Identifying stakeholders' values and preferences for management of Pacific herring (*Clupea pallasii*) in British Columbia, Canada

by

Jeffrey Scott

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Abstract

It is said that fisheries management is concerned with managing people, rather than fish. Often managers must make difficult decisions under conditions of uncertain scientific predictions, conflicting demands from stakeholder groups, or high risk of harm to the resource and/or its users. Previous publications have applied decision theory and management theory to fisheries management, but such approaches may not acknowledge the legitimacy of all competing viewpoints and values. Post-normal science, on the other hand, does so explicitly, and aims to resolve conflicts through collaborative effort based on high-quality information. This thesis explores the issues surrounding political conflicts over Pacific herring (*Clupea pallasii*) fisheries management in British Columbia, Canada in the 2010s, with a focus on the herring stocks in Haida Gwaii waters. These fisheries offer a unique yet generalizable case of stakeholder conflict, and an opportunity to examine that conflict's root causes through my own original framework that parses normative from descriptive claims made by competing groups, to ascertain what those groups consider quality information and desired outcomes. I present here research conducted by an interdisciplinary team between 2015 and 2017 as part of a larger project, which employed a novel value- and ecosystem-based management approach methodology developed by Lam et al. to investigate the normative values, descriptive beliefs and fishery management preferences of 47 individuals in Haida Gwaii and 28 British Columbian herring fishery participants. The semi-structured interviews within the values-based component consisted of values-ranking and management scenario-preference exercises, an exercise associating respondents' values with management scenarios, and open-ended questions on respondents' experience and beliefs about herring and its fisheries. Analysis tabulated respondents' value priorities and scenario preferences, and investigated descriptive beliefs about herring stocks. Results provide evidence that stakeholder groups' nominal values are quite similar, while their preferences for management of herring stocks in Haida Gwaii are starkly different, and potentially influenced by level of trust in the opposing group and in management. This suggests that trust-building between opposing stakeholder groups, and between management and stakeholders, is a necessary first step toward conflict resolution.

Lay Summary

This research attempts to describe and analyze the recent conflict over Pacific herring (*Clupea palassi*) fisheries in Haida Gwaii (HG), British Columbia (BC), Canada. It utilizes data from interviews conducted as part of a larger project with 47 residents of HG and 28 commercial herring fishery participants from outside HG to investigate respondents' personal values, perceptions of HG herring fisheries, and preferences for management of those fisheries. HG residents and commercial fishery participants seem to hold the same values, but differ strongly in their preferences for management. From respondents' comments, I argue that these differences stem from divergent perceptions of the causes of historically low herring populations, from opposing beliefs regarding the appropriate objectives of management, and from lack of trust in the other group and in the current management authority. I suggest the conflict could be better approached by explicitly acknowledging the legitimacy of competing groups' values and worldviews.

Preface

The research described in this thesis occurred as part of a number of other projects and initiatives, most notably the Peter Wall Institute for Advanced Studies (PWIAS) Solutions Initiative: *Collaborative Solutions for Haida Gwaii Herring Fisheries*, led by Mimi E Lam (MEL), Tony J Pitcher (TJP), and Evgeny A Pakhomov (EAP) from 2014 to 2016, and the NSERC Strategic Partnership Grant *Understanding the Ecosystem Role of Pacific Herring in Coupled Social-ecological Systems: Advancing Forage Fish Science*, led by TJP from 2013 to 2017. Other initiatives included the PWIAS Arts-based Initiative: *Herring People* (PIs: MEL, TJP, and EAP; 2016), which presented initial results of this work to the public in Vancouver, BC, Canada; PWIAS International Research Roundtables: *The Ethical Challenges of the Herring Food Web and Value Chains* (PIs: MEL, TJP, EAP, Matthias Kaiser (MK); 2016), which convened multi-disciplinary experts in Vancouver, BC and fostered discussions which influenced the theoretical direction of this work; PWIAS International Research Collaboration: *Negotiating and Assessing Value and Ethical Issues in Fisheries Management* (PI: MEL and EAP; 2017), which similarly influenced this work's theory. The Mitacs Accelerate Program: *Identifying Stakeholders' Values in British Columbia's Pacific Herring Fishery* (PI: MEL; 2017), directly funded my contribution to fieldwork, analysis and writing of this thesis.

The concept and methodology of the PWIAS Solutions Initiative, and of the work herein, are the primary product of Dr. Lam and are fully described in a manuscript co-authored by MEL, TJP, Szymon Surma (SS), Jeffrey Scott (me), Lawrence Ward (LW), April SGaana Jaad White (AW), Kate Millar (KM), EAP, and MK that was submitted for publication near the time of my defence and listed in Works Cited. I made contributions, with MEL, MK, KM and Sahir Advani, to the formulation of the Western values and helped to adapt the script used in interviews from the workshop designed by ML, MK, KM, and TJP. I participated in 12 of 47 interviews with Haida Gwaii residents, led by MEL, for training purposes and subsequently served as sole interviewer for 27 of 28 herring industry interviews. Artwork used in the interviews (see Appendix C) was introduced into the methodology by Drs. Lam and Pitcher collaborating with Haida artist and scientist AW through the Solutions Initiative and other PWIAS projects cited above.

I was responsible for the processing of all interview audio files and transcripts, and for all data extraction from transcripts. This data was used and independently analyzed for the manuscript mentioned above. I conducted all analyses presented herein, under the guidance of MEL and TJP, and with input from MK and LW, leading to the results presented in this thesis. Research questions 1 and 2 (Sections 1.4.1 and 1.4.2) were developed by Dr. Lam, with input from Drs. Kaiser and Pitcher. The descriptive vs normative claim framework (Section 1.2.4) and research questions 3 and 4 (Sections 1.4.3 and 1.4.4) presented in

Chapter 1 are my own, as are the interpretations of results (Section 4.1) and suggestions for application to BC herring fisheries management (Section 4.3) and fisheries management elsewhere (Section 4.4). The entirety of this thesis was written by me, and edited and approved by my supervisors.

The fieldwork with herring industry respondents I conducted for this thesis was approved by UBC's Behavioural Research Ethics Board, under ethics certificate # H14-03320.

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Dr. Matthias Kaiser embodies that interdisciplinarity and has contributed much insight to the concept of this project and my interpretations of its results; his generosity in hosting me at workshops at the Altonäer Stiftung für philosophische Grundlagenforschung in Hamburg, in 2015 and 2017, exposed me to many new ideas regarding the role of science in society, and helped refine many of the questions I explore herein. He and Dr. Lawrence Ward have been wonderful resources as members of my supervisory committee, guiding my research and continually offering constructive advice along the way.

Dr. Terre Satterfield's course, "Science, Policy and Values in Risk and Resource Management Contexts," was highly influential in the development of my work. Many of the ideas I present derive from her well-curated readings and challenging assignments; her personal guidance and professionality have also been invaluable.

This work received funding from the NSERC Discovery Grant, "The dynamics and restoration ecology of marine ecosystems," through the Peter Wall Institute Solutions Initiative "Collaborative Solutions for Haida Gwaii herring fisheries," and through a Mitacs Accelerate internship co-sponsored by the T. Buck Suzuki Environmental Foundation and Skipper Otto's Community Supported Fishery. Many thanks to Jim McIsaac at T. Buck Suzuki for his input and extension of opportunities such as the Young Fishermen's Gathering of 2017 in Victoria, BC; many thanks to Shaun and Sonia Strobel and Chris Kantowicz at Skipper Otto's for the many and varied opportunities (and seafood) they made possible.

Most importantly, thanks are owed my parents, who have seen less of me these past three years than they (or I) would prefer. Their love and encouragement got me to where I am today, and continue to help move me forward.

And finally, this work would not exist without the participation of 47 residents of Haida Gwaii and 28 members of the herring industry in BC. Thanks to Greg Thomas of the Herring Conservation and Research Society for his generous logistical support in locating participants, and for the invitation to attend the Herring Industry Advisory Board's post-season meeting in May 2017. Thanks also to retired fisherman Joe Bauer for his help in finding interviewees, and for sharing his years of wisdom with me on many occasions. And thank you to everyone who sat down with me to share your personal values, beliefs, preferences and stories. I hope this work can be of some value to you.

1 Introduction

It is often said that fisheries management is about managing people, rather than fish (Hilborn 2007). Often managers must make difficult decisions under conditions of uncertain scientific predictions, conflicting demands from stakeholder groups, or high risk of harm to the resource and/or its users (Lam 2012). Decision theory (McDaniels et al. 2003) and management theory (e.g., Walters 1986, Walters and Martell 2004) applied to fisheries management do not account for the interplay between stakeholders' descriptive and normative beliefs revealed by social and cognitive psychology. Identity-protective cognition, biased assimilation and other social cognitive biases (Kahan 2010) may complicate prescribed methods of conflict resolution by inhibiting consensus amongst all parties.

This thesis is structured in four chapters, beginning with an introduction in Chapter 1 to the issues surrounding political conflicts over Pacific herring (*Clupea pallasii*) fisheries management in British Columbia (BC), Canada in the 2010s, with a focus on the herring stocks in Haida Gwaii waters. These fisheries offer a unique yet generalizable case of stakeholder conflict, and an opportunity to examine that conflict's root causes through a framework that parses normative from descriptive claims made by competing groups. I present here research conducted between 2015 and 2017 that employed a novel methodology (Lam et al. *submitted*) to investigate the normative values, descriptive beliefs and fishery management preferences of 47 individuals in Haida Gwaii and 28 BC herring fishery participants. The research was part of and/or presented in six funded projects and initiatives led by Drs. Mimi Lam, Tony Pitcher and Evgeny Pakhomov (see Preface for details). The second chapter outlines the methods used in this study while the third presents the results of analysis. The final chapter discusses those results and their implications for herring management in BC, and offers conclusions from the research presented here.

This introductory chapter begins with a brief description of recent conflicts over management of Pacific herring in BC (for a comprehensive overview of Pacific herring fisheries in BC, see Appendix A). I next introduce the paradigm of Post-Normal Science (Funtowicz and Ravetz 1993), and then offer an analytical framework for parsing descriptive from normative claims in the controversy, discussing the benefits and complications of categorizing fisheries disagreements on that basis. I conclude by stating the objectives of this study.

1.1 Background: Recent conflicts over herring fisheries

1.1.1 Roe herring fishery in 2014

The closures of roe herring fisheries on Haida Gwaii (HG), West Coast Vancouver Island (WCVI) and Central Coast (CC) herring stocks in 2003, 2007 and 2008, respectively, meant steep declines in commercial value, but allowed stocks to rebuild by 2013 past the 25% biomass cutoff threshold Fisheries and Oceans Canada (DFO; see Appendix A) has established as a prerequisite for opening a commercial fishery (DFO 2014). However, DFO managers in 2014 recommended that the stocks concerned remain closed to fishing that year as a precautionary measure and to avoid conflict with First Nations who opposed such an opening (DFO 2014). Former Fisheries Minister Gail Shea did not concur, and instead ordered commercial openings for 2014, at a 10% harvest rate (DFO 2014). A federal court sided with five nations of the Nuu-chah-nulth to issue an injunction against the Minister and close commercial fishing of the WCVI stock that year (Secher 2014a). Separately, the commercial fleet chose to abstain from fishing in waters around Heiltsuk and Haida traditional territories, avoiding potential conflict on the water. Commercial fishers and First Nations alike agreed that DFO failed to adequately consult First Nations before making decisions, and expected improved consultation for the following year (Secher 2014b).

1.1.2 Roe herring fishery in 2015

However, a similar conflict arose in 2015. Again, based upon herring stock model results indicating biomasses above cutoff thresholds, Minister Shea ordered all major herring stocks open to fishing, and again met with strong resistance from First Nations. This time, the Haida Nation sought and won a federal court injunction halting the fishery around Haida Gwaii (Jones et al. 2017). In his decision, the federal judge issuing the injunction found compelling evidence of the potential for irreparable harm to the HG herring stock from a commercial fishery, as well as a "heightened duty for DFO and the Minister to accommodate the Haida Nation in negotiating and determining the roe herring fishery in Haida Gwaii," due to pre-existing commitments and agreements between the federal government and the Haida Nation (Council of the Haida Nation et al. v. Minister of Fisheries and Oceans 2015). Central among these commitments was the Gwaii Haanas Agreement (see Section A.4.4).

Meanwhile, Heiltsuk members occupied DFO administrative buildings to protest fishing in their area, prompting the closure of the CC fishery after some fishing had taken place (Hume 2015). The Nuu-chah-nulth also sought a court injunction against the Minister but failed, as the same federal judge who ruled in favour of the Haida declined to accept their argument for irreparable harm (Jones et al. 2017). As in

2014, First Nations expressed frustration with DFO's decision-making process, calling for further consultation and a review of the science behind their decisions (Hume 2015).

1.1.3 Roe herring fishery in 2016

In 2016 DFO managers deferred to forecasts from the Historical Management Procedure (i.e., AM1) to set harvest rules for contested areas, and closed the HG and WCVI stocks due to biomass forecasts below the harvest cutoff threshold. CC stocks were forecasted above the threshold, and DFO negotiated with the Heiltsuk a 7% harvest rate for roe and spawn-on-kelp (SOK) fishing that year (DFO 2015). Jones et al. (2017) describe the management process for 2016 as a departure from previous years', featuring greater collaboration on scientific advice (such as the Herring Technical Working Group (HTWG); see Section A.4.3.1) and a progression from coast-wide, top-down decision-making towards local co-management of stocks.

1.1.4 Roe herring fishery in 2017

Roe fisheries were closed again in 2017 for HG and WCVI stocks. Area 2W in Haida Gwaii was available for SOK operations but was not fished. Negotiations between the Heiltsuk and DFO centered on the Heiltsuk's concern over potential impacts of an oil spill that occurred near Bella Bella in 2016 (Hume 2016). The result was a precautionary quota of 215 tons, available only to seine license holders. Shortly prior to the season, the Kitasoo/Xai'xais Nation of the Central Coast released their own Management Plan for Pacific Herring, which excluded all commercial roe fishing from waters in their territory and set biomass cutoff thresholds for commercial SOK within designated areas, available only to members of the Nation (Kitasoo/Xai'xais 2017). As a result of the small quota allocation, and perhaps of the Kitasoo/Xai'xais Management Plan, no fishing occurred in CC stock during the 2017 season (DFO 2017a).

1.2 The herring conflict: Parsing the issues

1.2.1 The Pacific Herring Summit

The conflict in recent years over herring management in BC reflects a number of issues surrounding the science and management of the resource, and has fostered many efforts to identify and resolve those issues. In June 2015, the Ocean Modelling Forum, a forage fish research network, organized a Pacific Herring Summit in Richmond, BC, gathering researchers from DFO, the United States' National Marine Fisheries Service (NMFS), US state agencies and academia, as well as representatives of environmental non-governmental organizations (ENGOs), BC Coastal First Nations, Alaska Native groups, and the BC fishing industry. The two-day event discussed the cultural, economic and ecological issues of herring

management; Levin et al. (2016) compiled from these discussions a list of 32 questions regarding the ecological, socio-economic, political and institutional aspects of Pacific herring and its fisheries (see Appendix B). These questions are conspicuously phrased as descriptive queries, seeking objective answers to avoid discussion of controversial normative issues. Many of the queries do not specify, however, whether the answers sought are subjective and normative or objective and descriptive. For instance, "What is the relationship between Herring [sic] fisheries and broader issues of indigenous rights?" (Question 3) requires one of two answers: 1) a subjective, normative statement informed by the epistemic beliefs and held values of the respondent (e.g.: "Herring fisheries relate to broader issues of Indigenous rights as a symbol of past and continuing injustices committed by the government of Canada"), or 2) a non-partisan, descriptive statement describing the perceptions held by different groups of stakeholders (i.e.: "First Nations believe the relationship is *X*, while non-First Nations herring fishers believe it is *Y*"). In the latter case, each perception described is necessarily informed by both the epistemic beliefs and held values of each group; the answer is a descriptive statement describing the normative statements of others. This descriptive statement is more useful for decision-makers than the alternative, normative one, as it provides objective evidence for a decision maker to consider. It also explicitly separates the value judgements of stakeholders from the speaker's (assuming the speaker does not appear to favour any one of the viewpoints described).

