ecosystems have undermined stewardship practices and traditional ecological knowledge in Indigenous communities (Smith 1999, Adams and Mulligan 2003, Berkes 2012a, Turner et al. 2013a, 2013c), potentially creating a social-ecological trap. A social-ecological trap refers to situations in which "feedbacks between social and ecological systems lead toward an undesirable state that may be difficult or impossible to reverse (Cinner 2011)." The framework of social-ecological traps has been used in numerous case studies to better understand how feedbacks between ecological and social systems push communities (ecological or social) beyond sustainable

thresholds to new, undesirable states (Hughes et al. 2005, Steneck 2009, Cinner 2011). Situations of poverty, where socioeconomic factors drive humans to extirpate key resources, thus entrenching themselves deeper in poverty, are common social-ecological traps. For example, in coral reef systems of Eastern Africa, impoverished human communities resorted to resource depletions by intensifying harvesting efforts to get enough food to survive. Coupled with a lack of institutional management, this human response to resource dearth amplifies environmental degradation, and *vice versa* (Cinner 2011).

We[2] utilized the framework of social-ecological traps to analyze and understand the combined impacts of colonization and environmental degradation on Indigenous knowledge and culture. Colonization commonly included systemic repression of Indigenous cultures (via forced assimilation, religious conversion, displacement, etc.) to dismantle the cultural and generational means by which Indigenous Peoples transmit knowledge. For example, in Canada, the residential schooling system implemented from the mid-1800s until 1996 widely and profoundly impacted the transmission of culture and traditional ecological knowledge (Royal Commission on Aboriginal Peoples 1996). Damages to, or muting of, Indigenous culture, language, and traditional ecological knowledge can be very difficult to reverse due to their oral nature (Berkes 2012a). Declines in culturally important marine species further affects cultural (e.g., stewardship, fishing) practices and traditional ecological knowledge, creating a social-ecological trap.

Increasingly, the marine conservation literature highlights the value of incorporating traditional ecological knowledge into management to achieve sustainable use of resources and benefit communities (Berkes et al. 2000b, Johannes 2000, Drew 2005, Turner and Berkes 2006, Haggan et al. 2007, Berkes 2012a, Service et al. 2014, Eckert et al. *in press*). For example, in Kiribati, fishers' knowledge combined with traditional ecological knowledge helped ecological researchers identify abundance decreases in bonefish (*Azbula glossodonta*), and knowledge of preferred bonefish habitat was combined with traditional tenure management techniques to improve local conservation (Johannes and Yeeting 2000). While improving marine management, conservation that incorporates traditional ecological knowledge may also provide cultural opportunities for coastal Indigenous communities. For instance, amongst the Pacific Islands, a

[2] This chapter may be submitted for publication with co-authors Dr. Natalie Ban, Dr. Nancy Turner, and Clyde Tallio. "We" is used to refer to the collaborative nature of the work. I conceptualized, carried out, analyzed, and wrote the chapter. Co-authors and First Nations partners provided direction, guidance, and editing support.

return to traditional management (i.e., customary marine tenures) managing fisheries via temporal and spatial closures has served not only as a response to resource depletion, but also as a way forward in cultural revival (Johannes 1978, 2002).

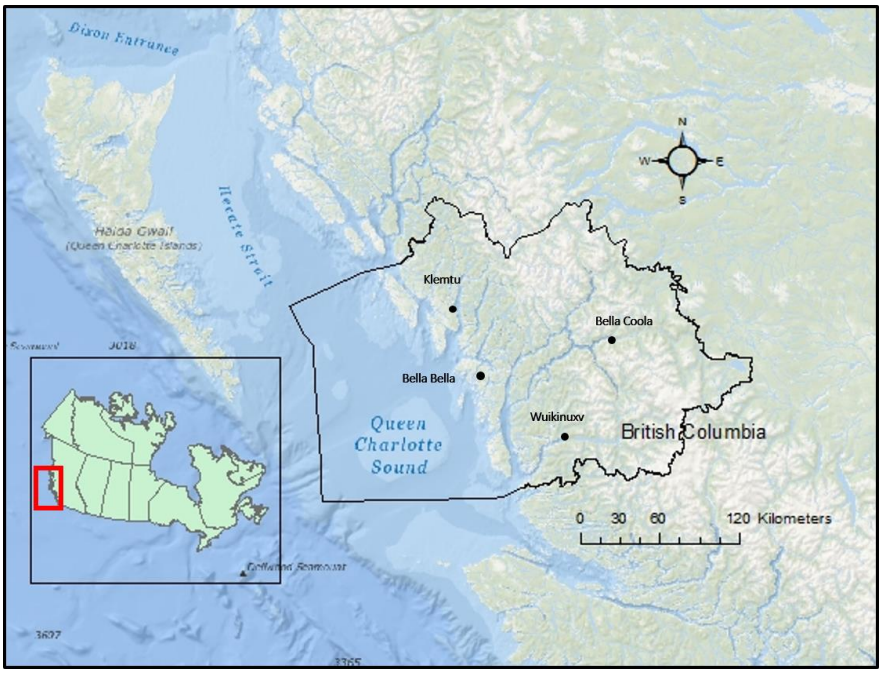
We examined whether the framing of social-ecological traps is useful in finding ways to move towards a more desirable social-ecological state. Our study was initiated by four First Nations – as many Indigenous communities are called in Canada – on the Central Coast of British Columbia (BC), Canada. Collectively, these Nations identified a focal species of ecological and cultural concern, Yelloweye rockfish (*Sebastes ruberrimus*), to integrate scientific and Indigenous knowledge into conservation. The original goal of the study was to quantify change in Yelloweye rockfish catches and abundance over time to inform management. Yet the quantitative summary (Eckert et al. *in press*), while important for informing conventional fisheries management, did not sufficiently reflect the cultural context, broader knowledge, and changes described by Indigenous knowledge holders. Here we summarize qualitative aspects of the study through the lens of a social-ecological trap. Yelloweye rockfish was originally chosen by the First Nations participants as the project's focal species because of its cultural, ecological, and economic value in BC, and because declines of the species have been documented by Indigenous and scientific knowledge (Eckert et al. *in press*, Frid et al. 2016) (Department of Fisheries and Oceans Canada 2015). Yelloweye rockfish have been harvested by First Nations for at least 1800 years (McKechnie 2007), likely much longer. They are listed as a Species of Concern under the Species At Risk Act (SARA) (COSEWIC 2008), and are particularly vulnerable to extirpation due to their long lifespan and slow life history traits (e.g. late age to maturity), and market popularity, amongst other factors (Love et al. 2002, Jarvis and Lowe 2008, Hixon et al. 2014). By focusing on changes to Yelloweye rockfish, we address the following questions: (1) Is there evidence of a social-ecological trap leading to the loss or degradation of traditional ecological knowledge?; (2) If a social-ecological trap exists, what factors characterize it?; and (3) Are there opportunities to escape from the social-ecological trap, and if so, what are they?

3.2 Methodology

Case Study: Central Coast of BC, Canada

Our study focused on the Central Coast First Nations of BC, Canada. We conducted research in partnership with four First Nation communities (Wuikinuxv, Heiltsuk, Kitasoo/Xai'xais, and Nuxalk Nations, with populations ranging from 80-1500 individuals) (Figure 3.1). BC's Central Coast is a productive temperate marine system, with oceanographic features ranging from exposed offshore islands to sheltered fjords and inlets. Within the study area, Indigenous Peoples have relied on marine resources, including fish, shellfish, marine mammals and marine algae, for thousands of years. These resources were – and continue to be – embedded within day to day life, culture, ceremony, and oral stories (Chapin et al. 2010, Berkes 2012). Like many Indigenous Peoples globally, Central Coast First Nations developed sophisticated management techniques, enabling sustainable use (Turner et al. 2000, Berkes 2012a, Turner 2014), many of which are well documented. For example, First Nations actively monitored salmon species abundance, managed and manipulated waterways through which they spawned, and selectively harvested them based on size, gender, abundance, and season (Butler and Menzies 2007, Thornton et al. 2015). Tidal fish traps (Menzies and Butler 2007a), and clam gardens (Lepofsky and Caldwell 2013, Groesbeck et al. 2014) are salient examples of conservation-oriented harvesting and enhancement strategies. More generally, customary marine tenure systems are documented (Matthews and Turner *in press*, Pinkerton 1994, Turner and Berkes 2006) as a means for managing important marine resources.

Figure 3.1. Map of study region. Bella Bella is home to the Heiltsuk Nation, Bella Coola to the Nuxalk Nation, Wuikinuxv to the Wuikinuxv Nation, and Klemtu to the Kitasoo/Xai'xais Nation. The combined traditional territories of the four member Nations are depicted.



Research Process

We developed research protocol agreements with each of the four participating First Nations, and started the project with community workshops to introduce the proposed research. The workshops also provided an opportunity for knowledge-holders to express interest in contributing. After the workshops and with community collaboration, we conducted semi-structured interviews with local knowledge holders, transcribed them, analyzed the information, and followed up with additional workshops to share preliminary results.

Semi-structured Interviews

We chose a semi-structured interview method in order to retain conversational rapport with knowledge holders and create the opportunity for new information to arise while ensuring that key questions were asked (Huntington 2000). In each of the four communities, we identified interview participants based on their fishing experience (>20 years of experience) (often Elders).

Stewardship directors within each community suggested the most knowledgeable individuals, and participants could also self-identify based on their interest in the project (subject to the experience threshold). Following initial interviews with key knowledge holders, we utilized a snowball sampling method (Huntington 2000), wherein participants recommended their knowledgeable acquaintances during interviews. Interviews generally lasted 1-3 hours; all were audio recorded and transcribed.

Analysis

Transcribed interviews were first read to determine common themes, which we coded into coarse categories (e.g. harvesting and preparation practices, perceived threats to marine resources, stewardship principles, etc.). We then coded these themes into finer categories (e.g. historical means of rockfish preparation, impacts of overfishing, etc.) for qualitative analysis. Systematic coding of answers regarding stewardship strategies, cultural value of rockfish, etc. was performed through NVivo software processing (*NVivo qualitative data analysis software; QSR International Pty Ltd. Version 10, 2012*).

The primary focus of interviews was to assess changes to size and abundance of Yelloweye rockfish, with results reported in Eckert et al. (*in press*). The theme of social-ecological traps was identified as a key issue after interviews were completed. To examine the existence of a social-ecological trap relating to Yelloweye rockfish use, we analyzed responses to questions about current and past harvesting strategies surrounding this species, and stories or stewardship values for this species. To determine the characteristics of the social-ecological trap, we analyzed questions about participants' childhood experiences fishing, and stewardship values embedded in teachings or traditional stories. Finally, to assess opportunities for moving beyond the identified social-ecological trap, we analyzed responses to questions about participants' concerns for the future of marine resources and for their culture, and about suggestions for improving management. We provided opportunities for participants to expand on their ideas for actions and approaches that would alleviate the problems and bring them hope, both for their culture and for local resources such as Yelloweye rockfish.