It seems clear that Levin et al. (2016) intend their more politically loaded questions to be answered in the descriptive manner above, as they explicitly refrain from prioritizing questions and frame their paper and the Summit as exercises in fact-gathering rather than decision-making. While this is a valid approach, it is incomplete in that Levin et al. (2016) miss an opportunity to clarify which of the issues raised by participants revolve around descriptive aspects of the resource and which are normative. Because value judgements are inevitable in fisheries management, normative statements must arise at multiple points of the decision-making process, whether in setting objectives, establishing criteria for meeting objectives, assessing the quality of descriptive evidence, or evaluating the evidence's performance against criteria. The approach taken by Levin et al. (2016) avoids explicit discussion of these considerations, and therefore fails to differentiate between, for example, uncertainty over the ecological role of herring (Questions 18-28), which is a descriptive issue, and disagreements over the distribution of fishery benefits (indirectly addressed by Question 30), which are normative in nature. Again, this approach is not faulty, as the authors clearly identify missing data needed to settle these debates over the management of herring fisheries. I argue, though, that it is inadequate, because, in

constructing their 32 questions, they deliberately avoid discussion of what those debates revolve around.

1.2.2 Descriptive vs normative claims in BC's herring conflict

In published accounts of the herring conflicts in BC, normative and descriptive issues are frequently left implicit, or conflated with one another. Consider the two quotes below:

> *"The First Nations … say there isn't enough fish and that any commercial roe herring fishery will negatively impact their [native] fishery […] The industry view is there's a lot of science behind the current stock assessment and that that science has indicated there is a reasonable return of herring on the central coast – and certainly a fishable abundance" Hume (2015).*

> *"We are saddened that it has come to this, but we cannot stand by while DFO uses flawed science to destroy a resource we have depended on for thousands of years" Canadian Press (2015).*

The first quote is from a BC herring industry representative and printed in the *Globe and Mail*, a Canadian newspaper, shortly before the roe fishery opened in 2015. The second quote is from a representative of the Heiltsuk Nation, quoted in a different *Globe and Mail* article in the same month. Both speakers make normative claims in their statements- the first implies that the science used to assess herring stocks is reliable, while the second speaker explicitly distrusts the science of DFO. The two speakers do not agree on the validity of the descriptive evidence DFO presented in its 2014/15 Integrated Fishery Management Plan (IFMP), indicating a divergence in their (value-laden) assessments of the stock assessment process.

Furthermore, the first speaker believes the amount of herring present on the Central Coast is "fishable," as indicated by science. Regardless of the actual state of herring stocks that year, however, science itself cannot indicate "fishability." The speaker is expressing a value judgement, shared by the drafters of DFO's herring management rules, that herring stocks above the pre-established biomass cutoff threshold (here, 25% of unfished equilibrium biomass (B_0)) may be fished without unacceptable risk of undesirable outcomes. By making a common but inappropriate appeal to science for justification of a normative judgement (Dietz 2013, Weinberg 1972), he is conflating the descriptive issues surrounding stock assessment of herring with the normative ones surrounding acceptable risk and desirability of

outcomes. This conflation, prevalent when discussing the BC herring conflict, hinders effective debate, as it leads to confusion over whether disagreement is over the *actual* or *ideal* state of the fisheries.

1.2.3 Post-Normal Science and the role of values

These disputes are full of uncertainty, value loading, multiple legitimate perspectives and high stakes— precisely the criteria used by Funtowicz and Ravetz (1993, 2003) to identify situations in which traditional concepts of how science should operate will prove ineffective, and where their paradigm of post-normal science (PNS) becomes applicable. PNS explicitly acknowledges the plurality of legitimate perspectives in any public (democratic) debate; it focuses not on unilateral discovery of an objective Truth, but on mutual dialogue with and respect for competing epistemologies. The goal of PNS is to find solutions based upon information determined to be of high quality— however quality may be defined by the interested parties (cf. Bradbury 1989).

In the public dialogue surrounding BC's herring conflict, the lack of this approach is glaring (but see Lam 2016, Lam et al. *submitted*). The quote from the industry representative featured in Section 1.2.2 attempts to cast normative issues as purely descriptive— DFO science is the only legitimate source of knowledge, and values are not present in decision-making. Were all parties instead to explicate the normative influences present in their management preferences, rhetoric could evolve past the invocation of science as a moral agent and address the value-laden issues that presumably underlie much of the conflict.

1.2.4 A framework for analyzing issues in BC's herring conflict

One aim of the PWIAS Solutions Initiative (see Preface) was to elicit the values of stakeholders and community members to provide guidance to management regarding the appropriateness of policy alternatives (Lam et al. *submitted*); this practical ethics approach (Kaiser 2006) fits within PNS as a means of describing the (normative) ethical concerns of the public whose interests are affected by policy decisions (Lam and Pauly 2010). This thesis follows the theoretical path set in its parent project. In this introduction, I've so far attempted to describe the published debate over the issues of BC's Pacific herring fisheries. Acknowledging the comprehensive set of questions compiled by Levin et al. (2016; Appendix B), and having argued against an approach that leaves normative considerations unconsidered, implicit, or conflated with descriptive ones, I opt to summarize and categorize the issues of herring management differently. I identify six broad areas of contention between stakeholder groups, DFO and outside experts, differentiated as three descriptive and three normative issues. This framework for analyzing the herring conflict recognizes the benefits of a PNS approach and offers an

explicit and clear distinction between two wholly different types of argument, one over the *actual* state of the fisheries and one over the *ideal* or *ethical* state. I summarize the issues below.

1.2.4.1 Descriptive issues in BC's herring conflict

1.2.4.1.1 Stock assessment

The greatest controversy over DFO's assessment of BC's five major and two minor herring stocks surrounds the methods by which their model's equilibrium unfished biomass (B_0; Surma *in review*), and spawn survey index parameters (Jones et al. 2017) are estimated, as these strongly influence estimates of spawning biomass (B_t). Critics claim the switch in 2011 to a method (AM2) which updates these estimates each year (Martell et al. 2011) has artificially inflated estimates of B_t while underestimating B_0 since AM2's implementation (e.g., Jones et al. (2017) accuse such annual updating of B_0 of exemplifying Pauly's (1995) shifting baseline phenomenon). Although DFO has investigated the strengths and weaknesses of the previous model (AM1) compared to AM2, and included results of both models in the 2015/16 and 2016/17 IFMPs, the debate over model assumptions reflects deep disagreement about the overall state of herring stocks in BC.

1.2.4.1.2 Stock spatial dynamics

The metapopulation structure and spatial dynamics of Pacific herring in BC may affect stocks' susceptibility to fishing effort, as well. Ongoing research is examining the interplay of stock structure and fleet dynamics in BC herring fisheries (Okamoto et al. 2016), but management has begun to address concerns of potential local extirpations. In the 2016/17 IFMP, DFO implemented a new rule for sub-areas within the Strait of Georgia (SOG), requiring specific criteria for the strength of a spawning event before fishing may take place in that location; this was "to ensure commercial fisheries are not opened on small areas of fish or spawn, and that opportunities for First Nations FSC [Food, Social and Ceremonial] fisheries can be provided on a priority basis" (DFO 2016). Definitive answers to questions regarding the site-fidelity of local spawning aggregations are needed to address the concerns of First Nations who claim the predictability of spawning events is necessary for their cultural wellbeing.

1.2.4.1.3 Ecosystem interactions

The complex role of environmental conditions in the ecosystems of BC's coast is not fully understood. The role of forage fish in the food web, serving as conduit species for channelling energy from low trophic levels to predators above, has fueled arguments for precautionary biomass cutoff thresholds of $0.3B_0$ - $0.8B_0$ (Pikitch et al. 2012, 2017; Lam 2015; Lam et al. *submitted*; Surma et al. *submitted*). Others (e.g., Hilborn et al. 2017), however, counter-argue that forage fish stocks are naturally highly variable,

and fishing such species impacts predators much less than typical ecosystem models might predict. Improving the ability to predict consequences to herring stocks from changes in primary production or predator abundances, and the reciprocal effects upon other species from herring fisheries, would better inform the debate over what harvest levels impact other species least, and what strategies are useful for rebuilding herring stocks under different climate regimes (Kumar et al. 2016, DFO 2017b, Lam et al. submitted, Pitcher et al. 2017, Surma et al. *submitted*).

1.2.4.2 Normative issues in BC's herring conflict

1.2.4.1 Appropriate biomass cutoff thresholds in ecosystem-based management

If understanding of BC's marine ecosystems were complete, there would still be left the question of how best to implement that knowledge in establishing fisheries policy. While all parties prefer to avoid undesired outcomes to both herring stocks and other species within the ecosystem, disagreement may arise over what defines an "undesired outcome." Even in cases of agreement regarding the desirability of consequences, different groups might hold vastly different perceptions of, or tolerances for, risk (Slovic 1992). Advocates of increasing the biomass cutoff threshold at which to open herring fisheries, for instance, likely have either a lower tolerance for the risk of overfishing stocks, or believe that a potential stock crash would be more undesirable than do their opponents. The discussion hinges upon what effects are considered undesirable, and what amount of risk is acceptable.

1.2.4.1.1 Access, allocation and distribution of fishery benefits

DFO does not lay out any socio-economic objectives in its 2016/17 IFMP, instead focusing on the preservation of the resource. How access to that resource is allotted, and how its benefits are distributed amongst users, is a pressing normative concern nonetheless. Currently license holders must pool their quota allotments in order to fish profitably; Jones et al. (2017) describe the pooling system as a *de facto* individual transferable quota (ITQ) scheme, and warn of the unintended effects such ITQs have produced in other fisheries (Ecotrust Canada and Ecotrust 2004, Pinkerton and Edwards 2009, Ecotrust Canada and T. Buck Suzuki Environmental Foundation 2015).

Meanwhile, concentration of herring license ownership among a few large processors, while moderate compared to other industries, has caused concern for many stakeholders (Haas et al. 2016). Its effects may be exacerbated by the geographic concentration of processing facilities in BC and the perishability of the product, creating the market distortion of a traditional oligopsony (Haas et al. 2016). DFO also makes no mention in its IFMPs of the economic multiplier effect of fishing within and among coastal BC communities, nor of the many non-economic benefits to fishers and their communities (O'Donnell et al.

2013). The conflict, broadly, is between two distributional alternatives: maximizing and concentrating fishery benefits in a few hands, to be redistributed through the Canadian market and tax system; and distributing benefits more widely across the province.

1.2.4.1.2 Management and governance of herring fisheries

The value judgements made by DFO managers in the above examples reflect also a preference for scientific evidence over traditional ecological knowledge (TEK). First Nations, academics, ENGOs and others argue for greater acceptance and inclusion of TEK in decision making processes, believing it to be equally valid for establishing facts about ecosystems First Nations have lived within for millennia (Lam 2014, von der Porten et al. 2016, Petrou et al. 2016; see Berkes 2012 for a general overview of TEK).

A closely related disagreement is over the meaningfulness of consultation in the management process, with many First Nations again arguing that DFO ignores their concerns, such as access to SOK; demands for managing herring at smaller scales to preserve local spawning aggregations (Jones 2015, Greba 2015, Brown 2015, Washington 2015, Jones et al. 2017) have not been implemented. Establishment of the Integrated Herring Harvest Planning Committee (IHHPC), HTWG, and increased bilateral negotiations in recent years have attempted to respond to these concerns, but complaints still arise over what kind and degree of consultation is desirable.

Complaints over the adequacy of consultations bleed into deeper issues over the appropriateness and legitimacy of the fisheries' overall governance structure. Many First Nations argue, on the basis of legal aboriginal rights and title to natural resources, for greater sovereignty over their territorial waters, including sole or co-management of their local fisheries (Canadian Charter of Rights and Freedoms s.35). Non-First Nations academics and ENGOs also support greater degrees of direct local involvement in management of local herring resources (Lam 2015, Fox et al. 2016, von der Porten et al. 2016; see Pinkerton et al. 2014 for a more general discussion of BC fisheries governance; Jentoft et al. 1998 offer broader discussion of fisheries governance theory), while the Pacific North Coast Integrated Management Area (PNCIMA; see Appendix A) and the Archipelago Management Board (AMB; see Appendix A) exemplify processes and arrangements for collaborative management. At issue is disagreement over legitimacy of the status quo and alternative regimes; i.e., which authority may justly claim responsibility for managing herring (and other) resources in BC waters?

1.3 Complications to the framework

Despite my compartmentalization of the conflict's issues into descriptive and normative categories, they are not, however, isolated from one another. Judgment used in evaluating the quality of data, theories, and models is necessarily normative, relying upon value-laden assumptions about what constitutes a legitimate descriptive claim. This manifests often in scientific disputes: when individuals or groups hold conflicting assumptions for claim evaluation, they will likely disagree over the validity of evidence. A growing body of empirical research reveals cognitive biases in the way humans process and evaluate information, with a variety of unconscious, affective factors influencing what descriptive beliefs we form (for recent reviews, see Levine et al. 2015, Sokol-Hessner and Phelps 2015). One manifestation of such motivated cognition is identity-protective cognition, whereby an individual evaluates new evidence against the established beliefs which form part of their identity, rejecting evidence which contradicts those beliefs and threatens that identity (Cohen et al. 2000). Kahan et al. (2007) demonstrate further that perceptions of risk vary with worldview (Douglas 1970), and argue that competing groups' discordant risk assessments reflect competing worldviews.

Cultural identity also influences trust in the source of a descriptive claim, influencing the believability of that claim. Kahan et al. (2006) demonstrate that individuals are more accepting of new information that challenges their established beliefs when it comes from someone they perceive as part of their own cultural group, while they reject conflicting information from cultural outsiders. Such affective heuristics for claim evaluation may not fit within traditional models of "rational" economic decision-making, but make evolutionary sense as means for maximizing fitness-enhancing behaviour while minimizing cognitive output (Fehr 2009, Levine et al. 2015).

Within my framework for analyzing the issues in BC's herring conflict, these findings nevertheless muddle the distinction between descriptive and normative claims. After all, if disagreement over a descriptive claim stems from the normative values held by that claim's assessors, it follows that such disagreement is, in fact, fundamentally normative in nature. As an example, I included disagreements over DFO's estimate of B_0 as a descriptive issue; the appropriateness of this estimate, however, is ultimately subject to normative evaluation. Any estimate of unfished biomass includes fundamental uncertainty (Hilborn 2002), and BC Pacific herring models exemplify this. The switch from AM2 to AM1 resulted in part from the determination that an annually updated B_0 is preferable to an estimate based upon historical abundance, though Martell et al. (2011) offer no reasons for why the alternative, Bayesian method was introduced to begin with. McKechnie et al. (2014) present evidence that herring

stocks for thousands of years were much higher than recent historical records, suggesting that the "currently used ecological baseline of the mid 20th century is inadequate for modern management." Surma et al. (*in review*) also estimate B_0 for BC herring stocks to be larger than current DFO estimates, and advise precaution as a result. The underlying assumptions behind opposing voices' beliefs regarding an appropriate baseline for herring biomass may have less to do with the technical details as with the implied management consequences. Solution aversion (Campbell and Kay 2014) can manifest as a form of motivated disbelief whereby individuals refuse to accept evidence that implies solutions at odds with their own values and principles; it could be that First Nations find an annually re-estimated B_0 an insidious attempt to reduce the barrier to commercial fisheries in their territorial waters (Jones et al. 2017), or that industry see a constant, past-abundance-based parameter as an unreasonable restriction on fair and rightful access (Hume 2015).

For the framework to be helpful, then, in analyzing the controversy surrounding herring fisheries, any investigation of the issues at hand must acknowledge that normative, often unconscious, considerations will inevitably influence what the "facts" are. It is not enough to simply classify which disputes concern the fisheries' actual versus ideal states, as any attempt to resolve the disputes along those lines may be inadequate. If mediators fail to recognize that a disagreement over stock size may rest upon the cultural appropriateness of assessment methods, or may have more to do with *who* is estimating the biomass than with *how*, the disagreement is unlikely to be resolved.

1.4 Questions to answer in this thesis

This thesis acknowledges these complications by examining how the normative interests of stakeholders in BC's herring fisheries bear upon their perceptions of and preferences for those fisheries. As part of the PWIAS Solutions Initiative led by Mimi Lam (Lam et al. *submitted*; see Preface also), and the Mitacs Accelerate Program (see Preface), I explore the issues at the heart of the conflict through interviews with members of the Haida Gwaii community and with members of the BC herring industry living outside of Haida Gwaii. I identify four broad questions to answer. The first two were formulated by Lam et al. (*submitted*) prior to research activities and investigated with directed methods (described in Sections 2.2 and 2.3.1), while the second pair I developed post hoc and investigated through analysis of respondents' comments (described in Section 2.3.2).

1.4.1 What values are important to stakeholders?

How do Haida Gwaii community members compare to herring industry members regarding the values they prioritize? If different, does this difference suggest a cultural divide between the Haida Gwaii community and the industry?

1.4.2 What preferences do stakeholders have for herring management and governance in Haida Gwaii?

How do Haida Gwaii community members compare to herring industry members regarding preference for alternative herring fisheries management scenarios? Regarding biomass cutoff threshold for the commercial SOK fishery, and for sac roe? These preferences presumably reflect respondents' perceptions of risk to herring stocks from overfishing. Choosing higher biomass cutoff thresholds would indicate perception of greater risk, and vice versa.

In terms of governance, how do Haida Gwaii community members compare to herring industry members regarding preference for Haida control of herring management in Haida Gwaii waters? For Haida co-management with DFO?

1.4.3 What perceptions do stakeholders hold regarding herring stocks in Haida Gwaii?

How do Haida Gwaii community members compare to herring industry members regarding perceptions of current herring stock size in Haida Gwaii? And how do the two groups compare in their perceptions of unfished equilibrium stock size? DFO management rules dictate fishery openings according to the ratio of current to unfished biomass; determining respondents' perceptions of these quantities reveals their agreement with DFO's stock assessments, and with the perceptions of other respondents.

1.4.4 How do stakeholders' normative interests influence their perceptions of the fisheries?

How do Haida Gwaii community members compare to herring industry members regarding trust in different knowledge sources? Are respondents in one group more likely than the other to trust DFO stock assessments? Or First Nations' TEK?

1.5 Conclusion

In this introduction, I have provided an overview of the recent conflicts over Pacific herring fisheries in BC. I have also discussed some controversies over how the fisheries are understood and managed, and introduced a framework, rooted in PNS, clarifying which debates concern issues of a descriptive nature and which concern normative goals. This approach is not without complications, though; human

psychology imposes ambiguity upon this attempted separation of descriptive and normative issues. The research objectives I lay out above address the interplay between human values, beliefs and preferences by investigating each separately in BC herring stakeholders. I describe the methodology used to pursue these objectives in Chapter 2.

2 Methods

In this chapter, I describe my research as it was carried out, within the context of other related projects. I begin by detailing how respondents were selected and who those people were, then describe the interview process each respondent went through. I then explain the analyses carried out upon categorical data, including initially planned tests as well as methods developed afterward to answer questions that arose in the preliminary analysis. I then discuss the analysis and use of qualitative data from respondents' interview transcripts.

2.1 Respondent selection & sample description

This study draws upon semi-structured interviews conducted with 47 members of the Haida Gwaii community between September 2015 and March 2016, and 28 members of the commercial herring industry located outside of Haida Gwaii between October 2016 and May 2017. Dr. Mimi Lam led all Haida Gwaii interviews, with assistance from myself and Dr. Tony Pitcher in the first 12, as part of the Peter Wall Institute for Advanced Studies (PWIAS) Solutions Initiative: *Collaborative Solutions for Haida Gwaii Herring Fisheries* (PIs: ME Lam, TJ Pitcher, and EA Pakhomov; 2014-2016). I conducted 27 of the industry interviews for the Mitacs Accelerate Program: *Identifying Stakeholders' Values in British Columbia's Pacific Herring Fishery* (PI: ME Lam; PWIAS 2016), with Dr. Lam conducting the 28th. Interview respondents in Haida Gwaii were selected initially from those who participated in one of two Haida Gwaii workshops held in the towns of Old Massett and Skidegate in April 2015 as part of the PWIAS Solutions Initiative cited above. Workshop participants were identified, in collaboration with the Council of the Haida Nation (CHN), to represent a cross-section of perspectives of the Haida Gwaii communities. Further interview respondents were identified through snowball sampling (cf. Lam et al. *submitted*). After an initial meeting in Steveston, BC with five members of the Herring Industry Advisory Board (HIAB) in September 2016, potential industry respondents outside of Haida Gwaii were identified by their participation in the HIAB and/or Integrated Herring Harvest Planning Committee (IHHPC). This was facilitated by Greg Thomas of the Herring Conservation and Research Society (HCRS), who was contacted by Dr. Lam after his response to her opinion piece (Lam 2015), and through snowball sampling.

Respondents were asked to record basic demographic details before their interviews (age, gender, ethnicity and occupation for Haida Gwaii residents; age, gender, ethnicity and place of residence for industry respondents), while additional details were gleaned from interview data. Haida Gwaii resident respondents included 37 men and 10 women, ranging in age from 21 to 91 years (mean age = 49;

median age = 44). Thirty respondents identified as Haida, 16 as non-Haida, and one chose not to identify their ethnicity. Ten respondents identified some role in local government as an occupation, 14 worked as scientists, four as educators, five as artists, seven as fishers and seven reported other occupations (five respondents reported more than one occupation); of these, 10 were retired. Although only seven recorded their occupation as fisher, a total of 15 respondents indicated in their interviews that they held approximately 10 years or more experience as commercial fishers; 13 of these fishers also had experience fishing herring commercially.

Industry respondents were all male, and ranged in age from 28 to 78 years (mean age = 61 years; median age = 63). Three identified as having First Nations ancestry, 23 identified as non-First Nations, and two declined to identify their ethnicity. Five identified their occupation as seafood processor, 23 as fisherman, 1 as scientist (one processor also fished); four of those fishermen were retired. Of those who fished herring, 13 primarily fished gillnet licenses, 9 primarily fished seine licenses, and one primarily harvested SOK. Five respondents mentioned affiliation with the United Fishermen and Allied Workers' Union (UFAWU), 14 mentioned affiliation with HIAB, one with the Native Brotherhood, and one with the HCRS (not all respondents were asked directly about their group affiliations).

2.2 Interviews

Interview methodology summarized here was developed by Lam et al. (*submitted*), and intended to elicit both "bottom-up" participation from stakeholders and "top-down" control from experts (Bremer et al. 2012, 2016). In each interview, respondents were presented with 12 cards, each representing a value and illustrated with an image from artist April White's repertory (descriptions in Table 2.1, images of the cards are found in Appendix C). Artwork was used to engage participants, elicit response, and to ground methods in a culturally relevant framing (Lam et al. *submitted*; see Section 4.2.2 for discussion of potential bias). Six of these values came from the traditional Haida values and ethics published in Jones et al. (2010). They were presented in English translation, with the Haida words alongside. Six other values were derived from sources in the moral psychology and applied ethics literatures (Mepham and Tomkins 2006, Bremer et al. 2012, Graham et al. 2012). The combined values were meant to comprise a comprehensive set of near-universal values (i.e., common to most cultures) to explore research participants' value relations with herring (Lam et al., *submitted*). The back of each card contained a short description of its value, with the Haida values also accompanied by the analogous principle for modern resource management identified in Jones et al. (2010). Due to misplaced interview materials, four industry respondents outside Haida Gwaii were shown unillustrated cards with only the

name of each value written on them, with verbal descriptions provided by the interviewer (JS). Respondents were asked to prioritize the set and elaborate upon what each value means to them in their personal lives and/or in terms of herring fisheries management. Multiple values could rank equivalently; e.g., Respect and Responsibility could both rank 1st, with the other 10 values ranking 2nd. This methodology for eliciting respondents' value priorities differs from that of Song and Chuenpagdee (2015) in its lack of constraints upon arrangement of value cards, which allows for greater variety of personal expression and greater explanatory detail from respondents' comments on their arrangements.

Table 2.1: Descriptions of values presented to respondents on cards. Illustrations associated with each value are found in Appendix C (Lam et al. *submitted*).

Values	
Respect *Yahguudang* or *Yakguudang*	Respect, for each other and all living things, is rooted in our culture. We take only what we need, we give thanks, and we acknowledge those who behave accordingly. (Precautionary approach)
"The world is as sharp as the edge of a knife." *Giid tll'juus*	Balance is needed in our interactions with the natural world. If we aren't careful in everything we do, we can easily reach a point of no return. Our practices and those of others must be sustainable. (Sustainable use) [This value is abbreviated as "balance" in Figure 3.1 and Table 3.1.]
Interconnectedness ("Everything depends on everything else.") *Gina waadluxan gud ad kwaagiida*	This principle is comparable to an integrated approach to management. (Integrated management)
Reciprocity (Giving and receiving) *Isda ad diigii isda*	Reciprocity (giving and receiving) is a respected practice in our culture, essential in our interactions with each other and the natural world. We continually give thanks to the natural world for the gifts that we receive. (Equitable sharing)
Seeking wise counsel *Gina k'aadang.nga gii uu tl' k'anguudang*	Our elders teach us about traditional ways and how to work in harmony. Like the forest, the roots of our people are intertwined. Together we consider new ideas and information in keeping with our culture, values, and laws. (Adaptive management/Best information)
Responsibility *'Laa guu ga kanhllns*	We accept the responsibility passed on (to us) by our ancestors to manage and care for the sea and land. We will ensure that our heritage is passed on to future generations. (Inclusive and participatory)
Sanctity	Sanctity is about accepting a sacred or spiritual element in the world.
Wellbeing	Wellbeing is about a good quality of life, a state characterized by essential features such as health, prosperity, and happiness.
Freedom	Freedom is about the ability to make your own choices on how to live your life.
Justice	Justice is about distributing benefits, risks and costs fairly.
Authority	Authority is about respecting social order and the rule of law.
Group solidarity	Group solidarity is about the sense of belonging and showing loyalty to a group.

Afterwards, respondents were shown four PowerPoint slideshow presentations originally presented at workshops in Skidegate and Massett, BC in April 2015. Twenty-two respondents in Haida Gwaii had previously seen the presentations at those workshops, and therefore were not shown these again, while 16 outside of Haida Gwaii did not view the presentations due to time constraints or technical issues. The presentations were: 1) an overview of the CHN's concerns regarding herring management in Haida Gwaii waters, originally presented by Russ Jones; 2) a one-slide summary of the results of the Lenfest Forage Fish Task Force (Pikitch et al. 2012); 3) a presentation of Kumar et al.'s (2016) Ecosim with Ecopath (EwE) model of the northern BC marine ecosystem, along with forecasts for the impacts of different herring harvest rates and cutoff thresholds on selected other species within the ecosystem (Surma et al. *submitted*); and 4) an overview of four proposed scenarios for management of herring fisheries in Haida Gwaii (Lam et al. *submitted*). The methodology described constitutes an integrated value- and ecosystem-based approach to fisheries management; see Lam et al. (*submitted*) for details.

The four proposed scenarios (Lam et al. *submitted*) were called: 1) A Whale of a Time, in which all commercial herring fisheries are closed in Haida Gwaii waters; 2) The Fish that Get Away, in which the commercial roe herring fishery is closed while a commercial spawn-on-kelp (SOK) fishery is open; 3) Hard of Herring, which was described as the status quo scenario; and 4) The Little Fish that Could, in which commercial roe herring and commercial SOK fisheries are managed separately. It should be noted that I departed from these descriptions when interviewing 27 of 28 industry respondents, referring to the scenarios as more narrowly defined situations where 1) A Whale of a Time referred to indefinite closure of both fisheries; 2) The Fish that Get Away referred to indefinite closure of the sac roe fishery and biomass cutoff threshold rule-based management of the SOK commercial harvest; 3) Hard of Herring referred to the status quo, where both fisheries are managed using the same biomass threshold; and 4) The Little Fish that Could referred to the two fisheries managed using different, unspecified biomass thresholds. This difference in the permanence of the described scenarios factored into how respondents interpreted them; see Section 2.3.2 for elaboration. An image from April White's repertory illustrated each of the scenarios (Lam et al. *submitted*), printed on paper sheets (Appendix C), though eight respondents outside Haida Gwaii were not shown these cards due to space constraints or misplaced materials. Respondents were asked to choose their preferred scenario of the four and explain their reasoning.

Those who chose to prioritize the value cards earlier were also prompted to place value cards upon the scenarios they felt represented those values, and to explain their reasoning. Respondents were neither

constrained by how many values could associate with each scenario, nor by how many scenarios each value could touch. Respondents were not required to use all values in this exercise, either.

Respondents were then asked to choose their preference for a biomass cutoff threshold for opening sac roe fisheries: 0% (i.e., fisheries always open), 25% (the current threshold), 50% (comparable to Pikitch et al.'s (2012) 40% recommendation for forage fish), 75% (comparable to Pikitch et al.'s (2012) 80% precautionary recommendation), or 100% (i.e., fisheries closed) of the estimated unfished biomass. Industry respondents outside of Haida Gwaii were also asked which of these scenario and threshold options they preferred for the other four major stock areas in BC. Where respondents stated a range, their preference was recorded as the minimum and maximum thresholds stated. Where respondents stated a percentage between the thresholds offered, their minimum preference was recorded as the threshold immediately below the stated percentage, and their maximum, the next highest. Respondents were not always asked to explicate which cutoff threshold they would prefer for a commercial SOK fishery, if they previously selected The Fish that Get Away or The Little Fish that Could scenario. Their answers were taken to pertain only to sac roe unless explicitly stated otherwise, which limited the number of responses concerning preferred SOK cutoff threshold level.

In the last section of the interview, respondents were asked open-ended questions, beginning with, "How do you think herring fisheries should be managed in Haida Gwaii?" and, for industry respondents outside Haida Gwaii, "How do you think herring fisheries should be managed in the other stock areas of BC?" Respondents were then prompted to describe their personal experience with herring and its fisheries, before concluding with the question, "What does herring mean to you?" Many other themes emerged as respondents volunteered information, and interviewers often altered interview structure to accommodate respondents' trains of thought and to explore novel themes. Responses to these open-ended questions, as well as other volunteered information, proved useful in supplementing and clarifying responses to the categorical items discussed above.

2.3 Analysis of categorical data

2.3.1 Initial analyses

Interviewers audio-recorded interviews digitally, and photographed value card arrangements for the prioritization and values-to-scenarios exercises. All digital files were transferred to password-protected computers and edited as needed to reduce background noise and lengthy silences. Transcripts of interviews were obtained from third-party commercial transcription services and uploaded to Nvivo

qualitative data management software, in which platform respondents' interpretations of values and answers to questions were coded.

Value prioritizations were scaled from rank 1 to 12, with equally ranked values sharing the median of unfilled ranks; e.g., if Respect and Responsibility ranked 1st, and all others ranked 2nd, then Respect = Responsibility = scaled rank 1.5, while all others = scaled rank 7.5. This was done to ensure all prioritizations were scaled to the same range of ranks, as not all respondents used all 12 possible ranks. When a respondent indicated certain values were inapplicable to them, or for any other reason did not include them in their prioritization, those values were assigned to the lowest rank possible in the respondent's prioritization.

The median rank of each value served to compare prioritizations between groups. The median rank serves as an indicator of the value's typical place within rankings for that group, and is less likely to be skewed by extreme rankings than is the mean. I tested differences in between-sample rankings of each value using the Wilcoxon-Mann-Whitney rank-sum comparison, and within-sample rankings using the Kruskal-Wallace analysis of variance by ranks. Kendall's coefficient of concordance (W) was calculated for each sample, and for all respondents, to compare how homogenous each group's respondents were in their prioritizations.

Scenario preferences were tabulated and the two samples' choices tested via G-test (log-likelihood ratio for contingency tables; Zar 2010). The same was done for threshold preferences. Note that methodological validation was provided by comparing respondents' scenario preferences with their biomass cutoff threshold preferences. For example, those who chose the no fishery (A Whale of a Time) scenario who also choose B_0 as their preferred threshold provided self-consistent responses. Scenario and threshold preferences were compared between samples and between sub-groups.

For the values-to-scenarios exercise, each scenario was scored by awarding points for each value card a respondent placed upon it, the points corresponding inversely to the rank assigned that value by the respondent. For example, if a respondent placed Respect and Responsibility upon a scenario, and those values' scaled ranks were 1 and 2, the number of points awarded that scenario would be 12 + 11 = 23. The scenario receiving the highest such value score from a respondent was then compared with the respondent's preferred scenario to test statistically using Cohen's kappa whether their prioritization of values held influence over their scenario preferences; this result is presented in Lam et al. (*submitted*) though not in this thesis (see Section 4.1.1 for discussion).