3.3 Results

Forty-three individuals participated in semi-structured interviews throughout our project (May 2015 - May 2016). Eighty-three percent of participants were men, and 17% women. Fourteen participants identified themselves as Kitasoo/Xai'xais, 14 as Heiltsuk, 7 as Wuikinuxv, and 8 as Nuxalk. Participants ranged in age from 27-88, with an average age of 61; we estimated ages in the case of 12 participants who did not disclose this information.

Evidence of a social-ecological trap

We found evidence of a social-ecological trap throughout all interviews, created by the intersection of social, economic, and health impacts of colonization, and environmental degradation caused primarily by overfishing. The presence of a social-ecological trap was supported by the limited traditional ecological knowledge regarding Yelloweye rockfish that participants were able to provide, the frequent mentions of the residential schooling system, and the observed depletions in abundance of key marine resources. However, our analysis indicated that core values of culture have been retained, suggesting that the trap is likely reversible. Thus, we assert that the traditional ecological knowledge of involved First Nations has not been lost, but rather has been thrust into a state of muted dormancy by the aforementioned causes.

Characteristics of the social-ecological trap

Here we describe the characteristics of the social-ecological trap, using quotes to demonstrate typical responses. Questions that helped to define the social-ecological trap were about modern and historical harvesting practices, and about stewardship principles and values.

Historically, harvesting and stewardship strategies and lessons were generationally passed in Indigenous communities of British Columbia (Turner et al. 2000, Turner and Berkes 2006). Forty-one of 43 (95.3%) participants in our study were exposed to fishing by their family members (parents, grandparents, aunts, uncles, etc.). At an early age, people were taught strategies for fishing Yelloweye rockfish and other species, as well as fish preparation methods. The two participants who were not taught to fish by a family member felt that they were largely "raised" in the residential school system, thus their ability to fish with their families was limited greatly. When questioned if his parents taught him important harvesting or stewardship principles, one participant responded, "No, my father never brought me up, the residential school brought me up (Anonymous 1, personal communication to LE, May 2015)." Several of the

participants taught to fish by their families reflected that their experiences together were limited to summers spent outside of residential schools.

The stewardship principles of First Nations and other Indigenous groups are often embedded within culture via lifeways, oral stories, and ceremony (Turner and Berkes 2006, Berkes 2012a, Turner et al. 2013a). We asked participants specifically about traditional stories regarding Yelloweye rockfish, and about general stewardship strategies applied to this and other fish. Only two of the 43 participants remembered being told stories about Yelloweye rockfish, and only one well-studied individual was able to recount a story. When asked about his memory of traditional stories, one elder immediately gestured towards the impacts of colonization:

"Christianity was really strong, they didn't allow anyone to pass a story to us. That's why we don't have any real stories…. There were a lot of masks, totem poles, talking sticks, rattles; they were all here! They were gathered and burned by the Church. Now we're slowly getting it back. Struggling." (Anonymous 2, pers. comm. to LE, August 2015)

Despite a lack of traditional stories that motivated or contextualized sustainable harvesting practices, *all* participants related a conservation principle when questioned about stewardship or management strategies for Yelloweye rockfish. All participants shared that they were taught from an early age to "take only what you needed …. (Anonymous 3, pers. comm. To LE, July 2015)." To expand, one participant explained,

"Yeah, [we were taught:] don't over catch, don't get too greedy. Just take what you need. So that's all I've been doing: get enough, go home. When I was younger, it was nothing to go out in one day and get what you need for the whole winter for salmon and you don't have to go out again. Nowadays, you have to go once a week or twice at times, just to get what you need…." (Anonymous 4, pers. comm. to LE, June 2015)

Others remembered more details surrounding this principle, and its foundation in respect towards critical resources;

"The Elders always talked about being respectful, not over-harvesting things. It's kind of weird to think about now, but [they] used to talk about how when you catch your first four fish. You're supposed to let your first four fish go. Same thing with berries, when you're picking berries,

you're supposed to throw the first four berries behind your back. They always talk about doing that…." (Anonymous 5, pers. comm. to LE, June 2015)

Some participants related that they were trained from a young age to align their actions with this principle, and others emphasized that the principle is "always something that we teach our younger people (Anonymous 2, pers. comm. to LE, August 2015)." Participants juxtaposed this ingrained principle with the strategies utilized by commercial and recreational harvesters: "We [First Nations fishers] only get enough to eat, we don't take a whole bunch [of fish] like these [commercial fishermen] that take the whole stock (Anonymous 2, pers. comm. to LE, August 2015)." Leaving a reproductively viable population for future generations was a key theme of the repeated waste avoidance principle, as was respecting resources. One elder expanded, "It's like you always hear the Elders say, the Creator has given all this to us to look after. It's our duty to look after it. (Anonymous 6, pers. comm. to LE, July 2015)"

The one participant (2%) able to relate stories involving traditional use, harvesting, or taboo surrounding Yelloweye rockfish was an individual in his late twenties, who had dedicated his youth and early career to studying the traditional law and ways of the Nuxalk Nation. One story he knew about Yelloweye rockfish involves the Q'umukwa, whose name literally translates "the wealthy one beneath the Sea" (or "Spirit Chief under the Sea"), who lived in a copper house, adorned in living and painted sea creatures. Bottom-dwelling fish (including large Yelloweye rockfish) are painted on the walls of his underwater home. In times of plenty, when the "Spirit Chief" dances, Q'umukwa sent the yelloweye paintings dancing off the walls of the house, to become living and provide themselves as food in order for the Nuxalk people to survive. Before each species was harvested, the community held a ceremony, reciting "qamxamilaw" to collectively show honor, respect, and gratitude for the fish's contribution to their survival.

Eight participants (18%) had personal recollection of, or otherwise knew of, a time when families stewarded designated geographic ocean areas via a customary tenure system, whereby hereditary chiefs steward areas and grant permissions to harvest resources.

"[There were] certain areas and families owned those places: clam bay, fish stream, berry picking grounds. Even the medicine, certain areas belonged to a family and you can't just go storming in there and get what you want, you have to ask permission." (Anonymous 2, pers. comm. to LE, August 2015).

One participant related the importance of monitoring in tenure systems.

“There [were] really strict rules on where you could harvest, and for a long time we had people patrol the rivers and monitor areas and they would dictate whether stocks were low and they would let people know …” (Anonymous 5, pers. comm. to LE, August 2015).

Other individuals were aware of former tenure practices, but had not experienced them within their lifetime; “[by the time I was fishing], ownership and title had disappeared… it did exist before (Anonymous 7, pers. comm. to LE, May 2015).”

Assessing opportunities to escape the social-ecological trap

Concerns about the future, and suggestions for moving forward, highlighted the participants’ suggestions for escaping the social-ecological trap.

Twenty-seven of 28 participants who chose to respond to the question regarding future concerns expressed serious worries for the future of Yelloweye rockfish and the ocean ecosystems upon which they rely. Nine respondents were explicitly worried about stock depletions leading to damage to cultural lifeways, food security, or language loss. Many individuals expanded concerns about Yelloweye rockfish to general concerns for all resources, reflecting an understanding of species interconnectedness.

“Well, commercialization [is the biggest threat to future resources] right now. Department of Fisheries (DFO) has not yet come to realize that… we have a circle of life, everything goes in a circle including us, it’s connected in one way or another.” (Anonymous 8, pers. comm. to LE, August 2015).

Two participants expressed fear of collectively losing competency in their Indigenous language, and seven were concerned that the youth of today were disconnected from traditional culture, harvesting practices, and increasingly from traditional foods. Television and technology, a lack of access to boats, and residential schools were blamed for this cultural disconnection. One elder lamented the intentional muting of her Indigenous language:

“Language is… I can't believe we're losing it… When I went to [residential] school I had a way of zipping my mouth and not saying a word, not letting anyone know what you are thinking… how [the schools] made it so easy for kids to lose their language, it really hurts. Some people

think it's right to speak the white man's language. Why? I don't know. You should be proud of who you are." (Anonymous 9, pers. comm. to LE, August 2015)

In regards to deterioration traditional foods, one participant offered, "They lose their health [when they lose their traditional foods]. They went to residential school and they lost it; when they came back they didn't know how to do it" (Anonymous 10, pers. comm., August 2015). Other interview participants tied their concerns regarding past and future cultural dormancy directly to the impacts of residential schools:

"I remember Elders, when I was younger… only language was the native [traditional] language. So, I remember some Elders trying to tell stories, but they would need someone to translate for them… they said the words [between the two languages] were so different that a lot of the stories were lost through translation. [The next] generation, [many of them] can't tell me a story, can't tell me a song or dance… And I think the products of residential school, didn't really teach them the ways, partly because a lot of it was lost. None of [language, culture, or stories] were passed on to us as kids, and that was really unfortunate but that's just the way it was…" (Anonymous 5, pers. comm. to LE, August 2015)

Despite recognizing past and current threats to their marine resources and culture, many participants provided concrete examples of hope and actions leading to ways beyond the trap. Eighteen participants provided suggestions for improving management of marine resources. Largely, when asked how to face many of the concerns they expressed for future marine resources, participants (55%) called for increased local management rights and integration of traditional ecological knowledge into management plans. "We need to be able to control the areas to be able to shut down [fishing in] nurseries for halibut, rock piles for cod, [etc.] (Anonymous 10, pers. comm. to LE, July 2015)."

Other participants (21%) were hopeful that community revival of culturally-based education systems, focused towards youth, were a positive way-forward in the face of environmental degradation and the aftermath of colonization. One elder involved in traditional education within her community spoke emphatically about the benefits of educating youth:

"If I could change something about the way people live [I'd increase traditional food education] … because I know one of the things we did have was called 'Community Kitchen'... [The

founder] did everything with our traditional foods, and she had more and more people coming out to help her cook, because what you'd do is you'd all work together cooking a meal. After you'd cook the meal, complete with dessert, you'd invite some people to come over and eat, and she had that community kitchen going for the whole winter. It was getting really popular, a lot more people were showing up, but things like that are going to have to happen again to generate the interest in people to get them back on track to eating a healthier diet of fish. Teaching kids how to eat, that's one of the things I really hope to try to create some social activities for the communities. [Knowledge holders are] taking kids out seaweed picking from the school, taking them out clam digging. And they have to clean the clams themselves and prepare it for freezing, they freeze it all up. Anything they put away, I think they jarred fish last year, and then they use the stuff that they prepare and preserve, they use it for different activities throughout the school year." (Anonymous 11, pers. comm. to LE, August 2015)

Some mentioned particular organizations that support the cultural development of community youth [i.e., The Supporting Emerging Aboriginal Scholars (SEAS) community initiative and the QQS Projects Society (expanded upon elsewhere)].