2.3.2 Follow-up analyses

Preliminary analysis suggested that vagueness in each scenario's description led to respondents occasionally interpreting the options as static management outcomes, rather than as rules for making management decisions. For instance, some Haida Gwaii residents stated a preference for implementing A Whale of a Time immediately (i.e., closing all commercial herring fisheries), but would support a commercial SOK fishery in the future if herring stocks rebuilt adequately. Such a preference, though, is equivalent to the management rule implied by The Fish that Get Away scenario, in which commercial sac roe is closed indefinitely and SOK fisheries are subject to a biomass cutoff threshold less than B_0. To more explicitly capture the management preferences of respondents, then, I qualitatively analyzed respondents' statements to categorize their preferences for four management rules: Rule A, in which all commercial roe fisheries are permanently closed in Haida Gwaii waters; Rule B, in which sac roe fisheries are permanently closed while commercial SOK is managed with a harvest control rule; Rule C, in which both commercial SOK and sac roe fisheries are managed using the same harvest control rule; and Rule D, in which commercial SOK and sac roe fisheries are managed using separate harvest control rules. In this re-analysis, only respondents explicitly preferring permanent closure of all commercial herring fisheries in Haida Gwaii were recorded as preferring Rule A; those explicitly amenable to an eventual opening of commercial SOK only were recorded as preferring Rule B; and so on.

Initial analysis of cutoff threshold preferences suggested a similar case to respondents' scenario preferences, in which some respondents who preferred Rule D chose a B_0 cutoff threshold for roe fishery openings. Again, it seems these choices for permanent closure refer to the upcoming season, rather than a long-term management rule. The cutoff threshold preferences were more difficult to recategorize, however, as respondents typically did not specify what threshold should apply were a roe fishery to eventually open. Instead, those respondents were omitted from analysis of stock size perceptions (described below). Many respondents choosing Rule B, on the other hand, preferred a roe fishery cutoff threshold less than 100%. In these cases, confusion seemed to arise over which fishery the cutoff threshold applied to, with the respondent indicating their preferred threshold for SOK instead; this was accounted for when analyzing stock size perception (described below).

When respondents interpreted the presented scenarios differently from one another, what occurred was a conflation of two separate questions: 1) "What rule(s) should be used to determine when each commercial herring fishery may open?" and, 2) "Which commercial herring fisheries should be open this year?" Classifying respondents' rule preferences clarified their answers to this first question, but the

second was neglected by interview protocol. To glean answers to this question, then, I reviewed all interview transcripts and identified, where possible, respondents' preferences for whether and which commercial herring fisheries should be allowed in Haida Gwaii waters for the upcoming season. This preference reveals whether the respondent believes B_t/B_0 is greater or less than their preferred cutoff threshold $(B_{crit})/B_0$.

This perception of relative abundance can be compared, within limits, to DFO's formal stock assessment (see Table 2.2). DFO estimated stock abundances below the biomass cutoff threshold ($B_{crit} = 0.25B_0$) prior to the two seasons these interviews preceded. Therefore, those respondents who opted for the current thresholds and who preferred fishery closures for the upcoming season implicitly agreed with the relative stock abundance estimated by DFO. Those who opted for the current cutoff thresholds but preferred openings in the upcoming season, however, implicitly disagreed with DFO over at least one biomass estimate. Those respondents believe the current Haida Gwaii stock abundance to be greater than DFO's assessed size, or they believe B_0 to be smaller than DFO's estimate used in stock assessment, or both. Those who favoured a more conservative cutoff threshold ($B_{crit} > 0.25B_0$) but felt a fishery was warranted for the next season necessarily believed current biomass to be greater than DFO's estimate, or that DFO's B_0 is overestimated, or both. No comparison may be made for those favouring both a higher cutoff threshold and an upcoming fishery closure, however; they necessarily believe the current stock size is smaller than their preferred threshold, but, without explication from the respondent, it is unclear how much smaller, or how large they believe B_0 to be.

Table 2.2: Prescription for determining respondents' estimates of relative herring biomass in Haida Gwaii waters; where B_{crit} = respondent's preferred biomass threshold for a fishery opening, D = respondent's preferred decision to open or close a fishery during the upcoming season, B_0 = respondent's estimate of unfished biomass, B_t = respondent's estimate of biomass prior to the upcoming season.

If	**And**	**Then**
$B_{crit} \leq 0.25B_0$	D=closed	$B_t/B_0 < 0.25$
$B_{crit} \leq 0.25B_0$	D=open	$B_t/B_0 \geq 0.25$
$B_{crit} > 0.25B_0$	D=closed	B_t/B_0 ? 0.25
$B_{crit} > 0.25B_0$	D=open	$B_t/B_0 > 0.25$

To clarify respondents' beliefs as to B_t and B_0, I searched transcripts for explanatory remarks volunteered by respondents regarding herring stocks in Haida Gwaii. I coded the perceptions of those respondents who chose to comment on the current herring stock biomass as less than, equal to, or

greater than DFO's estimate for the upcoming season, and did the same for those who volunteered their opinion as to B_0. Through this roundabout process of data gleaning, I attempted to assemble a set of data points describing respondents' 1) preference for biomass threshold, 2) perception of current stock biomass, and 3) perception of unfished equilibrium biomass. This would allow analysis of both respondents' normative and descriptive beliefs, which gets to the heart of the dispute over herring fisheries in Haida Gwaii.

Also central to the dispute is the issue of trust in different sources of knowledge. Respondents in both population samples often cited evidence from DFO or traditional Haida (or other First Nations') knowledge to support their descriptive beliefs about herring stocks, while many also dismissed or discredited evidence from one or both of those sources. Given that many individuals have a propensity to disbelieve factual claims offered by others outside their cultural group (Kahan et al. 2006), it is worthwhile, then, to investigate whether respondents' trust in either DFO science or First Nations' TEK relates to their perception of stock sizes (B_t and/or B_0). Respondents who mentioned DFO science and/or TEK in their interview were categorized as either trustful or distrustful of DFO stock assessment science and/or as trustful or distrustful of First Nations' TEK regarding herring stocks.

Finally, many responses to the question, "How do you think herring fisheries should be managed in Haida Gwaii?" contained preferences for greater involvement by CHN in management. I categorized respondents, then, as either volunteering or not a preference for co-management (between CHN and DFO) of herring fisheries in Haida Gwaii waters, and as either volunteering or not a preference for full Haida control of those fisheries. This information goes further toward understanding how normative beliefs about First Nations' rights and title, and/or about local vs federal sovereignty, influence preferences for herring fisheries management in BC.

2.4 Analysis of qualitative data

In addition to the categorical data collected as described above, much information came from less quantifiable statements respondents made in their interviews. Answers to the more open-ended questions, "How do you think herring fisheries should be managed in Haida Gwaii?" "How do you think herring fisheries should be managed in the other stock areas of BC?" (asked only of industry respondents) and, "What does herring mean to you?" revealed diverse normative and descriptive beliefs pertaining to the ecology, economics, politics and management of herring fisheries in BC. This qualitative data informed analysis of the categorical items, guided interpretations of results and suggested potentially fruitful lines of future study. A number of themes not investigated quantitatively

but mentioned commonly by respondents are described in Section 3.2 and discussed in Chapter 4. I make use of quotes I considered representative of common themes to illustrate those themes and provide specific details in respondents' original language. Other quotes are presented to highlight unique perspectives and themes that demonstrate the heterogeneity of opinion among the sampled respondents.

3 Results

In this chapter I present the results of analyses described in Chapter 2. I begin with categorical data, including values prioritizations, scenario, threshold and management rule preferences, preferences for upcoming fishing seasons, perceptions of Haida Gwaii herring stock abundances, trust in sources of information, and preferences for Haida Gwaii herring fisheries governance. I then describe the qualitative themes that emerged from respondents' comments throughout the interviews, placed within the descriptive-versus-normative framework introduced in Chapter 1.

3.1 Analyses of categorical data

3.1.1 Values prioritizations

Descriptive statistics for values prioritizations are summarized in Table 3.1 with Wilcoxon-Mann-Whitney test statistics, while Figure 3.1 illustrates the median rank of each value (note the abbreviation "balance" is used in place of "The world is as sharp as the edge of a knife"). More respondents from the Haida Gwaii sample ordered their 12 value cards into 4 ranks than in any other rank arrangement, while the modal number of ranks for the industry sample was 2. Differences between the samples' ranking distributions for all values were insignificant at α=0.05 (see Table 3.1 for U's and p-statistics). A Kruskal-Wallace analysis of variance by ranks revealed significant difference between the distributions of value rankings within both samples (H_{HG}=142, df=11, p_{HG}<<<0.01; H_{IND}=50, df=11, p_{IND}<<<0.01); in both groups' median rankings, the values Respect and Responsibility ranked significantly higher than all other values (non-parametric multiple contrast test; S_{HG}=92, df=11, p_{HG}<<<0.01; S_{IND}=28, df=11, p_{IND}=0.004). Sanctity ranked significantly lower than all others for Haida Gwaii residents (S=33, df=11, p<0.001) though not for industry (S=12, df=11, p=0.3). Kendall's W for respondents in the Haida Gwaii sample was 0.25, and, for those in the industry sample, 0.15. Concordance among all respondents in the study was W=0.21. The low levels of agreement among respondents reflect the large numbers of permutations allowed by the lack of constraints on the permitted number of ranks (cf. the "P+sort" method of Song and Cheuengpagdee 2014).

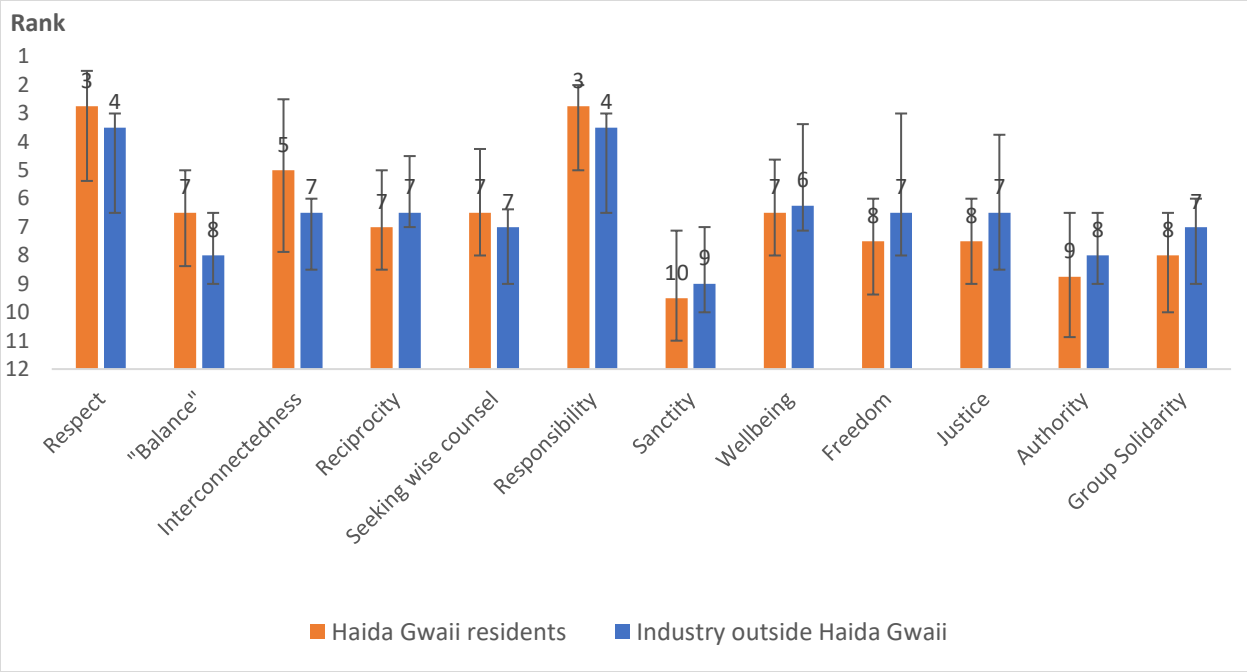

Figure 3.1*:* Median ranking assigned by respondents to each value, with upper and lower quartiles bracketed, by sample group. Rank 1=highest possible, rank 12=lowest possible. Data labels are rounded to nearest integer; some values are non-integer due to procedure used to scale original rankings from 1-12 (see Section 2.1). Haida Gwaii residents n=46, industry outside Haida Gwaii n=25.

Table 3.1: Median, 1st and 3rd quartile values for each value, by sample group, and Wilcoxon-Mann-Whitney U statistics, p-values comparing the two sample groups for each value. Haida Gwaii residents n=46; industry outside Haida Gwaii n=25.

	Haida Gwaii			Industry			Wilcoxon-Mann-Whitney test statistics	
	Median	1st quartile	3rd quartile	Median	1st quartile	3rd quartile	U	p
Respect	2.75	1.5	5.375	3.5	3	6.5	406	0.071
"Balance"	6.5	5	8.375	8	6.5	9	399	0.058
Interconnectedness	5	2.5	7.875	6.5	6	8.5	425	0.115
Reciprocity	7	5	8.5	6.5	4.5	7	475	0.338
Seeking Wise Counsel	6.5	4.25	8	7	6.375	9	459	0.250
Responsibility	2.75	2	5	3.5	3	6.5	396	0.053
Sanctity	9.5	7.125	11	9	7	10	479	0.363
Wellbeing	6.5	4.625	8	6.25	3.375	7.125	475	0.341
Freedom	7.5	6	9.375	6.5	3	8	439	0.160
Justice	7.5	6	9	6.5	3.75	8.5	438	0.158
Authority	8.75	6.5	10.875	8	6.5	9	501	0.528
Group solidarity	8	6.5	10	7	6	9	453	0.218

3.1.2 Scenario preferences

The four herring management scenarios presented, and the four management rules inferred from responses, were described above in Sections 2.3.1 and 2.3.2, respectively. Scenario preferences are shown in Figure 3.2; preferences for management rules appear in Figure 3.3. The main effect of reclassifying respondents' choices for specific management rules was to reveal many respondents who selected A Whale of a Time but were supportive of rules potentially allowing a commercial SOK fishery

only (Rule B), the status quo (Rule C) or separately managed SOK and sac roe fisheries (Rule D). Thirteen Haida Gwaii respondents held these preferences, as did three from industry, revealing few supporters of permanent fishery closures (Rule A). These classifications were due to comments made by those respondents indicating an openness to commercial sac roe and/or SOK fisheries opening should future stock status permit. After rule preference categorization, differences remain in the sample groups' aggregate preferences, with no Haida Gwaii, but a majority of industry, respondents choosing Rule C, and over a third of Haida Gwaii, but no industry, respondents preferring Rule B. Forty-five percent of Haida Gwaii and 38% of industry respondents preferred Rule D; for Rule A it was 16% and 4%, respectively. These results confirm that the two samples disagree significantly (log likelihood G=46; p <<< 0.01). Regarding the values-to-scenario exercise, 76% of Haida Gwaii respondents' most highly scored scenario matched their stated scenario preference, while 82% of industry respondents showed agreement between the two.

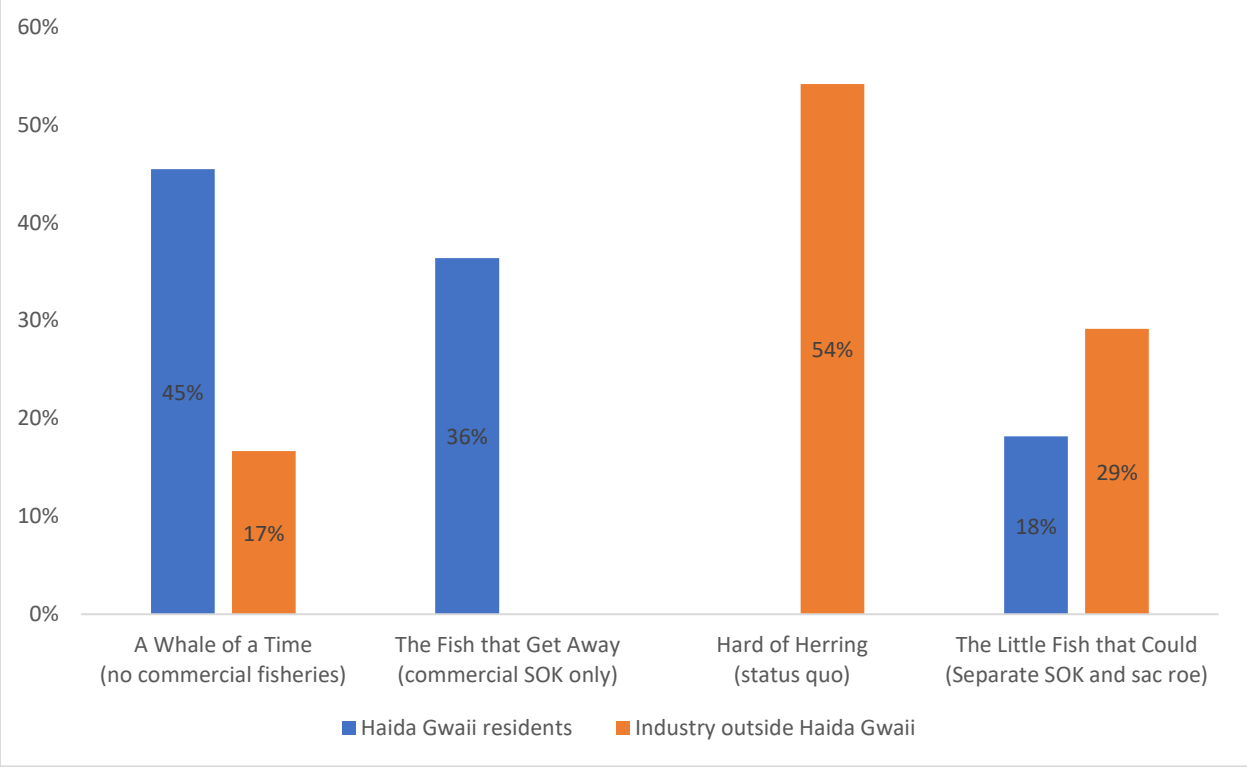

Figure 3.2: Percentages of respondents selecting each of four scenarios presented, by sample group. A Whale of a Time = commercial herring fisheries closed; The Fish that Get Away = commercial spawn-on-kelp (SOK) fishery only; Hard of Herring = current management strategy; The Little Fish that Could = commercial SOK and sac roe fisheries managed separately. Haida Gwaii residents n=44, industry outside Haida Gwaii n=24.

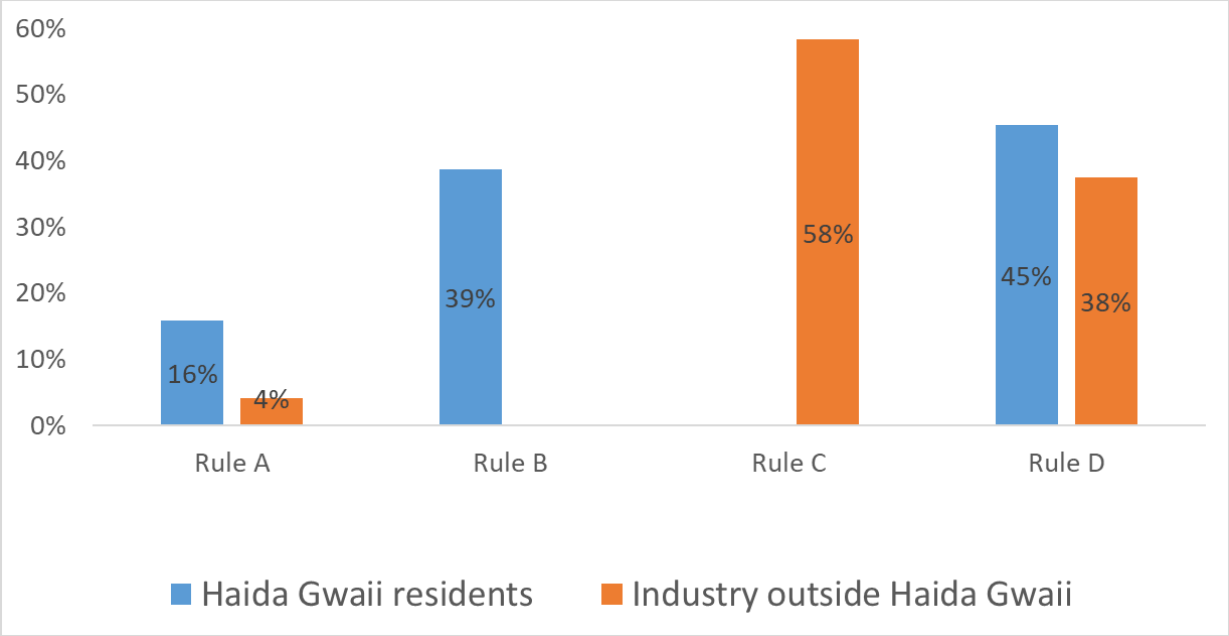

Figure 3.3: Percentages of respondents implying each of four management rules in their responses, by sample group. Rule A = commercial herring fisheries permanently closed; Rule B = sac roe fishery permanently closed, commercial spawn-on-kelp (SOK) fishery managed using biomass threshold Harvest Control Rule; Rule C = commercial SOK and sac roe fisheries managed using same Harvest Control Rule; Rule D = commercial SOK and sac roe fisheries managed using separate Harvest Control Rules. Haida Gwaii residents n=44, industry outside Haida Gwaii n=24.

3.1.3 Cutoff threshold preferences

Figures 3.4 and 3.5 show respondents' minimum and maximum preferred biomass cutoff thresholds, respectively, for opening the roe herring fishery in Haida Gwaii waters. Eleven Haida Gwaii respondents indicated a minimum and maximum value, or an intermediate value for their preference, one industry respondent did so, and all others chose a single threshold value. Again, Haida Gwaii respondents preferred significantly higher thresholds than did industry, for both minimum ($G=61$; $p << 0.001$) and maximum ($G=55$; $p << 0.001$) biomass levels. This conservatism is mostly in line with scenario preference results, but obscures some inconsistencies in responses. As noted in Section 2.3.2, some respondents who chose Rule D still preferred a 100% threshold for the roe fishery; this could be a similar case to respondents' scenario preferences, in which these choices for roe fishery closure refer to the upcoming season, rather than a long-term management rule. Also noted in Section 2.3.2, many who chose Rule B nonetheless preferred a threshold less than 100%. These preferences were taken to refer to the threshold for commercial SOK, rather than sac roe, and were treated accordingly when analyzing stock size perceptions.

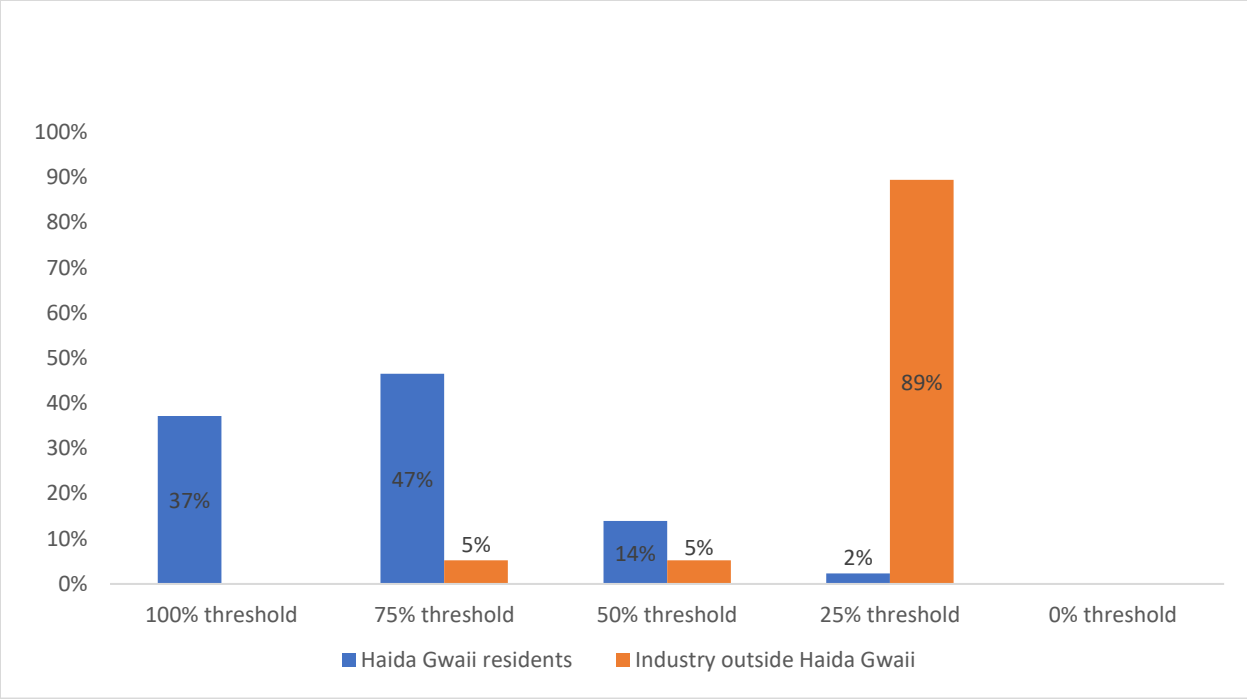

Figure 3.4: Percentages of respondents choosing each biomass level as a minimum preferable cutoff threshold for roe fishery openings, by sample group. Note that 100% threshold implies no fishery. Haida Gwaii residents n=43, industry outside Haida Gwaii n=19.

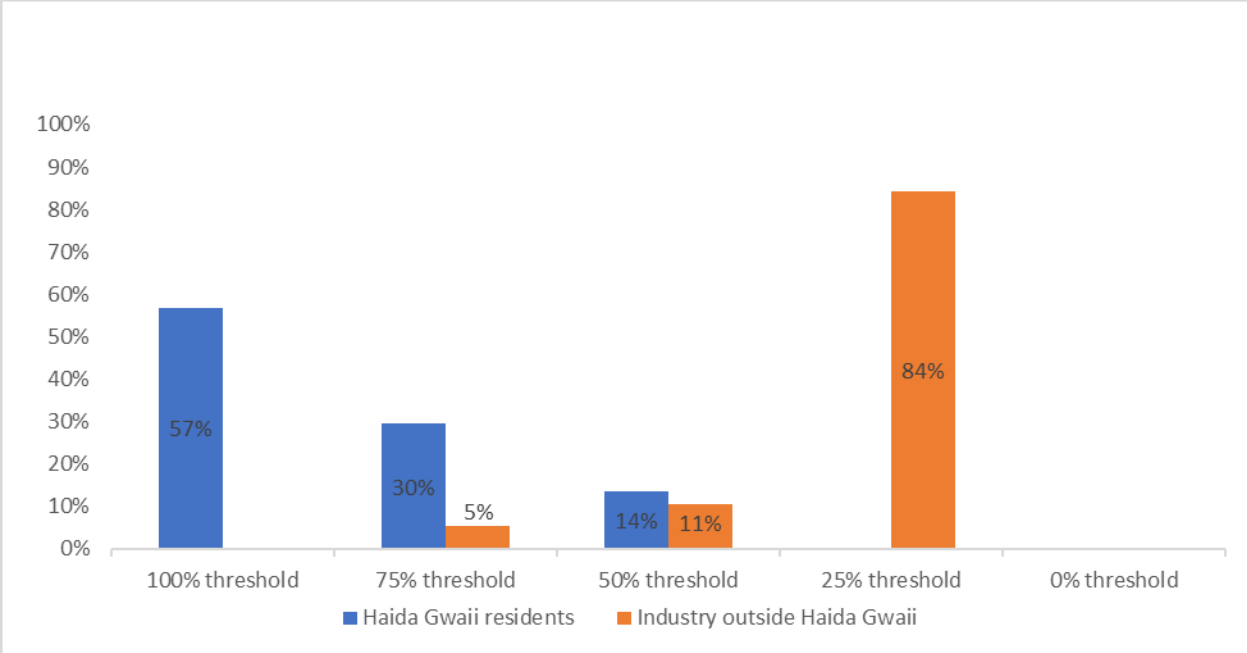

Figure 3.5: Percentages of respondents choosing each biomass level as a maximum preferable cutoff threshold for roe fishery openings, by sample group. Note that 100% threshold implies no fishery. Haida Gwaii residents n=43, industry outside Haida Gwaii n=19.

3.1.4 Preferences for upcoming season

Because respondents were not directly asked their preference for closure/opening of HG stock commercial fisheries in the upcoming season, not all provided information to assess. Many who preferred SOK only or Rule B did not go on to say whether they felt commercial SOK operations should begin immediately, and many who chose the status quo or Rule C made no comment as to the upcoming season's fisheries. Most Haida Gwaii residents made comments indicating their preference for the sac roe fishery (n=43), while almost half (n=24) did so regarding commercial SOK. Far fewer industry respondents, however, revealed their preferences explicitly enough to categorize, with only nine commenting on both commercial SOK and sac roe. Of those who did volunteer comments, Haida Gwaii ($G=60$, $df=1$, $p<<<0.001$) and industry ($G=6$, $df=1$, $p=0.01$) respondents alike favoured closure of the sac roe fishery overwhelmingly (Figure 3.6), while keeping SOK closed was favoured significantly by the Haida Gwaii subsample ($G=15$, $df=1$, $p<<0.001$) and non-significantly by industry ($G=3$, $df=1$, $p=0.09$).

3.1.5 Perceptions of Haida Gwaii stock size

All Haida Gwaii respondents who commented felt that the sac roe fishery ought to remain closed in the upcoming season, but they also preferred thresholds above the current $0.25B_0$ used by DFO. This obscured whether they perceived the current relative biomass of herring (B_t/B_0) to be greater or less than DFO's assessment. Only four industry respondents gave both a threshold preference for the sac roe fishery and indicated whether that fishery should open in the upcoming season, creating the same problem regarding relative stock size perceptions. Attempts to discern respondents' perceptions of absolute current and/or unfished biomass levels proved similarly unfruitful. Only one respondent in Haida Gwaii made comments explicit enough to compare to DFO's estimate of B_0 for the Haida Gwaii stock, while four industry respondents commented explicitly on B_t, and two upon B_0.

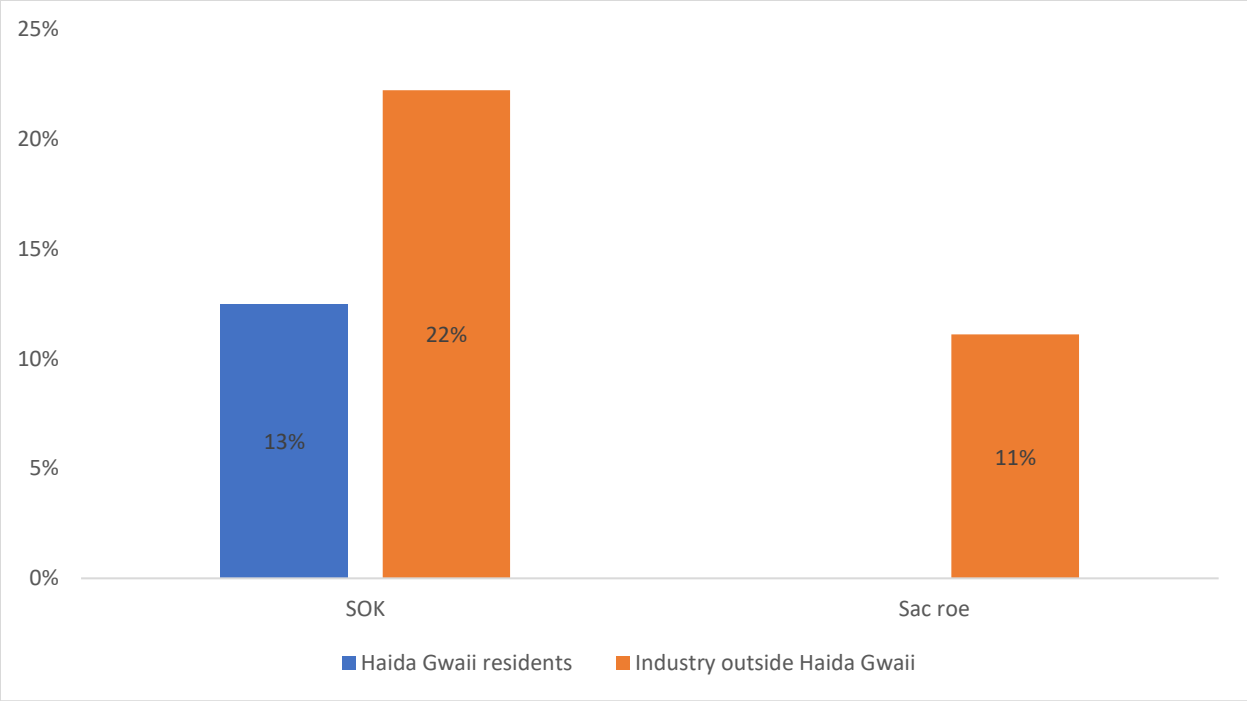

Figure 3.6: Percentage of respondents preferring opening of commercial spawn-on-kelp and sac roe fisheries in Haida Gwaii in the upcoming season, out of those respondents indicating a preference either way, by sample group. Haida Gwaii residents explicitly commenting on SOK n=24, and sac roe n=43; industry outside Haida Gwaii explicitly commenting on SOK n=9, and sac roe n=9.