One community leader emphasized the importance of promoting the knowledge of community Elders as a means of reviving youth knowledge and the tradition of oral story-telling;

"So, the way I see it now, is we're trying to bridge that gap between the youth and Elders, and so that's what we're trying to do. We only have a handful of Elders that really have a true understanding of that important knowledge that's been passed on. So, I think that things like fishing areas have been passed down, but not things like stories, or songs, or dances. We do still have a few cultural leaders in the community that have helped but we are trying to bridge those gaps right now." (Anonymous 5, pers. comm. to LE, August 2015)

An elder expanded on his motivation to enliven culture among community youth,

"[I want them to know] the economics of our people. For the younger generation, I want them to know how we lived [off the resources of the land]. At one time, you could live without money and the money was not important. If you put your hand any place in the garden, grab the sand from your garden and put it there… get a dollar bill and put it by its side… Get a match, try burning the sand that produces your vegetables, and burn this hundred-dollar bill. The hundred-

dollar bill will disappear and [the sand] is still there to support you." (Anonymous 6, pers. comm. to LE, July 2015)

3.4 Discussion

Our study suggests that there is a social-ecological trap on the Central Coast of British Columbia, where the impacts of colonization and environmental degradation threaten traditional knowledge and culture. Our research into a focal species (Yelloweye rockfish) revealed the interwoven nature of knowledge and lived experiences. Although our general interviews did not directly include questions about residential schools or colonization, participants brought up these topics, highlighting the ongoing impact of these experiences. Other studies have largely assessed social-ecological traps in relation to community resilience (Folke 2006), arguing that amplifying feedbacks can occur between social and ecological degradation in resource management (Cinner 2011, Steneck et al. 2011, Kittinger et al. 2013). We are not aware of studies that have analyzed the deterioration of traditional ecological knowledge through the lens of a social-ecological trap. Our results suggest, however, that the trap is reversible and that, despite environmental degradation and colonization, key means of cultural revitalization and opportunities for marine management that support Indigenous rights, while conserving key resources, exist and can be mobilized.

Historical and ecological evidence highlights the negative impacts of social and environmental damages to First Nations' knowledge; both colonization via forced assimilation, including residential schooling and on-going declines of key marine resources, are well-documented. For example, ecological data gathered within the study region show that Yelloweye rockfish populations have experienced decreases in both size and abundance (Frid et al. 2016). In fact, in BC, modern Yelloweye rockfish biomass is estimated to be at 18% of 1918 levels (Department of Fisheries and Oceans Canada 2015). Other key species of cultural importance (e.g., salmon, eulachon, herring, halibut, abalone) have similarly faced severe declines (Gresh et al. 2000, Levy 2006, Moody 2008). Because traditional ecological knowledge is place-based and dependent upon direct interactions with species, this knowledge system is likely to degrade in tandem with key resources (Berkes 2012a). Thus, the conservation of BC's marine biodiversity and the rights of First Nations are inherently linked (Frid et al. 2016).

The main social factor in the social-ecological trap in our case study was the residential school systems. The residential schooling system in BC was responsible for forcibly removing children from family homes, and instituting them into a system which sought to eradicate First Nations' cultures and traditions (Royal Commission on Aboriginal Peoples 1996, Smith et al. 2005, de Leeuw 2009). The impacts of residential schools and the forced acculturation and assimilation tactics that characterized them cannot be overstated; Canada now recognizes that these schools served a role in the intentional severing of First Nations cultural and familial ties, traditional ecological knowledge, and lifeways (Environics Research Group 2008). Today, this federally-implemented system, historically supported by churches and society at large, is attributed with perpetuating deep trauma and indignity surrounding traditional ecological knowledge, cultures, Indigenous food systems, and ceremonial and spiritual practices. Sadly, many international occurrences of systematic oppression of Indigenous Peoples exists. In Australia, Indigenous Peoples were forcibly dispossessed of land and killed in conflicts with colonizers (Greer 1993, Short 2003, Turner et al. 2013c). American Indians and Alaska Natives faced genocide at the hands of European colonizers (Brave Heart and DeBruyn 1998), and were forced into American Indian boarding schools that paralleled the residential schooling system in Canada (Brave Heart and DeBruyn 1998). These and countless other examples of international genocide and forced assimilation of Indigenous Peoples resulted in the UN Declaration on the Rights of Indigenous Peoples (United Nations Declaration 2008), but the scars and ongoing effects of colonization remain.

We suggest that the depth of stewardship values and local knowledge evidenced by study participants is the foundation for cultural revival. Although we documented a muted quality to traditional ecological knowledge surrounding rockfish, all participants remembered and honored the stewardship principle of limiting harvests to only what is needed, and most possessed a depth of local knowledge (e.g. about the size and abundance of Yelloweye rockfish, abundance hot spots, historic changes to populations) (Eckert et al. *in press*). Thus, the core of many stewardship strategies and cultural teachings remains intact within the four First Nations in this study, suggesting that rather than being lost, traditional ecological knowledge of member Nations was in reality dormant. The non-specific but ubiquitous sustainability values that emerged reflects the Indigenous ethic – that life is to be respected and that waste is deplorable – represented in other works (Turner and Berkes 2006). This ethos is witnessed repeatedly in First

Nations and other Indigenous cultures and may represent a worldview that was fundamental to avoiding depletion of vital local resources (Turner and Atleo 1998, Turner et al. 2000, Berkes and Turner 2006, Turner 2014). Despite the losses suffered in traditional ecological knowledge and the lack of traditional stories which might otherwise detail and infuse the evidenced stewardship ethic, our study affirms that the fundamental stewardship worldview remains healthy and intact amongst participant First Nations. Thus, focusing on and mobilizing the stories and customs that a few community members do recall, and that stewardship offices and community leaders have documented previously, may allow this ethic to be again informed by traditional oral stories and ceremonies.

Overcoming the social-ecological trap also needs to involve recovery of depleted resources, especially given the interconnectedness of First Nations' culture, traditional ecological knowledge, and the quality of surrounding environment and resources (Turner and Berkes 2006, Berkes 2012a). Recovering and sustaining fish stocks, via strategies such as marine protected areas (MPAs) and improved fisheries management, is critical for the continuation of cultural practices and knowledge transmission. MPAs, alongside other spatial and seasonal closures to fisheries, may promote conservation and restoration of rockfishes, including Yelloweye rockfish (Parker et al. 1994, Yamanaka and Logan 2010). Studies suggest that the implementation of such areas is strengthened when local communities are directly involved with the creation and implementation of marine conservation and management plans (Johannes 2002, Thornton and Scheer 2012).

Concrete steps are already being taken by First Nations to combat the social-ecological trap of knowledge and culture dormancy. Several participants placed hope in a new wave of cultural education for youth; such programs are on-going and include the Supporting Emerging Aboriginal Scholars (SEAS) community initiative and the QQS Projects Society, among others. Both SEAS and QQS target First Nations youth, and provide opportunities for participants to actively engage with traditional culture, ceremony, and resource harvesting. For example, at Koeye Camp (sponsored by QQS), community youth aged 8-15 engage in a combination of scientific learning and cultural rediscovery at a remote camp that was, and remains, stewarded and inhabited for thousands of years (http://www.qqsprojects.org/projects/koeye-camp/). The SEAS community initiative includes an out-of-classroom learning component which places

students within local ecosystems, and in the company of Elders and others knowledgeable about environmental features, exploring traditional stewardship and harvesting strategies as curriculum (http://www.emergingstewards.org/). Such programs enliven cultural tradition for Central Coast First Nations youth, attempting to return them to cedar big houses, traditional knowledge, dance, and ceremony, and the ecosystems which their ancestors have stewarded for millennia.

Achieving simultaneous success in cultural resurgence and marine species recovery requires revitalizing Indigenous management rights. Recognizing Indigenous title and rights to manage traditional territories will not only actively engage the traditional ecological knowledge of coastal First Nation communities, but will also allow for fisheries management to respond to local observations of declines (Eckert et al. *in press*, Frid et al. 2016). At the forefront of reviving Indigenous marine management rights is the Central Coast Indigenous Resource Alliance (CCIRA), a collaborative non-profit organization created by the four member Nations (Heiltsuk, Kitasoo/Xai'xais, Wuikinuxv, and Nuxalk) involved in this project, which seeks to inform resource management through a combination of independently-collected ecological research, and the local ecological knowledge and traditional ecological knowledge of member Nations (CCIRA 2016). CCIRA, which recognizes that the collective goal of its member Nations is to preserve resources and ecosystems for the benefit of future generations, has facilitated First Nations engagement in comprehensive marine use planning within their traditional territories. Recognizing the value of MPA planning and implementation for species conservation, member nations have proposed MPAs in their Central Coast marine use plan (Central Coast First Nations 2010), and are now engaged in MPA planning in collaboration with the provincial government (MaPP 2015) and negotiations with the federal government (MPA Network: BC's Northern Shelf 2016). Implementing these plans, alongside considering the independent species surveys and traditional knowledge surveys developed by CCIRA (Eckert et al. *in press*, Frid et al. 2016) provides a way forward in Indigenous cultural resurgence and marine conservation that would move beyond the identified social-ecological trap. Implementation of such marine planning through joint management is certainly possible, as evidenced by the recently created Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage site. The site, established in 2010, is managed by both the Government of Canada and the Haida Nation and reflects a recognized need by both parties to protect an ecosystem and resources of cultural importance (Parks Canada 2016).

Several limitations became evident during the study, some of which are echoed in other social research (Huntington 1998, Drew 2005, Clark 2008). It was occasionally fatiguing for Elders or other participants to answer all questions. The communities who partook in our study have hosted a variety of researchers, and many key participants engage frequently in interviews and thus face interview fatigue. Another limitation is that our general interview questions, which focused on changes to Yelloweye rockfish, were not designed to explicitly ask questions about the social-ecological trap; thus, just because something (e.g. a stewardship principle or an aspect of the trap) was not presented in our results does not mean that it does not exist; it may simply not have been identified because our questions did not trigger the response. As is typical, time was a limiting factor in data collection; most interviews lasted between 1-3 hours, and therefore sample size was limited by research time and the availability of participants. Several knowledge holders (approximately 2-3 per community) were unavailable or otherwise engaged at the time of our community visits, and thus unable to participate. Finally, this study was limited by both the researcher's limited world view, and the single-species focus imposed on participants. Because of the time limitations inherent to academic work, the breadth and depth of traditional ecological knowledge of involved First Nations, and the sophistications and nuances therein involved, could only be represented to the extent that 2 years of research allowed. The single-species worldview utilized for this questionnaire was chosen by team researchers and member Nations to best inform federal fisheries management practices, but may have conflicted with the holistic nature of Indigenous knowledge to the detriment of revealing traditional ecological knowledge surrounding Yelloweye rockfish.

Our case study, in collaboration with four First Nations on BC's Central Coast, allowed us valuable insights into a social-ecological trap faced by Indigenous Peoples here and elsewhere and, importantly, participants were able to identify ways to move beyond said trap. Indigenous Peoples trapped by the combined and amplifying impacts of colonization and resource degradation may find ways forward through a united strategy of focused cultural revival and the active recovery of degraded species and habitats. We suggest widespread recognition of Indigenous management rights – and the reassertion of these rights through traditional management measures – as a means of overcoming the social-ecological trap and thus simultaneously affirming Indigenous rights and marine species conservation.

Chapter 4: Discussion and Conclusion

4.1 Introduction

This thesis reflects three main goals: 1) to undertake research that is collaborative and inclusive, and addresses priorities established by participating First Nations; 2) to contribute to fisheries management and conservation recommendations by focusing on a species of cultural importance and exploring the applications of traditional and local ecological knowledge to species-level understandings; and 3) to contribute a marine social-ecological case study that investigates extending data baselines using traditional and local ecological knowledge and provides appropriate context. This chapter serves to highlight how I've accomplished these goals and my objectives. It also functions to synthesize other key "take-aways" from my work by: summarizing how I've contributed to the relevant literature; assessing study limitations that arose throughout the project; discussing salient marine management recommendations; and finally, recommending future research directions.

4.2 Goal 1: Undertaking Collaborative and Inclusive Research

At the initiation of my project, I sought to undertake research that was collaborative and inclusive of the Heiltsuk, Kitasoo/Xai'xais, Wuikinuxv, and Nuxalk Nations' knowledge and interests. The need for "decolonized" methodologies (Smith 1999) in work exploring Indigenous knowledge is increasingly recognized by scholars and human rights activists alike. Decolonizing research is that which recognizes the intrinsic value and validity of Indigenous cultures, knowledge, and worldviews. It seeks to empower and revitalize Indigenous communities to direct, guide, and implement research occurring within their traditional territories (Smith 1999, Adams and Mulligan 2003). To accomplish this goal, I engaged actively with the Central Coast Indigenous Resource Alliance (CCIRA) and with member Nations. I also chose to study a species which they collectively identified as culturally and economically valuable (Yelloweye rockfish ; *Sebastes ruberrimus*). After the First Nations initiated the work in the Spring of 2015, I developed research protocols with each Nation individually. These protocols paved the way for

collaborative work by making my intentions and the needs of the Nations explicit before data collection began. To uphold established protocols, I made the project adaptable to local needs; I engaged in community workshops and discussions to introduce the project and goals, and held follow-up workshops in each community. All data collected was returned to the stewardship or resource directors in each Nation, and no data was published without unanimous consent, per our research agreements.

Although I accomplished my goals of engaging in inclusive and collaborative research with the four First Nations involved, I acknowledge that truly decolonizing research was not fully achieved within the scope of my work. Such research requires the integration of Indigenous researchers and authors into the research team. For non-Indigenous researchers, longer time-scales of working and living within communities are critical to enacting work that is totally decolonizing. My desire is that the work represented within this thesis provides a stepping-stone to achieve such wholly integrative methodologies and research.

4.3 Goal 2: Applying Indigenous Knowledge to Fisheries Management and Conservation

My second project goal was to contribute to fisheries management and conservation recommendations through focusing on a single species, Yelloweye rockfish, and the traditional and local ecological knowledge regarding this species. My first objective and initial step to accomplishing this goal was to demonstrate the use of traditional and local ecological knowledge to extend historical baselines that are scientifically limited either temporally or spatially. Using a "vessel-based" approach (Murray et al. 2007) and semi-structured interview methodology (Huntington 2000) allowed me to explore traditional and local ecological knowledge possessed by member Nations, and rendered data about Yelloweye rockfish size and abundance that, when analyzed, provided information that preceded scientific baselines for the region. Overwhelmingly, participants had observed steep declines in the abundance and size of Yelloweye rockfish.

Traditional and local ecological knowledge about Yelloweye rockfish revealed important key results. Median observed historical size of Yelloweye rockfish from the 1950s-1980s was more than double modern observed Yelloweye rockfish size. This change was largely attributed to

commercial fishing, sports fishing, and less so to other factors (e.g. forestry, global warming), with the 2000s most frequently cited by participants as the decade within which most observable change had occurred. Historical data generated via interviews with First Nations individuals were supported by the fact that amalgamated interview estimates of modern Yelloweye rockfish size aligned well with ecological data collected independently in the region. This information is pertinent to the management of Species-At-Risk-Act (COSEWIC 2008) listing of Yelloweye rockfish, and adds to a growing body of literature that shows concurrence between scientific data and traditional or local ecological knowledge (Berkes et al. 2000b, Service et al. 2014, Thurstan et al. 2016). My research thus supports the application of such data sources in conservation sciences. My results also facilitated accomplishing my goal of addressing priorities elicited by First Nations; the data generated via this study can be used by CCIRA-member Nations to inform their fisheries management plans (Central Coast First Nations 2010) and negotiations with the Department of Fisheries and Oceans Canada (DFO).

Focusing on a focal species of cultural importance – Yelloweye rockfish – throughout my project not only allowed me to apply local and traditional ecological knowledge as reliable means to extend historical data baselines, but also revealed the depth of species-specific knowledge possessed by Indigenous Peoples. This depth has widespread management and conservation implications that I expand up further in Section 4.5.

4.4 Goal 3: Marine Social-Ecological Case Study

I aimed to contribute a marine social-ecological case study that investigates extending data baselines using traditional and local ecological knowledge and provides appropriate context. I accomplished this goal by considering the complex social and ecological components of my case study area. This consideration allowed me to recognize the intricate history of First Nations and their relationship to local resources (Turner et al. 2000, Berkes 2012a, Turner 2014), the impacts of colonization (Environics Research Group 2008), and the complexity of local marine and terrestrial systems, amongst other factors that constitute the social-ecological case study. My second objective, which led me to investigate the utility of a social-ecological framework for assessing impacts within the case study social-ecological system, allowed me to directly

accomplish this goal. Though social-ecological traps (defined in Ch.3) have been previously used to understand threats to complex marine social-ecological systems (Cinner 2011, Steneck et al. 2011, Kittinger et al. 2013), they have not been applied to situations of Indigenous knowledge or culture loss.

By analyzing the system through the lens of a social-ecological trap, I was able to assess recent impacts of colonization (largely, via residential schools) and those of local environmental degradation on Indigenous knowledge, culture, and lifeway. Not only does my thesis recognize and identify Indigenous knowledge dormancy as the result of a social-ecological trap within which resource depletion and colonization interact to amplify Indigenous knowledge loss, but it seeks to find ways beyond the loss through suggestions of interview participants. Although most social-ecological traps are challenging to reverse (Platt 1973, Cinner 2011), interviews with First Nations participants revealed the retention of a stewardship principle, despite the muting of traditional ecological knowledge. This principle, which recognized the interconnections of humans, ecosystems and species, and highlighted the importance of not overharvesting local resources, provides a starting point to revitalize aspects of lost Indigenous knowledge. Further, many participants asserted that current organizations and programs (CCIRA, QQS, SEAS) provide hope and action for the resurgence of Indigenous knowledge and culture. Considering the social-ecological system and project through this lens allowed me to describe and contextualize important nuances related to traditional and local ecological knowledge in a way that would not have otherwise been captured, and highlight ways beyond a trap that otherwise may threaten Indigenous cultures and lifeways. The lens of a social-ecological trap, and its application to Indigenous knowledge loss, fills an evident gap in social-ecological systems literature and is applicable to research globally.

4.5 Implications for Fisheries Management

My thesis findings have several key implications for fisheries management, both locally and globally. Generally, my project adds to a growing body of literature that supports the integration of traditional and local ecological knowledge into marine management and conservation science by revealing the depth of such knowledge, its applicability to fill gaps in scientific data, and its concurrence with ecological data (Johannes 2000, Berkes 2004, 2012a, Menzies and Butler 2007b, Turner and Spalding 2013, Beaudreau and Levin 2014).

Locally, my study results suggest both general and specific implications for fisheries management, most of which are discussed in my second chapter. The insight into historical changes and species-level knowledge possessed by First Nations participants indicate the need to include First Nations in current and future fisheries management plans. First Nations expertise is vital when setting conservations goals for species for which the extent of depletions is not scientifically known. For example, the evidence that Yelloweye rockfish body size has decreased substantially over the last 5-6 decades should have direct species-specific management implications for the DFO. First, it provides critical data beyond prior baselines, thus emphasizing that DFO take seriously the data and management strategies possessed by Coastal First Nations. Second, the reality that the largest and thus most fecund Yelloweye rockfish (Birkeland and Dayton 2005, Dick et al. 2017) have decreased substantially on the Central Coast bodes poorly for stock health and sustainability. Increasing local monitoring and improving enforcement of Rockfish Conservation Areas (RCAs) within the study region, as well as creating new RCAs that directly incorporate the knowledge of First Nations, are recommended as the first steps in achieving a Yelloweye rockfish population with a healthy age-structure.

Further, because intergenerational knowledge and cultural attributes are passed through the practices of traditional harvesting and dependent upon the continued existence of critical marine resources, appropriately conserving species such as Yelloweye rockfish is inextricably linked with upholding First Nations' rights. While the intricate link between Indigenous rights and marine biodiversity conservation has been described elsewhere (Central Coast First Nations 2010, Frid et al. 2016), the identification and analysis of a social-ecological trap created by the combined impacts of colonization and environmental degradation further emphasizes the need for federal management bodies (such as the DFO) to recognize the rights of First Nations to manage local resources. The responses of participants in this study suggest concurrence that a return to local management schemes would allow First Nations to overcome the trap of knowledge, culture, and lifeway loss and provide opportunities for Indigenous resurgence. Due to the depth of applicable traditional and local ecological knowledge of involved Nations, millennia-long experiences in managing key resources without extirpation (Turner et al. 2000, Lepofsky and Caldwell 2013), and in recognition of the inherent rights of First Nations after

centuries of colonization (Environics Research Group 2008), I recommend that DFO directly engage local First Nations communities throughout marine management planning processes. Furthermore, the federal government should restore opportunities for proprietary Indigenous marine management in traditional territories, as has occurred elsewhere (Johannes 2002, Aswani and Hamilton 2004).

4.6 Contributions to Relevant Literature

I sought to overcome literature gaps in both marine historical ecology and social-ecological systems theory. Despite the increasingly accepted use of non-traditional data sources (e.g. archives, historical photography, etc.) to extend historical baselines through marine historical ecology studies (McClenachan 2009, McClenachan et al. 2012, Lotze and McClenachan 2013, Kittinger et al. 2015), the use of traditional and local ecological knowledge to fill such gaps remains limited (Narchi et al. 2014). Thus, I compiled and analyzed traditional and local ecological knowledge about Yelloweye rockfish to overcome this gap and showcase its utility within the field. My work generated a historical baseline as far back as the 1950s where no fisheries-independent scientific data existed beyond 2003, and identified decreasing trends in both size and abundance of Yelloweye rockfish that were known amongst First Nations fishers but previously undocumented.