3.1.6 Trust in sources of information

Trust in DFO stock assessment science varied between the two sample groups, with Haida Gwaii residents who commented on the respective knowledge sources placing high trust in TEK ($G=11$, $df=1$, $p<0.001$) and little trust in DFO science ($G=7$, $df=1$, $p<0.01$), while industry was evenly split regarding DFO science and non-significantly distrustful of TEK ($G_{TEK}=0.1$, $df=1$, $p=0.7$; see Figure 3.7). Sample sizes for these comments were again low due to lack of direct inquiry by interviewers, but many more respondents made statements regarding their level of trust in management by DFO and/or First Nations, without specifically addressing the knowledge sources used to inform each. This suggests that respondents' management preferences depend more on their trust in these institutions' motives than do their perceptions of what knowledge sources are legitimate.

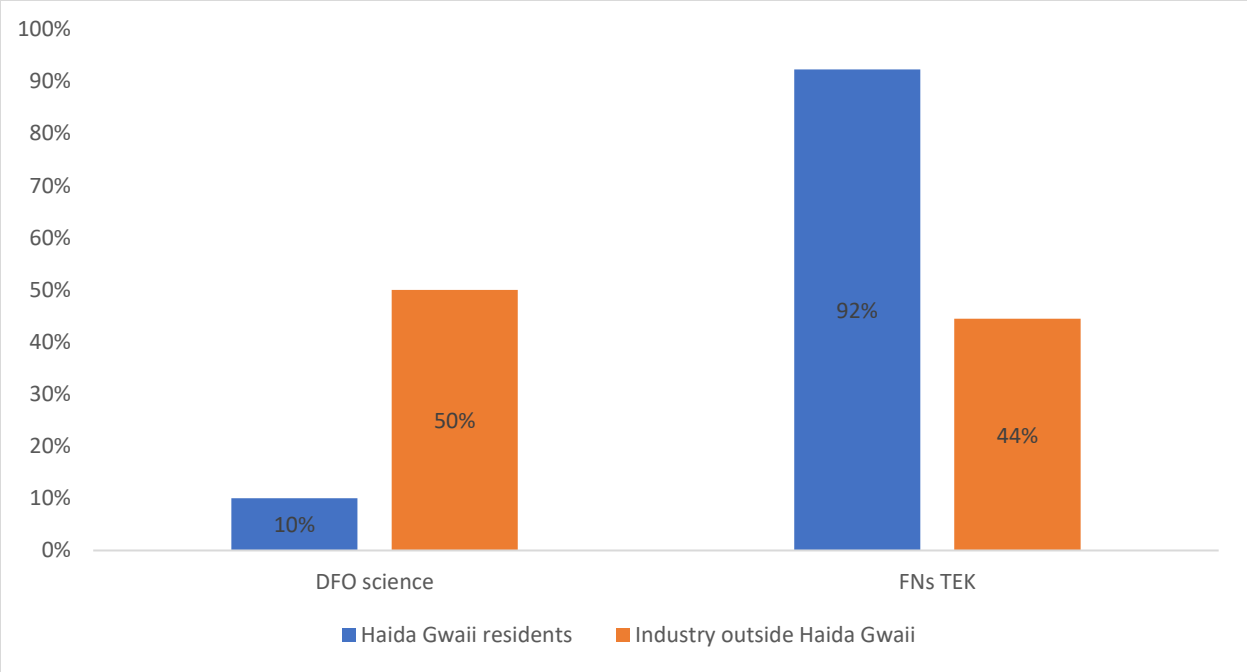

Figure 3.7: Percentages of respondents who trust DFO stock assessment science and First Nations' TEK, out of those respondents volunteering statements of trust/distrust in each, by sample group. Haida Gwaii residents DFO science n=10, First Nations TEK n=13; industry outside Haida Gwaii DFO science n=14, First Nations TEK n=9.

3.1.7 Preferences for Haida Gwaii fisheries governance

Respondents frequently volunteered opinions regarding the governance structure of fisheries management, often in response to the prompt, "How do you think herring fisheries should be managed in Haida Gwaii?" More than half of Haida Gwaii residents suggested greater involvement of CHN through some sort of co-management scheme with DFO, while over a quarter preferred full Haida control over the resource (there was some overlap of respondents, with 15% amenable to both options).

Industry respondents were less enthusiastic, with 29% favouring co-management between CHN and DFO (G=6, df=1, p=0.01) and only 4% agreeable to full control by CHN (G=8, df=1, p=0.004).

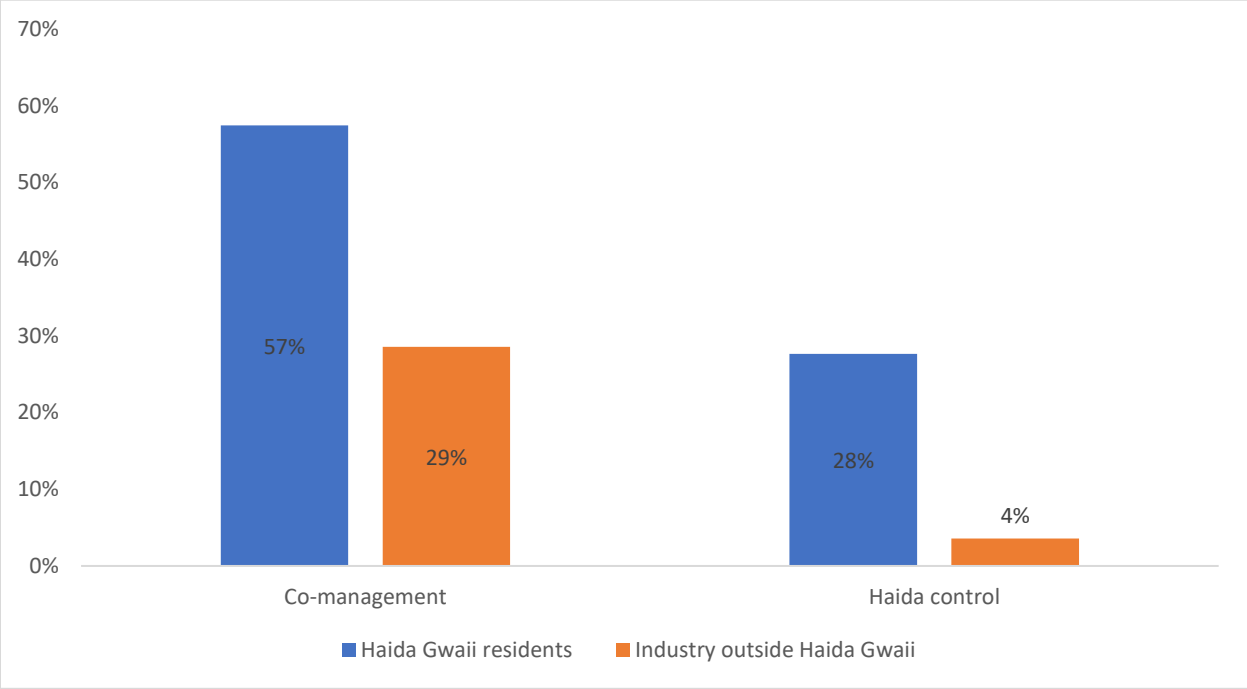

Figure 3.8: Percentages of respondents who volunteered a preference for CHN co-management of and full Haida control of herring fisheries in Haida Gwaii waters, by sample group. Haida Gwaii residents n=47, industry outside Haida Gwaii n=28.

3.2 Analysis of qualitative data

Throughout the interviews, a number of themes emerged as respondents answered prompts and elaborated on their personal views of herring fisheries science, socio-economics, management and governance. I address these themes within the analytical framework introduced in Section 1.2.4, dividing them between descriptive and normative concerns.

3.2.1 Descriptive issues

3.2.1.1 Stock assessment

While attempts to glean perceptions of absolute and relative stock size fell short due to the lack of explicit statements from respondents, many comments arose regarding the assessment of the Haida Gwaii herring stock. Haida Gwaii respondents had relatively little to say regarding the methodology of data collection or analysis by DFO, perhaps because CHN has been involved in spawn survey operations with DFO for the past few years (DFO 2015, 2016). Industry respondents, on the other hand, expressed skepticism that the current data collection program for Haida Gwaii is adequate, citing a lack of effort in

both acoustic and spawn surveys, and perceived conflict of interest in CHN's oversight of the spawn survey. They also expressed confusion and some qualms over the modelling methodology, particularly regarding the transition from AM2 to AM1. Some industry respondents cast more fundamental doubt on the reliability of forecasting models in general, indicating preference for direct estimation of herring stocks via acoustic surveys immediately prior to the roe and SOK fisheries.

Respondents disagreed over the impact of the SOK fishery upon herring stocks, with Haida Gwaii residents and some industry members believing strongly that the impacts were negligible, while other industry respondents questioned that assumption. Skeptics felt that mortality caused by closed pond SOK operations led to far higher mortality of spawning herring than claimed by advocates, through direct injury and through increased transmission of viruses and/or parasites. Some also believed local disappearances of annual spawning aggregations could be due to closed pond SOK harvests directly extirpating an entire stocklet's age 0 cohort (though the term "stocklet" was never used in this context; see following Section 3.8.1.2), polluting the spawning habitat with dormant viruses or fish carcasses, and/or overharvesting local kelp beds. Agreement was universal that open pond SOK operations result in less mortality and habitat degradation than closed pond.

3.2.1.2 Stock spatial structure

Respondents from Haida Gwaii and industry both tended not to discuss the population structure of herring extensively. Some Haida Gwaii respondents lamented the lack of spawning aggregations in areas once known for their reliability, typically blaming commercial overharvest in the past. One retired SOK fisherman there suggested a more appropriate criterion for evaluating stock abundance would be spawning presence across all historic spawn sites: "They [DFO] don't look at where the herring used to be. They just go by percentage. […] I'd like to see herring in all these places." Few, however, explicitly addressed whether such local spawn aggregations are comprised of genetically distinct stocklets. Industry respondents who addressed the issue refuted the idea of stocklets categorically. As one commercial seine fisherman from the Greater Vancouver area explained: "I mean there are places that they go because the substratum is what they like to spawn on. Is it the same herring that was there in the year before? I don't think so."

3.2.1.3 Ecosystem interactions

The role of herring as a forage species was emphasized by respondents in Haida Gwaii and industry alike. Those in Haida Gwaii often referenced the presented value of Interconnectedness to discuss ecosystem interactions involving herring, and often implied that the abundances of its predators are

positively correlated with its own. By extension, overfishing was seen as a threat not just to herring but to higher trophic level species as well. Some industry respondents professed skepticism towards fishing's impacts, with one retired seine fisherman from Greater Vancouver citing Hilborn et al. (2017) to claim that commercial fishing of herring had limited effects upon predator species. Industry respondents generally agreed that bottom-up, oceanographic effects are the primary driver of herring populations in BC, while many Haida Gwaii respondents indicated that environmental factors are likely responsible for the lack of HG stock recovery in the absence of fishing pressure.

Top-down effects of predation upon herring stocks also arose in discussions of food-web interactions. Industry members complained about the situation in the Gulf of Georgia, where California (*Zalophus californianus*) and Steller sea lion (*Eumetopias jubatus*) populations have increased recently (Wiles 2015, Gearin et al. 2017, Harvey et al. 2017). They feel the impact of so many pinnipeds feeding on herring is likely to be large over time, though Haida Gwaii has not experienced the same population growth. A handful of residents there, however, see predation by humpback (*Megaptera novaeangliae*) and grey whales (*Eschrichtius robustus*) as a significant impediment to herring's recovery (though grey whales are not predators of herring; Kumar et al. 2016). One man, an historian on Haida Gwaii, recounted his theory of whale predation:

> *"[…] When we started losing our herring roe-on-kelp is when the grey whales started entering the inlet. There was one or two at a time, gradually built up over time to like what [a fisherman from Haida Gwaii] was saying, about 80-something he counted in the inlet at one time. To me, after that blitz, we started losing all our herring and it still hasn't recovered. I believe this would be mid-90s when all that happened."*

3.2.2 Normative issues

3.2.2.1 Appropriate biomass cutoff thresholds in ecosystem-based management

Just as respondents expressed a range of beliefs about herring life history, ecosystem interactions, and fisheries' impacts, they also exhibited a range of preferences for how these considerations ought to influence management objectives. Industry members who felt that the effects of SOK harvesting are underestimated tended to reject the proposition to manage SOK and sac roe fisheries with different thresholds and/or harvest rates, while Haida Gwaii respondents who saw SOK as a less impactful fishery

disagreed. The perception of herring's importance in the food web of northern BC also seemed to influence preferences for the management of the respective fisheries, with those who feared knock-on effects from herring fisheries advocating higher thresholds, and those dismissing such effects more inclined to favour the status quo. For respondents in both samples, the perception that excessive predation threatened herring recovery warranted at least a scientific consideration of marine mammal culls. Those who suggested this tended to agree that any cull would be ethically and/or politically tricky, and that First Nations might have greater moral authority to carry it out following traditional practice.

3.2.2.2 Access, allocation and distribution of fishery benefits

Beyond the issues of ecological sustainability, socio-economic considerations arose often in interviews. Haida Gwaii respondents tended to resent the distribution of benefits from the sac roe fishery and its related processing and distribution, in which few locals work. As many see it, any sac roe fishery opening would result in negligible economic benefit to the community, while potentially ruining locals' ability to harvest SOK for FSC purposes. This poorly perceived cost-benefit ratio was the primary rationale for many who chose no fishery, or Rule A, or commercial SOK only, or Rule B. Additionally, many Haida Gwaii respondents questioned the perceived waste in the end use of sac roe fish carcasses, giving ethical preference to SOK over sac roe as a result.

Most industry respondents had fewer concerns regarding the ethicality of product end use, but many did voice complementary concerns over the distribution of benefits in herring fisheries. Primary amongst them was the concentration of access in the hands of a few large processors, with Canadian Fish Company (Canfisco) singled out most often. Independent fishers complained that Canfisco and other processors use their ownership of licenses to dictate terms and unduly influence management decisions. One gillnet fisherman from Greater Vancouver explained: "They lend a fisherman money and then they have what's been called a trawling agreement […] [T]he fishermen now have to deliver their fish only to [Canfisco…] It's a lot more control than you can show on paper." Multiple fishers suggested that owner-operator clauses, which require license owners to also fish their quota allocation, could alleviate many of the problems independent fishers face. Processors and some fishers, on the other hand, viewed the state of the industry as an ethically neutral product of fair business practices. They extolled the benefits produced by sustaining employment during otherwise slow fishing months, and the precautionary measures taken in concert with DFO to set annual total allowable catches (TACs) lower than recommended by the Department's harvest control rule.

Other industry members saw the progression toward greater accommodation of First Nations' complaints (such as in the Central Coast) as a threat to their own access of commonly owned resources. In this view, herring stocks belong to the Crown, and should be managed for the benefit of all Canadians (cf. Pitcher et al. 2017). They felt the decline of First Nations' participation in herring and other commercial fisheries may underlie much of the struggle for greater sovereignty over resources in coastal First Nations' territories; thus believing well-managed fisheries that provide economic opportunities for all participants would be the fairest and surest solution.

3.2.2.3 Process of decision making in management

A common perception amongst Haida Gwaii respondents was that DFO herring management decisions unfairly favoured the interests and advice of the fishing industry, concentrated in BC's Lower Mainland, over those of First Nations further up the coast. DFO was viewed as an untrustworthy extension of the interests of herring processors, who placed short-term profits over long-term sustainability and the concerns of small communities. This sentiment was echoed by one gillnetter from Greater Vancouver, who felt industry capture of management threatened the interests of commercial fishers as well:

> *"When you go there [to a HIAB meeting] it used to be all fishermen and a couple of processors, now it's basically all processors and a few fishermen. The roles have changed and they dominate the advisory board, they dominate the fisheries, they dominate the licenses[…] So that's a huge thing and they have a huge influence on DFO and they basically tell the advisory board what they want for tonnage[…]- they basically lay out what should be caught."*

At the same time, other fishers and processors complained that bilateral consultations between DFO and First Nations circumvent the transparent nature of HIAB and IHHPC meetings, and felt that IHHPC is itself an unnecessary departure from science-based management. They saw any attempt by DFO to accommodate interests of groups other than the fishing industry as an intrusion of politics into what was previously a purely science-driven decision-making process, where the only objective was the long-term sustainability of herring stocks.