Studies that analyze social-ecological traps have been utilized to analyze marine social-ecological systems, but have not, to my knowledge, been applied to the issue of Indigenous knowledge loss. While previous studies used the trap concept to better understand the mechanisms and feedbacks within systems impacted by poverty (Cinner 2011), those which lack appropriate management or implementation of management plans, and others (Steneck et al. 2011), my project is novel because it analyzes ways in which colonization and environmental degradation interact to exacerbate Indigenous knowledge loss. I use the lens of a social-ecological trap to highlight ways out of the trap, thus adding to the growing body of literature while simultaneously seeking to benefit and support local cultural resurgence.

4.7 Study Limitations

Several key limitations arose throughout the research process, many of which have been expanded upon in previous chapters. First, interview fatigue was a factor in data collection. The First Nations involved in my project are recognized for their knowledge and insight by researchers both internally and externally. Thus, many individuals have participated in countless studies. Second, as is a limitation for many studies that utilize traditional and local ecological knowledge, ecological accuracy of interview data is limited, due to the nature of human memory and the timeline about which questions are asked. However, I used methods that I believe minimized inaccuracies inherent to interview data (e.g. a vessel-based interview questionnaire, a relatively large sample size), and reiterate that the changes noted in Yelloweye rockfish size are nonetheless significant due to the magnitude of change. Third, time-limited fieldwork forced us to miss a few key participants in each community, who were unavailable at the time of data collection. Working with four individual and distinct First Nations posed challenges and time limitations. Restricted field time and research funds needed to be split accordingly, and dedicating research resources to a similar project within a single community might have allowed for a more detailed or in-depth study of community themes. However, the perspectives and themes revealed from working amongst four Nations (with unified goals) were core to the results elicited in this study, and allowed a large and more diverse participant sample size that strengthened the validity of collected data.

Academic deadlines are often at odds with community processes and timelines. Thus, future graduate students pursuing topics in the area of Indigenous knowledge should consider the implications of their own timeline, and recognize that it may not necessarily be beneficial or plausible for the Indigenous community with which they engage. Specifically, a Master's degree limits total time spent engaged within communities. More time spent embedded within every community would have strengthened both my research and my relationships with engaged First Nations communities. The fact that the four involved Nations initiated my project made the work feasible within the scope of a Master's degree, but it is important to weigh key trade-offs and consider personal timelines before engaging in research with Indigenous communities.

Finally and importantly, it is worth noting that the worldviews of the involved First Nations (and many Indigenous Peoples) recognize the inextricable interconnectedness of species and

ecosystems (Turner et al. 2000, Berkes 2012a). Thus, a single species approach, although it made the research goals more realistic to attain, at times is at odds with this worldview. We (myself, CCIRA, and member First Nations) deliberately developed this single-species focus because it aligns with conventional fisheries management techniques utilized by the DFO. However, sophisticated Indigenous knowledge and worldview does not fit into this framework of conventional management, nor should it necessarily be forced to. Truly decolonizing marine research should develop research goals and questionnaires that are holistic, and are informed by the Indigenous ideal and scientific reality that all species and components of local ecosystems (and thus management strategies and implications) are interwoven.

4.8 Suggestions for Future Research

There remain key directions for ways forward in research related to this thesis. My work suggests the significant value of traditional and local ecological knowledge for filling gaps in historical scientific data or in data-poor regions. The use of this non-traditional data source should be more broadly applied in areas, such as on the Central Coast, where Indigenous fishers rely on local resources. My project also serves to strengthen the case for reassertion of Indigenous management rights and application of traditional management strategies to modern fisheries management. More academic research should seek practical ways to integrate Indigenous and scientific management, and marine management and conservation schemes should consider traditional and local ecological knowledge in functional management applications.

The project and data represented in this thesis hinged upon collaboration and on-going engagement with four First Nations communities; future academic research should strive to implement a decolonizing approach (Smith 1999, Adams and Mulligan 2003) to a greater extent than was feasible in this research. Implementing this approach would include further engaging in research questions that are First Nations-driven, recognizing Indigenous priorities, engaging Indigenous researchers throughout the project, and producing results that are directly and immediately applicable to Indigenous communities' welfare and interests. Although my project accomplished many of these to some extent, future research should be partially or fully

conducted by First Nations individuals, should include First Nations knowledge holders and researchers as co-authors on questionnaires and academic manuscripts, and should seek to better align fundamental project goals with holistic Indigenous worldviews. Conducting further work in the direction of decolonization and revival of Indigenous rights will require engaged and self-aware scholars, and tireless and well-supported work by Indigenous communities and individuals. It also necessitates federal government departments willing to accept the validity and significance of Indigenous knowledge and rights, and translate this acceptance to research and decision-making. I hope my project may serve as a stepping stone toward this end.

References

Adams, W. M., and M. Mulligan. 2003. *Decolonizing nature: strategies for conservation in a post-colonial era*. Earthscan Publications, London.

Al-Abdulrazzak, D., R. Naidoo, M. L. D. Palomares, and D. Pauly. 2012. Gaining perspective on what we've lost: the reliability of encoded anecdotes in historical ecology. *PloS one* 7(8):e43386.

Aswani, S., and R. J. 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.

Ban, N. C., M. Mills, J. Tam, C. C. Hicks, S. Klain, N. Stoeckl, M. C. Bottrill, J. Levine, R. L. Pressey, T. Satterfield, and K. M. A. Chan. 2013. A social-ecological approach to conservation planning: Embedding social considerations. *Frontiers in Ecology and the Environment* 11(4):194–202.

Beaudreau, A. H., and P. S. Levin. 2014. Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. *Ecological Applications* 24(2):244–256.

Berkeley, S. A., M. A. Hixon, R. J. Larson, and M. S. Love. 2004. Fisheries sustainability via protection of age structure and spatial distribution of fish populations. *Fisheries* 29(8):23–32.

Berkes, F. 2004. Rethinking community-based conservation. *Conservation Biology* 18(3):621–630.

Berkes, F. 2012a. *Sacred ecology: Traditional ecological knowledge and management systems*. Routledge, London.

Berkes, F. 2012b. Implementing ecosystem-based management: evolution or revolution? *Fish and Fisheries* 13(4):465–476.

Berkes, F., J. Colding, and C. Folke. 2000a. *Linking social and ecological systems: management practices and social mechanisms for building resilience.* Cambridge University Press, Cambridge, UK.

Berkes, F., J. Colding, and C. Folke. 2000b. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10(5):1251–1262.

Berkes, F., and N. J. Turner. 2006. Knowledge , learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology* 34(4):479–494.

Birkeland, C., and P. K. Dayton. 2005. The importance in fishery management of leaving the big ones. *Trends in Ecology & Evolution* 20(7):356–8.

Bopp, L., L. Resplandy, J. C. Orr, S. C. Doney, J. P. Dunne, M. Gehlen, P. Halloran, C. Heinze, T. Ilyina, R. Séférian, J. Tjiputra, and M. Vichi. 2013. Multiple stressors of ocean ecosystems in the 21st century: Projections with CMIP5 models. *Biogeosciences*

10(10):6225–6245.

Brave Heart, M. Y. H., and L. M. DeBruyn. 1998. The American Indian holocaust: Healing historical unresolved grief. *American Indian and Alaska Native Mental Health Research* 8(2):60–82.

British Columbia Marine Conservation Analysis (BCMCA). 2011. Marine Atlas of Pacific Canada: a product of the British Columbia Marine Conservation Analysis (BCMCA).

Butler, C., and C. Menzies. 2007. Traditional ecological knowledge and indigenous tourism. Page 27–42. *Tourism and indigeous peoples: Issues and Implications*. Elsevier Ltd, Oxford.

Canada – British Columbia Marine Protected Area Network Strategy. https://www.for.gov.bc.ca/tasb/slrp/pdf/ENG_BC_MPA_LOWRES.pdf. 2014. :1–35.

CCIRA. 2016. Central Coast Indigenous Resource Alliance. https://www.ccira.ca.

Central Coast First Nations. 2010. *Central Coast First Nations Marine Use Plan Executive Summary. http://ccira.ca/media/documents/pdf/central-coast-executive-summary-email.pdf*.

Chapin, F. S., S. R. Carpenter, G. P. Kofinas, C. Folke, N. Abel, W. C. Clark, P. Olsson, D. M. S. Smith, B. Walker, O. R. Young, F. Berkes, R. Biggs, J. M. Grove, R. L. Naylor, E. Pinkerton, W. Steffen, and F. J. Swanson. 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology and Evolution* 25(4):241–9.

Cinner, J. E. 2011. Social-ecological traps in reef fisheries. *Global Environmental Change* 21(3):835–839.

Cinner, J. E., and S. Aswani. 2007. Integrating customary management into marine conservation. *Biological Conservation* 140(3–4):201–216.

Cisneros-Montemayor, A. M., D. Pauly, L. V. Weatherdon, and Y. Ota. 2016. A global estimate of seafood consumption by Coastal Indigenous Peoples. *Plos One* 11(12):e0166681.

Clark, T. 2008. "We're over-researched here!": Exploring accounts of research fatigue within qualitative research engagements. *Sociology* 42(5):953–970.

Colding, J., and C. Folke. 2001. Social taboos: Invisible systems of local resource management and biological conservation. *Ecological Applications* 11(2):584–600.

Conklin, H. C. 1957. *Hanunoo agriculture: a report on an integral system of shifting agriculture in the Philippines, Forestry Development Paper 12*. Rome.

Cooke, S. J., and I. G. Cowx. 2004. The role of recreational fishing in global fish crises. *Bioscience* 54(9):857–859.

COSEWIC. 2008. COSEWIC Assessment and Status Report on the Yelloweye Rockfish Sebastes ruberrimus in Canada. *Committee on the Status of Endangered Wildlife in Canada.*

Covington, W. W., P. Z. Fulé, M. M. Moore, S. C. Hart, T. E. Kolb, J. N. Mast, S. S. Sackett, and M. R. Wagner. 1997. Restoring ecosystem health in Ponderosa Pine forests of the southwest. *Journal of Forestry* 95(4):23–29.

Danielsen, F., N. D. Burgess, A. Balmford, P. F. Donald, M. Funder, J. P. G. Jones, P. Alviola,

D. S. Balete, T. Blomley, J. Brashares, B. Child, M. Enghoff, J. Fjeldsa, S. Holt, H. Hubertz, A. E. Jensen, P. M. Jensen, J. Massao, M. M. Mendoza, Y. Ngaga, M. K. Poulsen, R. Rueda, M. Sam, T. Skielboe, G. Stuart-Hill, E. Topp-Jorgensen, and D. Yonten. 2009. Local participation in natural resource monitoring: A characterization of approaches. *Conservation Biology* 23(1):31–42.

Deevey, E. S. 1969. Coaxing history to conduct experiments. *BioScience* 19(1):40–43.

Dempsey, J. 2011. The politics of nature in British Columbia's Great Bear Rainforest. *Geoforum* 42(2):211–221.

Department of Fisheries and Oceans Canada. 2015. Stock Assessment for the outside population of Yelloweye Rockfish (Sebastes ruberrimus) In British Columbia, Canada for 2014. *DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.* 60.

Department of Fisheries and Oceans Canada. 2016. Pacific region integrated fisheries management plan: groundfish.

Dick, E. J., S. Beyer, M. Mangel, and S. Ralston. 2017. A meta-analysis of fecundity in 337 rockfishes (genus Sebastes). *Fisheries Research* 187:73–85.

Dowling, N., D. Smith, I. Knuckey, A. Smith, P. Domaschenz, H. Patterson, and W. Whitelaw. 2008. Developing harvest strategies for low-value and data-poor fisheries: Case studies from three Australian fisheries. *Fisheries Research* 94(3):380–390.

Drew, J. A. 2005. Use of traditional ecological knowledge in marine conservation. *Conservation Biology* 19(4):1286–1293.

Eckert, L. E., N. C. Ban, A. Frid, and M. McGreer. 2017. Diving back in time: Extending historical baselines for Yelloweye rockfish with Indigenous knowledge. In press. *Aquatic Conservation: Marine and Freshwater Ecosystems*.

Environics Research Group. 2008. *Final Report: 2008 National Benchmark Survey. Prepared for Indian Residential Schools Resolution Canada and the Truth and Reconciliation Commission*.

Espinoza-Tenorio, A., M. Wolff, I. Espejel, and G. Montaño-Moctezuma. 2013. Using traditional ecological knowledge to improve holistic fisheries management: Transdisciplinary modeling of a lagoon ecosystem of Southern Mexico. *Ecology and Society* 18(2).

ESRI. 2015. ArcGIS Desktop. Environmental Research Systems Institute, Redlands, CA.

First Peoples' Cultural Council (FPCC). 2014. B.C. First Nations Languages 2014.

Folke, C. 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change* 16(3):253–267.

Frid, A., M. McGreer, D. R. Haggarty, J. Beaumont, and E. J. Gregr. 2016. The crossroads of spatial protection, central place fisheries, and indigenous rights. *Global Ecology and Conservation* 8:170–182.

Gadgil, M., F. Berkes, and C. Folke. 1993. Indigenous knowledge for biodiversity conservation.

Ambio 22(2–3):151–156.

Gilchrist, H. G., M. L. Mallory, and F. Merkel. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. *Ecology and Society* 10(1):20.

Grainger, J. 1940. Historical ecology of the fungi. *The Naturalist*:285–287.

Greer, S. 1993. Australian Aboriginal Societies and Heritage. Page *in* N. Loos and T. Osanai, editors. *Indigenous Minorities and Education: Australian and Japanese Perspectives of their Indigenous Peoples, The Ainu, Aborigines and Torres Straight Islanders*. Sangusha Publishing, Tokyo.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An Estimation of Historic and Current Levels of Salmon Production in the Northeast Pacific Ecosystem: Evidence of a Nutrient Deficit in the Freshwater Systems of the Pacific Northwest. *Fisheries* 25(1):15–21.

Groesbeck, A. S., K. Rowell, D. Lepofsky, and A. K. Salomon. 2014. Ancient clam gardens increased shellfish production: Adaptive strategies from the past can inform food security today. *PLoS ONE* 9(3).

Gutiérrez, N. L., R. Hilborn, and O. Defeo. 2011. Leadership, social capital and incentives promote successful fisheries. *Nature* 470(7334):386–389.

Hackett, P. 2005. From Past to Present: Understanding First Nations Health Patterns in a Historical Context. *Canadian Journal of Public Health/Revue*:S17–S21.

Haggan, N., and P. Brown. 2002. Aboriginal fisheries issues: the west coast of Canada as a case study. Pages 17–20*in* D. Pauly and M. Palomares, editors.*Production Systems in Fishery Management*. Fisheries Centre University of British Columbia, Vancouver, British Columbia.

Haggan, N., B. Neis, and I. Baird. 2007. *Fishers' knowledge in fisheries science and management*. UNESCO Publishing, Venice.

Haggarty, D. 2013. *Rockfish conservation areas in B . C . : Our current state of knowledge*. The David Suzuki Foundation.

Hallwass, G., P. F. Lopes, A. A. Juras, and R. A. Silvano. 2013. Fishers' knowledge identifies environmental changes and fish abundance trends in impounded tropical rivers. *Ecological Applications* 23(2):392–407.

Halpern, B. S., S. Walbridge, K. A. Selkoe, C. V. Kappel, F. Micheli, C. D'Agrosa, J. F. Bruno, K. S. Casey, C. Ebert, H. E. Fox, R. Fujita, D. Heinemann, H. S. Lenihan, E. M. P. Madin, M. T. Perry, E. R. Selig, M. Spalding, R. Steneck, and R. Watson. 2009. A Global Map of Human Impact on Marine Ecosystems. *Science* 948(2008):948–953.

Hardin, G. 1968. The Tragedy of the Commons. *Science* 162:1243–48.

Heaslip, R. 2008. Monitoring salmon aquaculture waste: The contribution of First Nations' rights, knowledge, and practices in British Columbia, Canada. *Marine Policy* 32(6):988–996.

Hilborn, R., J. M. L. Orensanz, and A. M. Parma. 2005. Institutions, incentives and the future of

fisheries. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 360(1453):47–57.

Hixon, M. A., D. W. Johnson, and S. M. Sogard. 2014. BOFFFFs: on the importance of conserving old-growth age structure in fishery populations. *ICES Journal of Marine Science* 71:2171–2185.

Hughes, T. P., D. R. Bellwood, C. Folke, R. S. Steneck, and J. Wilson. 2005. New paradigms for supporting the resilience of marine ecosystems. *Trends in Ecology and Evolution* 20(7):380–386.

Huntington, H. P. 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. *Arctic* 51(3):237–242.

Huntington, H. P. 2000. Using traditional ecological knowledge in science : Methods and applications. *Ecological Applications* 10(5):1270–1274.

Jackson, J. B., M. X. Kirby, W. H. Berger, K. a Bjorndal, L. W. Botsford, B. J. Bourque, R. H. Bradbury, R. Cooke, J. Erlandson, J. a Estes, T. P. Hughes, S. Kidwell, C. B. Lange, H. S. Lenihan, J. M. Pandolfi, C. H. Peterson, R. S. Steneck, M. J. Tegner, and R. R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293(5530):629–37.

Jarvis, E. T., and C. G. Lowe. 2008. The effects of barotrauma on the catch-and-release survival of southern California nearshore and shelf rockfish (Scorpaenidae, Sebastes spp.). *Canadian Journal of Fisheries and Aquatic Sciences* 65(7):1286–1296.

Johannes, R. 1998a. The case for data less marine resource management: Examples from tropical nearshore fisheries. *Trends in Ecology and Evolution* 13(98):243–246.

Johannes, R. 2000. Ignore fishers' knowledge and miss the boat. *Fish and Fisheries* 1:257–271.

Johannes, R. 2002. The Renaissance of community-based marine resource management in Oceania. *Annual Review of Ecology and Systematics* 33(1):317–340.

Johannes, R. E. 1978. Traditional marine conservation methods in Oceania and their demise. *Annual Review of Ecology and Systematics* 9(1978):349–364.

Johannes, R. E. 1998b. Government supported, village-based management of marine resources in Vanuatu. *Ocean & Coastal Management* 40:165–186.

Johannes, R. E., and B. M. Yeeting. 2000. I-Kiribati knowledge and traditional management of lagoon resources. *Atoll Research Bulletin*(489):1–24.

King, M., and U. Faasili. 1999. Community-based management of subsistence fisheries in Samoa. *Fisheries Management and Ecology* 6(2):133–144.

Kittinger, J. N., E. M. Finkbeiner, N. C. Ban, K. Broad, M. H. Carr, J. E. Cinner, S. Gelcich, M. L. Cornwell, J. Z. Koehn, X. Basurto, R. Fujita, M. R. Caldwell, and L. B. Crowder. 2013. Emerging frontiers in social-ecological systems research for sustainability of small-scale fisheries. *Current Opinion in Environmental Sustainability* 5(3):352–357.

Kittinger, J. N., L. McClenachan, K. B. Gedan, and L. K. Blight. 2015. *Marine Historical*

Ecology in Conservation. University of California Press.

Lancaster, D., P. Dearden, D. R. Haggarty, J. P. Volpe, and N. C. Ban. 2017. Effectiveness of shore-based remote camera monitoring for quantifying recreational fisher compliance in marine conservation areas. *Aquatic Conservation: Marine and Freshwater Ecosystems*:1–10.

Lancaster, D., D. R. Haggarty, and N. C. Ban. 2015. Pacific Canada's Rockfish Conservation Areas: Using Ostrom's design principles to assess management effectiveness. *Ecology and Society* 20(3):41.

Lavides, M. N., N. V. C. Polunin, S. M. Stead, D. G. Tabaranza, and J. R. Comeros, M.T. Dongollo. 2009. Finfish disappearances around Bohol, Philippines inferred from traditional ecological knowledge. *Environmental Conservation* 36(3):235–244.

de Leeuw, S. 2009. "If anything is to be done with the Indian, we must catch him very young": colonial constructions of Aboriginal children and the geographies of Indian residential schooling in British Columbia, Canada. *Children's Geographies* 7(2):123–140.

Lepofsky, D., and M. Caldwell. 2013. Indigenous marine resource management on the Northwest Coast of North America. *Ecological Processes* 2(1):12.

Levy, D. 2006. BC Sockeye salmon population declines: Probable causes and recommended response strategies. *Sierra Club of Canada*.

Lichtman, M. 2013. *Qualitative research methods for the social sciences.* Sage Publications.

Lotze, H. K., and L. McClenachan. 2013. Marine historical ecology: informing the future by learning from the past. Pages 165–200*in* M. Bertness, B. Silliman, J. Bruno, and J. Stachowicz, editors.*Marine Community Ecology and Conservation*. Sinauer,.

Lotze, H. K., and B. Worm. 2009. Historical baselines for large marine animals. *Trends in Ecology & Evolution* 24(5):254–62.

Love, M., M. Yoklavich, and L. Thorsteinson. 2002. *The Rockfishes of the Northeast Pacific*. University of California Press, Berkeley, CA.

Mallory, M. L., H. G. Gilchrist, A. J. Fontaine, and J. A. Akearok. 2001. Local ecological knowledge of lvory Gull declines in Arctic Canada. *Arctic* 56(3):293–299.

Mangel, M., H. K. Kindsvater, and M. B. Bonsall. 2007. Evolutionary analysis of life span, competition, and adaptive radiation, motivated by the Pacific rockfishes (Sebastes). *Evolution; international journal of organic evolution* 61(5):1208–24.

MaPP. 2015. Central Coast Marine Plan.

Martin, K. St., B. J. McCay, G. D. Murray, T. R. Johnson, and B. Oles. 2007. Communities, knowledge and fisheries of the future. *International Journal of Global Environmental Issues* 7(2/3):221–239.

Matthews, D., and N. Turner. (n.d.). The Culture of Oceans: Marine Habitats and Traditional Management Systems of Indigenous Peoples on the Northwest Coast. Page *in* P. Levin and M. R. Poe, editor. *Conservation for the Anthropocene Ocean*. Elsvier, Amsterdam.