3.2.2.4 Governance of herring fisheries

Residents of Haida Gwaii tended not to directly criticize the science used by DFO, but directed their distrust toward the Department's management. Given their general trust in TEK, their views on the fisheries' socioeconomic benefits, and their broad disdain for current management decision-making, it

follows that Haida Gwaii respondents view traditional Haida values and objectives as better guides to sustainable and equitable management. Many Haida referenced their ancestors' resource management on the islands to reinforce their claims, while Haida and non-Haida respondents argued that local management would inherently be more responsive to the needs of the community and the resources it relies upon. In many respondents' rationales for their scenario and rule choices, herring management seemed a symbolic fight; a proxy battle for many other instances of past injustice toward the Haida Nation and/or a reaffirmation of Haida rights and title.

Though roughly a third of industry respondents expressed sympathy for greater indigenous and/or local sovereignty (Figure 3.8), more believed the sole authority for fisheries management in Canadian waters lay with the federal government. They regarded the rule of law as necessary for resolving the disputes at hand, and did not believe First Nations held rights to herring resources other than those for FSC (or were agnostic to that question). One gillnetter expressed frustration over the battle for authority, but admitted that he would appreciate some clarity from the court system on the issue:

> *"Our constitution is very ambiguous and it can be interpreted to say that they [First Nations] do have those rights. […] that authority I would love to know, because if the Ahousat band, if they all own those herring and their roe, I want to know. Then maybe I can make a deal with that band and go fishing. If Canada owns those fish and I have to go to Canada to get the rights, then Canada should be saying, 'Okay, you got your 100 ton quota, go fish it. And if those Indians try to stop you, we'll use the resources of Canada to protect you.'"*

4 Discussion

This chapter summarizes and interprets the results presented in Chapter 3, drawing upon the background and theoretical framework presented in Chapter 1. I first address how the data collected and analyzed here help answer the four questions posed in Section 1.4, then discuss the limitations of this study. Having acknowledged its caveats, I then describe potential applications of my research to BC herring management. I conclude by discussing broader issues raised by this research, regarding the ethical practice of science in a democratic fisheries management system.

4.1 Addressing the questions

4.1.1 What values are important to stakeholders?

The differences were insignificant between Haida Gwaii community members' and industry respondents' value prioritizations. Both samples indicated that Respect and Responsibility stood above the rest, that Sanctity was less important, and that all others were generally on par. Despite the apparent agreement over values prioritizations, however, the samples diverged sharply in their preferences for management scenarios, rules, threshold levels and governance arrangements regarding Haida Gwaii herring fisheries. How do we reconcile these seemingly incongruous results?

One possibility is that respondents' choices for values were under-defined, and lacking a means of measuring how well each value is realized in different scenarios (Gregory et al. 2012). Were respondents given criteria, defined in terms of how each value manifests in outcomes, against which to rate each scenario, results may have proved more differentiated, and helped also to bridge the gap between respondents' values and their scenario preferences (see also Lam 2017). Translating values or principles into measurable objectives is a key component of the structured decision making approach (Gregory et al. 2012) and has proven effective in other environmental management contexts (e.g., Gregory et al. 2008, Failing et al. 2013).

The values-to-scenarios exercise conducted during interviews attempted to explore this values-preferences relationship in a different way. Results, however, reflect a few shortcomings of the procedure. Respondents were not limited in how they rationalized the applicability of values to each scenario, and some chose to associate highly ranked values with their least-favoured scenario(s) to highlight what they felt was lacking. The respondents' distributions of values across scenarios varied widely, also, as some respondents felt it appropriate to associate each value with a single scenario, while others associated one or more value with multiple scenarios. Some simply placed all values upon their

preferred scenario, without much elaboration. This apparent heterogeneity in the cognitive processes underlying responses casts doubt on the explanatory power of quantitative analysis presented in Lam et al. (*submitted*), where the correspondence between stated and value-based scenario preferences is given as 73% correspondence (Cohens Kappa = 0.61). However, the exercise itself spurred many respondents to explicitly consider how their values are manifested in various aspects of the herring fisheries. The qualitative themes presented in Section 3.2.2 draw in part from comments made during this exercise, validating the usefulness of asking respondents to describe scenarios in terms of their values, and providing further data for any investigation that attempts to associate values orientations with preferences.

Another hypothesis is that the agreement upon values is superficial. It could be that respondents interpreted the different values in very different ways, such that Respect for one respondent meant moderation in consumption, and, for another, honesty in interpersonal interactions. The semantic differences between these two interpretations would not be captured, then, by the quantitative ranking system used here. They could, though, be inferred from the descriptions respondents gave to each value upon prompting. A non-rigorous examination of these descriptions did reveal a variety of interpretations for each value, with some respondents simply accepting the value as described on its card, some illustrating it through personal anecdotes, and others discussing it in the abstract.

A potentially fruitful avenue of investigation lies in this diversity of interpretation. Statements made by respondents regarding each value could be coded to fit within one of the four broad value orientations described by Schwartz (1994), the "group-grid" orientation space of Douglas (1970), environmental value priorities of Dietz et al. (2005), or other moral/value/ideology classification systems (e.g., Kluckhohn and Strodtbeck 1961, Graham et al. 2012). One could then test the hypothesis that a respondent's values orientation correlates with their preferences for management, or with other variables. Given prior evidence that such values orientations can predictably affect individuals' preferences (Dietz et al. 2005; Kahan 2007), this could offer further insight into how the normative beliefs of stakeholders in Haida Gwaii herring fisheries influence their preferences for management.

4.1.2 What preferences do stakeholders have for herring management and governance in Haida Gwaii?

Haida Gwaii respondents unanimously rejected the status quo management rule (Rule C), instead favouring rules in which commercial SOK and sac roe fisheries receive different treatments, either by banning sac roe entirely (Rule B) or by managing the two with separate harvest control rules (HCRs;

Scenario D). Their counterparts in industry, meanwhile, rejected with one voice the proposed rule allowing commercial SOK only (Rule B), and preferred instead the current regime (Rule C). And, despite initial reactions amongst Haida Gwaii respondents, an indefinite moratorium on all commercial herring fisheries (Rule A) proved unpopular to both samples.

I present generalized conclusions on both samples' management and governance preferences for Haida Gwaii below. These conclusions are derived from the categorical results in Section 3.1 and qualitative data from Section 3.2. Each sample's rationales are broken down into five areas of concern: ecological, cultural, economic, governance, and waste/end use.

4.1.2.1 Haida Gwaii respondents' preferences

The local community opposes the current management regime, and prefers a system which prioritizes commercial SOK over sac roe fishing, for the following reasons:

4.1.2.1.1 Ecological

Haida Gwaii residents perceive an unacceptably high risk to the long-term health of herring stocks, fearing that improperly managed commercial sac roe fisheries could overfish stocks and result in local extirpations. They see this as a threat both to the herring and to its predators, and place high intrinsic and/or existence value upon the ecosystem's continued functioning. They feel commercial SOK results in an acceptably low risk of overharvest, and is therefore viable at lower stock levels than is sac roe fishing.

4.1.2.1.2 Cultural

They perceive, as a result of those reasons in Section 4.1.2.1.1, an unacceptably high risk to traditional SOK harvesting opportunities and to other FSC and commercial harvesting opportunities for predator species, such as halibut. They see this as a threat to their culture and wellbeing, and place high instrumental value in the ecosystem services which provide these benefits. Again, they feel commercial SOK results in an acceptably low risk of ecosystem disruption, and complements the FSC SOK harvest.

4.1.2.1.3 Economic

Residents perceive an unacceptable imbalance between local and distant benefits and costs from commercial sac roe fishing, seeing most economic benefits accruing to license holders in the Lower Mainland of BC, while local residents bear the risks described in Sections 4.1.2.1.1 and 4.1.2.1.2. They see this as detrimental to the local community's wellbeing while also being intrinsically unfair. Due to the downward trend in herring roe market prices, they perceive the enterprise of sac roe fishing in

Haida Gwaii to be impractical, regardless of its permissibility. They feel the commercial SOK fishery provides greater economic benefit to its mostly local license holders, and results in acceptably low risks.

4.1.2.1.4 Governance

They feel that DFO has no rightful authority to unilaterally manage waters claimed by the Haida Nation, and that legitimacy in fisheries management requires at least a cooperative arrangement involving CHN. This perceived lack of legitimacy stems from diminished confidence in DFO's ability to manage stocks for sustainable harvest, as evidenced by past stock collapses, and from the belief in CHN's rightful authority over local waters, as part of the Haida Nation's unceded rights and title.

4.1.2.1.5 Waste/end use

Residents judge the end-products of sac roe fishing to be unacceptably wasteful, due to the use of processed herring carcasses for fishmeal (see also PWIAS Herring Roundtable: *The Ethical Challenges of the Herring Food Web and Value Chains*; referenced in Preface). They feel FSC, commercial SOK and the food herring fishery are more acceptable in that their end-products are destined for direct human consumption, with little by-product.

4.1.2.2 Herring industry members' preferences

Members of the herring industry outside of Haida Gwaii, meanwhile, largely support the current management regime and oppose suggestions for permanent exclusion from either the sac roe or SOK fishery in Haida Gwaii, for the following reasons:

4.1.2.2.1 Ecological

They perceive an acceptably low risk from commercial roe and SOK fishing to the long-term health of herring stocks. They feel the current HCR has been successful at preventing overharvest of herring stocks throughout BC since its implementation, and therefore see no need to alter it. They see natural ecosystem processes as more influential than fisheries upon herring stocks. They believe the risk of commercial SOK harvesting (closed-pond operations, at least) to herring stocks is underestimated by DFO and SOK proponents, and therefore oppose suggestions that it receive preferential management. They place somewhat lower intrinsic/existence value upon herring and its ecosystem, but high instrumental value on ecosystem services for the economic and other benefits supplied to fishers, industry, and the larger economy.

4.1.2.2.2 Cultural

As in Section 4.1.2.2.1, industry members perceive the risks to herring stocks and their predators to be acceptably low, and that natural ecosystem processes bear blame for any failure of FSC harvests. While they support the recognized rights of the Haida and other First Nations to FSC harvest, within sustainability bounds determined by DFO science, they view suggestions for preferential management of commercial SOK as unfairly favouring First Nations' commercial access over that of non-First Nations. They see correlation between declining participation of First Nations in commercial fisheries and increased conflict over access rights, and suggest that greater exercise of First Nations' existing commercial rights, within the existing management system, could lead to greater cultural value for First Nations as well. They are proud of their own non-indigenous fishing culture, though they tend to speak of it primarily as a means of income, and therefore see the cultural value of fishing inextricably tied to its economic performance.

4.1.2.2.3 Economic

Industry respondents generally agree that the concentration of licenses in the Lower Mainland, and among a handful of processors there, is partly the result of reduced employment in all BC fisheries, the causes of which are many and complex. Views are mixed, however, on whether that concentration was the inevitable and ethically neutral outcome of a shrinking industry, or whether those processors, Canadian Fishing Company chief among them, unfairly leveraged their size and regulatory influence to bolster and maintain their control over access and prices. Those who view the processors' clout as unfair place much blame upon them for the decline in economic and cultural benefits from commercial fishing among smaller communities on BC's coast, and view the processors' interests as myopic and detrimental to the long-term sustainability of herring fisheries. These respondents, typically independent or retired fishers, tend to view First Nations' complaints with more sympathy. Those who see no ethical issues with the processing bloc's influence view the criticism as misdirected, and perceive said influence as greatly overstated. They feel there is adequate opportunity for all parties to gain from appropriately managed herring fisheries.

4.1.2.2.4 Governance

While sympathies among industry respondents are mixed in regard to the legitimacy of the Haida's and other First Nations' claims to commercial access rights and territorial sovereignty, legal uncertainty over those claims is perceived as a significant obstacle to resolution of the herring conflicts in Haida Gwaii and other First Nations' territories. Those who interpret Canadian law to extend license holders' access

to all waters claimed by the Crown are opposed to the notion that First Nations could exclude access to their territorial waters. They see the federal government, through DFO, as the only legitimate authority over fisheries in Canada, and favour strict enforcement of access rights in future conflicts. Those who side with First Nations over access believe claims to Aboriginal rights and title are legitimate, and/or feel local residents are better suited to manage local waters than distant government bodies. They see little to gain from opening commercial fisheries in Haida Gwaii or other contested areas, because such operations would be only marginally profitable, would risk further conflict, and/or would be disrespectful of First Nations whose claims are infringed.

4.1.2.2.5 Waste/end use

Industry members are generally less concerned with the ethicality of herring end-products, though some gillnetters view their gear type as more selective than purse seines, and therefore less wasteful of male herring. Some in the industry do have qualms about the recently increased participation in the herring food and bait fishery, whose exports are believed largely destined for fishmeal. Whether those concerns are of an ethical nature is unclear, as any change in markets would be economically noteworthy to market participants.

4.1.3 What perceptions do stakeholders hold regarding herring stocks in Haida Gwaii?

There were not enough explicit comments made by respondents to draw any conclusions regarding their perceptions of absolute B_t or B_0 sizes, nor their perceptions of B_t/B_0, relative to DFO's estimate at that time. It was thus often difficult to discern whether a preference for present fishery closure reflected a perception that the stock was too small to fish because: 1) its biomass was smaller than required by DFO's HCR; or 2) its biomass equaled or was greater than DFO's threshold, but the true equilibrium unfished biomass was larger than DFO's estimate; or 3) the biomass was smaller than DFO's threshold *and* true B_0 was larger than DFO's estimate. Most respondents appeared agnostic as to the absolute numbers for either metric, and it may be unrealistic to expect even well-informed lay people to have precise or accurate perceptions of such large, mostly unseen amounts of fish.

Haida Gwaii respondents nonetheless expressed the opinion frequently that the local herring stocks were not large enough to support a sac roe fishery. While non-biological issues, such as the ethicality of the end-product, likely influenced a number of these opinions, it remains clear from their comments that residents of Haida Gwaii perceive higher risks associated with sac roe fishing than do most commercial fishers. This could stem from the perception of many that the fishery's risks and benefits are not borne equally between the two groups, or it could reflect inherent cultural differences in risk

perception (Douglas 1970; Slimak and Dietz 2006; Kahan et al. 2007). A more appropriate analysis to undertake in the future, then, would be to code respondents' statements regarding risk attitudes and perceptions, and test for any correlations with their value orientations (as proposed in Section 4.1.1). This would allow insight on how respondents' risk perceptions relate to their values, and whether their management preferences reflect those perceptions, as well.

4.1.4 How do stakeholders' normative interests influence their perceptions of the fisheries?

As discussed in Section 4.1.2, respondents did not provide enough explicit comments to confidently gauge their perceptions of herring stock size, meaning only limited conclusions may be drawn as to how their normative interests influence their perceptions. I have already speculated that respondents' values orientations, levels of trust in DFO management, and perceptions of risk may all influence their preferences for management and governance of fisheries in Haida Gwaii; there is little direct evidence from these narrow results, however, that stock size perceptions are influenced by normative beliefs. Where respondents did disagree with DFO's stock size estimates, lack of trust in the scientific methodology appeared to be the cause. Among industry respondents volunteering expressions of trust in knowledge sources, the split in opinion regarding both First Nations' TEK and DFO science could reflect greater appetite than acknowledged by HIAB representatives for more collaborative data collection and knowledge generation. On the other hand, for those industry respondents who preferred the status quo but did not voice an opinion as to whether fisheries should soon open, a tendency to defer to DFO's judgement on the matter suggests trust in the Department's management as well as science.

4.2 Limitations of this study

4.2.1 Sample size and representativeness

The Haida Gwaii sample contained 47 respondents and the sample of industry members outside Haida Gwaii, 28, representing populations of approximately 3500 (Statistics Canada 2017) adult Haida Gwaii residents and approximately 400 active and retired commercial herring fishers and processors (from industry respondents' estimates; DFO does not collect data on employment). These sample sizes are not large enough to produce high confidence in any extrapolation to their respective populations (Krejcie and Morgan 1970), if their members are selected randomly. But respondents in both groups were selected non-randomly via judgement sampling (Marshall 1996), with the intention of compiling samples representing the variety of viewpoints in their respective populations. Because there is no way of knowing the actual distribution of viewpoints across each population, there is no guarantee that the

distributions of sampled data match those of the populations; therefore, quantitative results should not be regarded as precise estimates of proportionality in the populations. Because respondents were purposefully selected to maximize range, however, the accuracy of the sentiments identified here is less uncertain; the wide spectrum of values, perceptions and preferences gathered from qualitative analyses is likely to represent the breadth and detail of opinion found among respondents' peers.