McClenachan, L. 2009. Documenting loss of large trophy fish from the Florida Keys with historical photographs. *Conservation biology : the journal of the Society for Conservation Biology* 23(3):636–43.

McClenachan, L., A. Cooper, M. McKenzie, and J. Drew. 2015. The importance of surprising results and best practices in historical ecology. *BioScience*:932–939.

McClenachan, L., F. Ferretti, and J. K. Baum. 2012. From archives to conservation: Why historical data are needed to set baselines for marine animals and ecosystems. *Conservation Letters* 5(5):349–359.

McGreer, M., and A. Frid. 2017. Declining size and age of rockfish (Sebastes spp.) inherent to indigenous cultures of Pacific Canada. In Press. *Ocean and Coastal Management*.

McKechnie, I. 2007. Investigating the complexities of sustainable fishing at a prehistoric village on western Vancouver Island, British Columbia, Canada. *Journal for Nature Conservation* 15(3):208–222.

Mellado, T., T. Brochier, J. Timor, and J. Vitancurt. 2014. Use of local knowledge in marine protected area management. *Marine Policy* 44:390–396.

Menzies, C. R., and C. F. Butler. 2007a. Returning to selective fishing through indigenous fisheries knowledge: the example of K'moda, Gitxaala Territory. *The American Indian Quarterly* 31(3):441–464.

Menzies, C. R., and C. F. C. F. Butler. 2007b. Returning to selective fishing through Indigenous fisheries knowledge. *American Indian Quarterly* 31(3):441–464.

Meyer, W. J., and C. L. Crumley. 2011. Historical ecology: Using what works to cross the divide. Pages 109–134*in* T. Moore and X. L. Amanda, editors.*Atlantic Europe in the first Millennium BC: Crossing the Divide*. Oxford University Publishers, Oxford.

Moller, H., F. Berkes, P. O. B. Lyver, and M. Kislalioglu. 2004. Combining science and traditional ecological knowledge : Monitoring populations for co-management. *Ecology And Society* 9(3):2.

Moody, M. F. 2008. Eulachon past and present. *Resource Management and Environmental Studies*(March):292 p.

Morato, T., R. Watson, T. J. Pitcher, and D. Pauly. 2006. Fishing down the deep. *Fish and Fisheries* 7(1):24–34.

MPA Network: BC's Northern Shelf. 2016. What's Happening? Introducing the Northern Shelf Bioregion MPA Network. http://mpanetwork.ca/bcnorthernshelf/whats-happening/.

Murray, G., B. Neis, and J. P. Johnsen. 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* 34(4):549–571.

Murray, G., B. Neis, and D. C. Schneider. 2007. Lessons from a multi-scale historical reconstruction of Newfoundland and Labrador fisheries. *Coastal Management* 36(1):81–

108.

Myers, R. A., and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. *Nature* 423(6937):280–283.

Narchi, N. E., S. Cornier, D. M. Canu, L. E. Aguilar-Rosas, M. G. Bender, C. Jacquelin, M. Thiba, G. G. M. Moura, and R. de Wit. 2014. Marine ethnobiology a rather neglected area, which can provide an important contribution to ocean and coastal management. *Ocean and Coastal Management* 89:117–126.

Nazarea, V. D. 1999. *Ethnoecology: Situated knowledge/located lives*. University of Arizona Press.

Parker, S. J., S. A. Berkeley, J. T. Golden, D. R. Gunderson, J. Heifetz, M. A. Hixon, R. Larson, B. M. Leaman, M. S. Love, J. A. Musick, V. M. O'Connell, S. Ralston, H. J. Weeks, and M. M. Yoklavich. 2000. Management of Pacific Rockfish. *Fisheries* 25(3):22–30.

Parks Canada. 2016. Gwaii Haanas Management. http://www.pc.gc.ca/eng/pn-np/bc/gwaiihaanas/plan/plan1.aspx.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology & Evolution* 10(10):430.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese, and F. Torres. 1998. Fishing Down Marine Food Webs. *Science* 279(5352):860–863.

Pinheiro, J., and D. Bates. 2000. *Mixed Effects Models in S and S-Plus*. Springer, New York.

Pinkerton, E. W. 1994. Local Fisheries Co-management: A Review of International Experiences and Their Implications for Salmon Management in British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 51(10):2363–2378.

Pitcher, T. J. 2004. Back to the Future: Advances in Methodology for Modelling and Evaluating Past Ecosystems as Future Policy Goals. *Fisheries Centre University of British Columbia* 12(1).

Platt, J. 1973. Social traps. *American Psychologist* 28(8):641–651.

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.

Pollnac, R., P. Christie, J. E. Cinner, T. Dalton, T. M. Daw, G. E. Forrester, N. a J. Graham, and T. R. McClanahan. 2010. Marine reserves as linked social-ecological systems. *Proceedings of the National Academy of Sciences of the United States of America* 107(43):18262–18265.

Posey, D. A. 1985. Indigenous management of tropical forest ecosystems: the case of the Kayapo Indians of the Brazilian Amazon. *Agroforestry Systems* 3:139–158.

Price, K., A. Roburn, and A. MacKinnon. 2009. Ecosystem-based management in the Great Bear Rainforest. *Forest Ecology and Management* 258(4):495–503.

Royal Commission on Aboriginal Peoples. 1996. *Report of the Royal commission on aboriginal*

peoples, perspectives and realities, Vol.4. Ottawa.

Service, C. N., M. S. Adams, K. a. Artelle, P. Paquet, L. V. Grant, and C. T. Darimont. 2014. Indigenous knowledge and science unite to reveal spatial and temporal dimensions of distributional shift in wildlife of conservation concern. *PLoS ONE* 9(7):e101595.

Short, D. 2003. Reconciliation, Assimilation, and the Indigenous Peoples of Australia. *International Political Science Review* 24(4):491–513.

Smith, D., C. Varcoe, and N. Edwards. 2005. Turning around the intergenerational impact of residential schools on Aboriginal People : Implications for health policy and practice. *Canadian Journal of Nursing Research* 37:38–60.

Smith, L. T. 1999. *Decolonizing Methodologies: Research and Indigenous Peoples*. Page *Social Policy Journal of New Zealand*. Zed Books, London.

Snively, G., and J. Corsiglia. 1997. Knowing home: NisGa'a traditional knowledge and wisdom improve environmental decision making. *Alternatives Journal* 23(3):22–27.

Steneck, R. 2009. Marine Conservation: Moving Beyond Malthus. *Current Biology* 19(3):117–119.

Steneck, R. S., T. P. Hughes, J. E. Cinner, W. N. Adger, S. N. Arnold, F. Berkes, S. A. Boudreau, K. Brown, C. Folke, L. Gunderson, P. Olsson, M. Scheffer, E. Stephenson, B. Walker, J. Wilson, and B. Worm. 2011. Creation of a gilded trap by the high economic value of the Maine lobster fishery. *Conservation Biology* 25(5):904–912.

Swetnam, T. W., C. D. Allen, and J. L. Betancourt. 1999. Applied historical ecology : Using the past to manage for the future. *Ecological Applications* 9(4):1189–1206.

Szabó, P. 2015. Historical ecology: Past, present and future. *Biological Reviews* 90(4):997–1014.

Thornton, T., D. Deur, and H. Kitka. 2015. Cultivation of salmon and other marine resources on the Northwest Coast of North America. *Human Ecology* 43(2):189–199.

Thornton, T. F., M. L. Moss, V. L. Butler, J. Hebert, and F. Funk. 2010. Local and Traditional Knowledge and the Historical Ecology of Pacific Herring in Alaska. *Journal of Ecological Anthropology* 14:81–88.

Thornton, T. F., and A. M. Scheer. 2012. Collaborative engagement of local and traditional knowledge and science in marine environments. *Ecology and Society* 17(3).

Thurstan, R. H., S. M. Buckley, J. C. Ortiz, and J. M. Pandolfi. 2016. Setting the Record Straight: Assessing the Reliability of Retrospective Accounts of Change. *Conservation Letters* 9(2):98–105.

Turner, N., D. Deur, and D. Lepofsky. 2013a. Plant management systems of british columbia's first peoples. *BC Studies* 179:107.

Turner, N. J. 2003. The ethnobotany of edible seaweed (Porphyra abbottae and related species; Rhodophyta: Bangiales) and its use by First Nations on the Pacific Coast of Canada. *Canadian Journal of Botany* 81(4):283–293.

Turner, N. J. 2014. *Ancient Pathways, Ancestral Knowledge: Ethnobotany and Ecological Wisdom of Indigenous Peoples of Northwestern North America*. McGill Queen's University Press, Montreal, QC.

Turner, N. J., and R. E. Atleo. 1998. *Pacific North American First Peoples and the Environment*. Page *Environment and development values in the pacific*. Center for Studies in Religion and Society, State University of New York, Albany, NY.

Turner, N. J., and F. Berkes. 2006. Coming to understanding: Developing conservation through incremental learning in the Pacific Northwest. *Human Ecology* 34:495–513.

Turner, N. J., F. Berkes, J. Stephenson, and J. Dick. 2013b. Blundering Intruders: Extraneous Impacts on Two Indigenous Food Systems. *Human Ecology* 41(4):563–574.

Turner, N. J., R. Gregory, C. Brooks, L. Failing, and T. Satterfield. 2008. From invisibility to transparency: Identifying the implications. *Ecology and Society* 13(2).

Turner, N. J., M. B. Ignace, and R. Ignace. 2000. Traditional ecological knowledge and wisdom of Aboriginal Peoples in British Columbia. *Ecological Applications* 10(5):1275–1287.

Turner, N. J., M. Plotkin, and H. V. V. Kuhnlein. 2013c. *Indigenous Peoples' Food Systems & Well-being: Interventions & Policies for Healthy Communitiesdigenous*. Food and Agricultural Organization, Montreal, QC and Rome, Italy.

Turner, N. J., and K. L. Turner. 2008. "Where our women used to get the food": cumulative effects and loss of ethnobotanical knowledge and practice; case study from coastal British Columbia. *Botany* 86(2):103–115.

Turner, N., and P. R. Spalding. 2013. " We might go back to this "; Drawing on the past to meet the future in northwestern North American Indigenous communities. *Ecology and Society* 18(4):29.

United Nations Declaration. 2008. United Nations Declaration on the Rights of Indigenous Peoples. *United Nations General Assembly*(Resolution 61/295):10.

Valbo-Jørgensen, J., and A. F. Poulsen. 2000. Using Local Knowledge as a Research Tool in the Study of River Fish Biology: Experiences from the Mekong. *Environment, Developement and Sustainability* 2(3):253–376.

Veblen, T. T., and D. C. Lorenz. 1986. Anthropogenic disturbance and recovery patterns in montane forests, Colorado front range. *Physical Geography* 7(1):1–24.

Worm, B., E. B. Barbier, N. Beaumont, J. E. Duffy, C. Folke, B. S. Halpern, J. B. C. Jackson, H. K. Lotze, F. Micheli, S. R. Palumbi, E. Sala, K. A. Selkoe, J. J. Stachowicz, and R. Watson. 2006. Impacts of Biodiversity Loss on Ocean Ecosystem Services. *Science* 787(2006):787–790.

Worm, B., R. Hilborn, J. K. Baum, T. a Branch, J. S. Collie, C. Costello, M. J. Fogarty, E. Fulton, J. Hutchings, S. Jennings, O. P. Jensen, H. K. Lotze, P. M. Mace, T. R. McClanahan, C. Minto, S. R. Palumbi, A. M. Parma, D. Ricard, A. Rosenberg, R. Watson, and D. Zeller. 2009. Rebuilding global fisheries. *Science* 325:578–585.

Yamanaka, K. L., and G. Logan. 2010. Developing British Columbia's inshore rockfish conservation strategy. *Marine and Coastal Fisheries* 2(1):28–46.

Appendix A: Interview Questionnaire

Interview Protocol for Experienced Fishers/Elders

Geographical sampling to be used:

- Interview experienced fishermen and women from each of the Four Nations in the Central Coast
- Utilize a snowball sampling method within each community; ask interviewees if they are willing/able to direct us to experienced fishers/ food preparers (long history of experience in rockfish harvest, 20-30 years)
- Talk with local resource departments and other knowledgeable individuals (if applicable) for additional fisheries information

First Communication

Initial communication will be made through flyers, letters of invitation, community presentation, reference by community stewardship offices, the community liaison, and/or other key contacts (e.g., CCIRA Conservation Ecologist Alejandro Frid).

If applicable, the **online/phone introduction** will follow as (example given for Lauren Eckert):

Hi. My name is Lauren Eckert. I'm a researcher at the University of Victoria working to learn more about rockfish on the Central Coast and assist the Central Coast Nations in marine use planning and fishery management. My project seeks to extend data on rockfish and lingcod by speaking with experienced fishermen such as yourself. You have been recommended as someone with important knowledge and a long history of involvement in local fisheries. If you are willing, I am interested in interviewing you. In an interview, we would record your fishing history by asking about vessels, gear, fishing locations, and changes you've observed in rockfish and lingcod size, abundance, and habitats over your career as a harvester/ person engaged in food preparation. The interview will take approximately 2-3 hours to complete. Participation is voluntary and, should you agree to participate, you will be free to refuse to answer particular questions and to withdraw from the study at any time. There is a financial honorarium of $25/hr offered to all participants.

Interview

Ethics:

- Thoroughly review the consent form in its entirety. Ask if they would like someone to go over the form with them. If they indicate yes, and there is a third party present, have them read it. If there is no third party present then read the form out to them carefully pausing frequently to ensure that they have understood each section. Leave plenty of room for questions and concerns.

- Explain that participation in the interview is **completely voluntary**, that it will be taped with their permission but that they can turn off the tape at any time. They will decide what happens to the tape, typed transcript, and additional information from the interview. The transcript will be reviewed with participants.
- Ask participants to sign in appropriate places and check off appropriate selections if photos/video will be taken. Signature indicates that he/she understands what the research is about, understands that it is completely voluntary, and consents to being interviewed. Leave a copy of signed consent form with the interviewee.

Basic Demographic Information

For this first part of the interview, we will ask some general background questions about where you are from and where you grew up.

1) Where were you born? _____
2) Where currently living? _____
3) For how long? _____
4) What do you do for a living? _____
5) *What First Nation and clan are you part of? _____
6) *Year Born _____
7) *Gender M _____ F _____

Fishing Experience

In the next part of the interview, we will ask you some questions about your experience with fishing for rockfish and lingcod—where you have fished, for how long, etc. and about who you have fished with.

8.) How many generations has your family been involved in fishing? _____

9.) Always based in this community? Yes _____ No _____ If no, explain:
_____

10.) Age when you started fishing _____

11.) What was your motivation to start fishing? _____

12.) What type of fishing have you been involved in?

__ food __ commercial __ recreational (guiding)

13.) General areas where you have fished? _____

14.) Are you still fishing? _____ In what capacity?_____

15.) (If no longer fishing) Last season fished _____

16.) Total years fishing _____

17.) Who did you fish with when you started? _____

18.) Who taught you how to fish? _____

19.) Have you taught anyone to fish? _____

Vessel-Based Questions

This section of the interview will ask you about vessels you have fished on throughout your life where rockfish and/or lingcod have been target or by-catch species. We will then use the vessels you list as a guide for recalling your fishing history and your experiences. We will begin by asking basic questions about vessels and their characteristics, and then talk about the fishing activity that occurred on each vessel.

	Vessel 1	**Vessel 2**	**Vessel 3**	**Vessel 4**
Name?				
Years fished				
Ownership				
Type of Boat				
Vessel Description: • Tonnage • Length/width/depth • Material • Engine Type (hpower) Gas/Diesel				
Navigation Equipment (i.e. fish finder, sound signalling devices, magnetic compass)				
Species Fished (target)				
Bycatch (if rockfish/lingcod)				
*Licenses/Permits Held				
Crew Size/Composition				

Role on vessel (i.e. crew. Captain, etc.)				
Other/Notes				

We now will ask you questions about your general experiences on each vessel, and ask about noteworthy changes or fishing events you experienced while you were fishing on each vessel. When discussing rockfish species or size, I will provide photographs and sized cut-outs to participants.

- During the time you fished with this vessel, do you recall especially unusual changes or periods of change, or was your time on the vessel run-of-the-mill? (if the latter, ask for clarification and ask the questions below separately for each period; if all the same and a vessel was used for more than 10 years, ask questions by decade)
- When fishing with this vessel, what gear did you typically use for rockfish?
    - Type; how set
    - Amount: (e.g., # of hooks)
    - Size: e.g., mesh size, length of longlines
    - Bait Type
    - **Depth (important for age structure correlations)**
    - What size(s) of rockfish and lingcod were you targeting?
- Roughly when would your fishing season start (in terms of months)? When would it end?
    - Why would it start/end then?
- What was your catch like (with that gear, that vessel)?
    - Average Haul (or day or season – be explicit about unit for transcript)
    - Good
    - Poor Catches
    - What would be considered a good season?
    - Did catches change over course of season, i.e. tend to go down? Up? Cause? Did size change over the season?

- What rockfish species / lingcod did you target/commonly catch? **(show photos)**

Location

The next set of questions will ask about <u>where</u> you fished with this vessel for rockfish and lingcod (exclude these questions if interviewing women who did not go fishing, but who have experience preparing the catches):

- Where did you fish for rockfish and lingcod with this vessel? (Location of grounds; **use area-specific charts; focus on Central Coast only)**
    - Place name of the area, if applicable
    - Characteristics of location (depth, vegetation, prevailing winds, etc.)
    - Which species did you catch most often in that location?

- Were there places where you weren't allowed to fish for rockfish, or where you had to get permission to fish? Other than restrictions imposed externally (i.e., from DFO), what restrictions (if any) surround(ed) rockfish harvest (i.e. size, season, area etc)? *potential erosion of traditional restrictions

Size and abundance

<u>Potential Species</u>

Yelloweye
Quillback
Canary
Silvergray
Vermillion
Tiger
Yellowtail
China
Black
Copper
*Greenling
*Lingcod
*Halibut

After going through the list, ask:

- Are there any other species that we haven't asked about that they'd like to tell us about?

The next set of questions will ask about all the species mentioned above, in turn, if they were identified as fished.

For _____ species, for each vessel:

- What was the average size of fish of that species that you caught? (bring general size cut-outs)
- What was the typical range of sizes?
- What was the maximum size fish you caught? Where did you catch it? (indicate location on map)
- How abundant were they? (e.g., was it easy to get the catch that you wanted?)
- What size(s) were you targeting?

Changes over time

The next questions will ask you about your experiences with and perceptions of rockfish and lingcod in general over your lifetime of fishing experiences.

Changes in Fish and Fisheries over your Careers (Catch per Unit Effort):

Where and why have you changed location/depth where you fished for rockfish and lingcod over time?

Have changes in rules and regulations (local/DFO) played a major role in your fishing strategies and experiences?

What changes, if any, have you noticed since the implementation of Rockfish Conservation Areas (2007)?

Are there any important consequences for ocean habitats of different types of fishing gear (i.e. trawl nets used by other fisheries, etc.)

These next questions are about rockfish and lingcod and their environments in general, to determine fish and ecosystem changes.

Over your time fishing for rockfish/lingcod, have you noticed any ecological changes?

Have you noted changes in rockfish/lingcod predator populations or behaviors that you attribute to changing rockfish/lingcod populations (see below for example, predator expansion questions)?*

Have you noted changes in rockfish/lingcod prey populations that you attribute to changing rockfish/lingcod populations?

In your experience on the coast, what are the most obvious physical changes you have witnessed to coastal systems (i.e. tidal patterns, precipitation changes, temperature changes, extreme weather events, etc.)?

Do you believe there are strong indicators of climate change occurring in your area?

What might be the consequences (ecological, economic, etc) of depleted rockfish/lingcod populations?

If you have noted changes in predator activities:

- Identify the predators (fish, seals/sea lions, etc)
- Was/Is there an active hunt to manage the predator?
- Are any rockfish/lingcod predators competing with human populations for rockfish?
- Have predator population numbers notably changed?
- Has predator behavior notably changed?
- What are rockfish/lingcod predators eating (instead of rockfish/lingcod)?

Cultural Rockfish/Lingcod Information:

Stewardship

- What traditional methods (if any) were used to avoid depleting rockfish/lingcod populations? Are any still used?
- Other than restrictions imposed externally (i.e., from DFO), what restrictions (if any) surround(ed) rockfish/lingcod harvest (i.e. size, season, area etc)?
- How/ do you handle the death of captured fishes (barotrauma)?

Stories and art

- Do you know about any stories/folklore surrounding rockfish/lingcod? Are you willing to share some?*
- Are there specific words in your language for rockfish? Specific species? Their habitats or fishing gear?
- Were or are there ceremonial procedures/considerations involved in catching rockfish/lingcod?
- Are rockfish/lingcod included in any local ceremonies?
- Are rockfish/lingcod portrayed in local art?

Final Questions

- Do you have any photos to share of rockfish or their habitats?
- What, in your view, are the factors that most put rockfish/lingcod at risk in this area?
- Do you have any recommendations you would like to make regarding changes in fisheries science related to rockfish/lingcod? Fisheries management?
- Do you feel it is a worthwhile effort to conserve rockfish/lingcod? Do you think it is necessary?

- How did you feel about today's interview (specifically vessel-based questions)? Do you have any ideas to improve the process or questions?
- Is there anything else you would like to tell us, or feedback you would like to offer?

Post interview things to do:

- Make sure the tapes are labelled with place, date, interviewer initials, interview number
- Pay and thank interviewees, retain receipts
- Label maps with interviewee information; take photos of maps as back-up
- Ensure that notes and any other sheets are labelled