4.2.2 Potential bias in interview materials

The images used to illustrate the value cards and scenarios came from the repertory of Haida artist April White, and were chosen by the artist to represent their associated themes as she saw appropriate (see Appendix C), with close collaboration from Drs. Lam and Pitcher. These associations reveal her own interpretations of the presented values and scenario outcomes; e.g., the status quo, or Hard of Herring, scenario image features an ocean conspicuously devoid of prey for the single orca in the frame. These interpretations could be perceived as more appropriate by individuals whose cognitive processes resemble Ms. White's than by those who think differently; in the status quo scenario example, those who similarly associate a near-empty ocean with commercial herring fishing could find themselves primed to dislike the scenario that image depicts. Conversely, the traditional Haida imagery used in Ms. White's work could induce negative reactions from individuals who associate such indigenous art with perceived indigenous objectives in herring fisheries. This seemed to be the case for one seine fisherman from Greater Vancouver, who had difficulty with the values prioritization exercise. As he explained: "[…] it's not my culture to pick up and read that stuff. I mean it's all nice artwork, something I'd hang on my wall, but to interpret the meaning of it…" The artwork for him raised questions about the objectivity of the research project itself, as it did for at least four other industry respondents.

Additionally, the choice of values from Haida and Western sources could be seen as a source of bias. Haida values included Haida translations and interpretations from Jones et al. (2010), and were thus distinguishable from the Western values cards, whose descriptions were shorter, not explicitly linked to natural resource stewardship, and derived broadly from sources in the moral psychology and applied ethics literatures (Mepham and Tomkins 2006, Bremer et al. 2012, Graham et al. 2012). The Haida values resonated strongly with many Haida and other First Nations respondents (and many non-First Nations respondents) who seemed to feel strong cultural connection to the ideals expressed and the language used to express them. Some non-Haida Gwaii industry respondents, however, took exception to the perceived implication that indigenous cultures valued fisheries resources more so than Westerners. For example, the written description of Responsibility states: "We [Haida] accept the

responsibility passed on (to us) by our ancestors to manage and care for the sea and land. We will ensure that our heritage is passed on to future generations[,]" provoking an indignant response from one respondent. The active fisherman from Greater Vancouver cited a retired colleague of his (also interviewed for this study) who claimed Croatian fishing heritage spanning 300 years, along with the wide variety of backgrounds BC commercial fishers hail from, to highlight the cultural value of fishing to non-First Nations individuals.

Finally, it is my personal opinion, and not of my co-authors of Lam et al. (*submitted*), that the names given to the four presented scenarios most likely conveyed bias to respondents, who could immediately perceive that the status quo scenario (Hard of Herring) was labelled pejoratively. Respondents from Haida Gwaii seemed to have few problems with these titles, but industry respondents were less acceptant. Many who chose the status quo remarked upon its name while doing so, signaling further suspicion of the project's intentions.

Lacking a proper randomized control group, I can offer no evidence that the methodology did not introduce bias in responses. Happenstance did, however, offer a sort of pseudo-control: four industry respondents were given unillustrated, unelaborated descriptions on paper for each value, in lieu of the value cards, due to my misplacement of interview materials. These respondents, plus two others, also did not receive illustrated scenarios; they instead were given descriptions of each scenario, with scenario names omitted, before selecting their preference. Though not randomized controls, these small subsamples' value prioritizations and scenario preferences were not significantly different from their fellow industry respondents' ($G=0.7$, $df=3$, $p=0.9$), which suggests there was no strong bias on categorical results arising from the images, descriptions and nicknames. Additionally, many respondents in Haida Gwaii were asked specifically whether the card images, descriptions, or nicknames had influenced their decision-making; only one admitted the possibility.

While this evidence certainly does not rule out bias in the methodology used, I contend, along with my co-authors of Lam et al. (*submitted*), that any potential for bias does not change the validity of the conclusions presented here. Respondents in any study make statements and choose options presented to them based upon a milieu of conscious and unconscious inputs; the affective responses to environmental cues, including appearance and behavior of the interviewer, location of the interview, and other, uncontrollable variables, contribute often heavily to the responses offered. Each respondent came to these interviews with pre-conceived notions of BC herring fisheries and the conflicts between First Nations and the industry/DFO, and no framing of the questions asked within could prove neutral to

the variety of viewpoints encountered. Instead, the questions and materials used here were carefully chosen to reflect and complement the values and preferences communicated publicly by the CHN prior to this research project, to encourage participation by members of the Haida Gwaii community (see Section 4.2.1), and to facilitate discussion of relevant issues through a culturally sensitive framing (Lam et al. *submitted*; cf. Bremer et al. 2012, 2016).

Subsequent expansion of the PWIAS Solutions Initiative project to include industry stakeholders outside Haida Gwaii obligated that the same framing be used, to allow direct comparison of the two samples. This comparison proved informative: that the framing appears to have been somewhat divisive was no surprise, and provided an opportunity to examine the qualitative effects of cultural identity upon respondents' values, beliefs and preferences. That it provoked often pointed skepticism of this project's intent begs a deeper examination of the role scientific research plays in disputed public issues where multiple perspectives compete for dominance (Raman et al. 2018), and highlights the difficulty (or impossibility) of achieving true objectivity in research (see Section 4.4).

4.3 Usefulness to management/conflict resolution

4.3.1 How can DFO science increase stakeholder confidence in assessments?

DFO's stock assessment methodology aroused skepticism in some and perplexed more of the respondents in this study, who voiced concerns about the objectivity and quality of data collection and accuracy of results. Given the distrust between industry/DFO and First Nations such as the Haida, greater face-to-face collaboration involving all parties could help build working relationships and foster mutually agreed-upon knowledge bases for making decisions, as prescribed by PNS. The HTWG is an example of this in practice, where quantitative experts from First Nations, DFO, academia and elsewhere have cooperatively examined the AM1 and AM2 models for their relative strengths and weaknesses, leading to the publication of both models' results in recent years' herring IFMPs.

Progress in this area could continue with bipartisan discussions as to the appropriate estimate of B_0 for Haida Gwaii and other stocks, as this is a contested parameter (Surma et al. *in review*), and one that assessment models rely heavily upon. The disagreements between Haida Gwaii residents and industry members over the spatial structure of herring stocks and the potential ecosystem impacts of herring fisheries also require further evidence to settle scientifically. The willingness of DFO science to consider and incorporate findings from academic and other external researchers (e.g., Smith 2017, Pitcher et al.

2016, Lam et al. *submitted*) will be crucial if all parties are to agree upon the descriptive nature of herring stocks.

Another avenue for cooperation is in preseason acoustic surveys, in which many industry respondents placed greater faith than in model forecasts. Test vessels staffed with technicians from industry, local First Nations and DFO science could collaboratively establish survey protocol that all parties view as appropriate and collect data that all parties agree is impartial and accurate. The multi-party composition of such survey cruises could also facilitate personal relationship building, which is essential for trust building between stakeholder groups and management.

4.3.2 Connecting with ecosystem modelling approaches

This research was connected to an ecosystem-modelling component of a larger project (Lam et al. *submitted*, Surma et al. *submitted*; see Preface also), with the intention of this values-based approach complementing an ecosystem-based approach to fisheries management; the product being a values- and ecosystem-based approach to management (VEBMA; Lam et al. submitted). The merit of the VEBMA approach is to provide decision-makers tools for assessing both the modelled impacts of alternative fishing policies upon an ecosystem, and the predicted responses of stakeholder groups (Lam et al. *submitted*). This allows those decision-makers to choose policies considering both the descriptive effects upon herring and other species and the normative concerns of stakeholders, maximizing both ecological and political objectives. In BC, the VEBMA approach could allow DFO managers to better balance mandates for conservation of multiple species, and economic productivity, while considering stakeholders' values and interests (Lam et al. *submitted*).

4.3.3 How can the potential for future conflicts be minimized?

Most statements from Haida Gwaii respondents concerning the trustworthiness of DFO concerned the Department's objectives for management, rather than its scientific quality. If management is to adequately encompass all stakeholders' concerns, then, a significant gap in trust needs bridging. Haida Gwaii residents feel frustrated by the process of consultation they believe has led nowhere in the past, and desire more substantial involvement in the management of herring fisheries. As of now, the mandate of DFO includes the enforcement of a variety of legislation, most of which obligates sustainable harvest of fishery resources and avoidance of harm to ecosystem components; few, if any, hard criteria exist regarding the economic and social impacts of fishing. While IHHPC meetings provide opportunities to raise and debate issues of economic and social equity, more fruitful debate could come about if the central objectives of management were transparent, explicit and precise. This is the aim of the

methodology presented here: to foster inclusive, transparent and accountable decision-making (Lam et al., *submitted*).

The deeper issue of indigenous rights and title lies beyond the remit of DFO; this matter requires judgement from the Canadian court system before the legitimacy of DFO's versus First Nations' managerial authority can be established. The courts could resolve this issue and provide the benefit of certainty to all stakeholders, without DFO having to choose sides. In the meantime, allowing greater involvement by First Nations in the setting of fisheries objectives in their territorial waters would not necessarily concede authority, but would foster the trust needed to avoid further conflicts over fishing access.

4.4 Lessons for fisheries management elsewhere

I've demonstrated that, in BC's herring fisheries, disputes over descriptive issues couple with disagreements over normative concerns to produce a conflict full of uncertainty, value loading, multiple legitimate perspectives and high stakes (see also Lam 2016). The PNS paradigm of Funtowicz and Ravetz (1993, 2003) offers an approach to deal with these normative considerations that denies any privilege to one group's authority over others', and instead operates by incorporating all voices in resolving conflicts. Were DFO to acknowledge the legitimacy of other sources of knowledge, including First Nations' TEK, fishers' local ecological knowledge and external scientific research, progress could be made at establishing mutually agreed upon facts and mutually acceptable management objectives.

In fisheries management systems anywhere within democratic societies, the paradigm of PNS can help managers recognize the inescapable role of values in decision-making and the need for engagement with stakeholders to identify which values are pertinent. PNS demands that managers accept the plurality of knowledge sources in the fishery, and work cooperatively to identify knowledge that all parties can agree upon (Lam et al., *submitted*). This collaborative and public approach to solving problems in complex, high-stakes, highly uncertain situations is not only inherently democratic, but also pragmatic, sharing responsibility for sustainable management among all stakeholders (Lam and Pauly 2010).

4.5 Conclusion

The framework I introduced in this thesis extends a long line of thought regarding the proper roles of science and values. Weinberg (1972) and Dietz (2013) have argued for making explicit what questions science can and cannot answer when communicating results to the public. I cite these two authors in

particular because they made their arguments in different eras and while working in different fields. Though Weinberg's concerns lay mostly around issues of nuclear power and public safety, while Dietz's lie mostly around public perception of global climate change, both warn against the instinct of many experts and non-experts to conflate scientific expertise with moral authority. To avoid this pitfall, experts must explicitly separate facts from values and make clear, when advocating for one course of action over another, where their expertise ends and their personal, unprivileged values hold sway.

I have applied and broadened this prescription to the herring conflict in BC, where multiple groups, not just a Science and a Public, lay competing claims to both epistemic and normative authority. Following the above prescription requires an understanding of each group's epistemic beliefs and normative values; the research detailed in the previous chapters attempted to describe them. These personal values, perceptions of herring fisheries and preferences for management in Haida Gwaii will hopefully aid management to find points of potential rapprochement between industry and Haida Gwaii residents (and other First Nations communities in BC), and perhaps to identify areas of concern not previously voiced. I hope also that the findings from this case study prove useful in other management contexts, by emphasizing the utility in explicit demarcation of the descriptive and the normative, and in recognition of the PNS paradigm.

Works cited

Ahousat Indian Band and Nation v Canada (Attorney General). 2013. Pages 1–13.

Ainsworth, C. H. 2006. Strategic Marine Ecosystem Restoration in Northern British Columbia.

BC Ministry of Agriculture. 2011. 2011 British Columbia Fish Processing Employment Survey Results.

Beacham, T. D., J. F. Schweigert, C. MacConnachie, K. D. Le, and L. Flostrand. 2008. Use of Microsatellites to Determine Population Structure and Migration of Pacific Herring in British Columbia and Adjacent Regions. Transactions of the American Fisheries Society 137(6):1795–1811.

Beamish, R. J., A. J. Benson, R. M. Sweeting, and C. M. Neville. 2004. Regimes and the history of the major fisheries off Canada's west coast. Progress in Oceanography 60(2–4):355–385.

Benson, A. J., S. P. Cox, and J. S. Cleary. 2015. Evaluating the conservation risks of aggregate harvest management in a spatially-structured herring fishery. Fisheries Research 167(2015):101–113.

Berkes, F. 2012. Sacred Ecology. Routledge. 392pp.

Bradbury, J. A. 1989. The Policy Implications of Differing Concepts of Risk. Science, Technology, & Human Values 14(4):380–399.

Bremer, S., A. S. Haugen, and M. Kaiser. 2012. Mapping core values and ethical principles for livelihoods in Asia. Pages 419–424in T. Potthast and S. Meisch, editors.Climate change and sustainable development: Ethical perspectives on land use and food production. Waginingen Academic Publishers.

Bremer, S., M. M. Haque, A. S. Haugen, and M. Kaiser. 2016. Inclusive governance of aquaculture value-chains: Co-producing sustainability standards for Bangladeshi shrimp and prawns. Ocean and Coastal Management 131:13–24.

Brown, F., and Y. K. Brown. 2009. Staying the course, staying alive coastal First Nations fundamental truths: Biodiversity, stewardship, and sustainability. Page Biodiversity British Columbia.

Brown, K., M. Slett, and C. Humchitt. 2015. Presented at Pacific Herring Summit, Richmond, Canada, 2015. Accessed from < http://oceanmodelingforum.org/wp-content/uploads/2015/06/04_ Brown.pdf> on 8/27/2017.

Brown, R., M. Edgars, C. Jones, J. Russ, W. R. Jr, E. Sills, M. Stewart-burton, D. Brown, W. Davies, T. Greene, H. Jones, R. J. Sr, and R. Olson. 2011. Haida Marine Traditional Knowledge Study Volume 1: Methods and Results Summary 1:1–96.

Campbell, T. H., and A. C. Kay. 2014. Solution aversion: On the relation between ideology and motivated disbelief. Journal of Personality and Social Psychology 107(5):809–824.Canadian Charter of Rights and Freedoms, s 8, Part I of the Constitution Act, 1982, being Schedule B to the Canada Act 1982 (UK), 1982, c 11.

Canadian Press. 2015. Heiltsuk Nation ready to protect herring against commercial fishery. The Globe and Mail, March 26, 2015. Accessed from <https://www.theglobeandmail.com/news/british-columbia/heiltsuk-nation-ready-to-protect-herring-against-commercial-fishery/article23636646/> on 8/27/2017.

Cleary, J., A. Benson, N. Taylor, and S. P. Cox. 2016. Forage Fish Management and Conservation in the Salish Sea. Presented at Salish Sea Ecosystem Conference, Vancouver, Canada, 2016. Accessed at <http://cedar.wwu.edu/ssec/2016ssec/species_food_webs/94/> on 8/27/2017.

Cohen, G. L., J. Aronson, and C. M. Steele. 2000. When Beliefs Yield to Evidence: Reducing Biased Evaluation by Affirming the Self. Personality and Social Psychology Bulletin 26(9):1151–1164.

Council of the Haida Nation et al. v. Minister of Fisheries and Oceans. 2015. Pages 1–22.

DFO. 2007. A new ecosystem science framework in support of integrated management.

DFO. 2014. Stock Assement and Management Advice for British Columbia Pacific Herring: 2013 status and 2014 forecast.

DFO. 2015. STOCK ASSESSMENT AND MANAGEMENT ADVICE FOR BC PACIFIC HERRING: 2015 STATUS AND 2016 FORECAST.

DFO. 2016a. Pacific Region Integrated Fisheries Management Plan Pacific Herring November 7, 2016 To November 6, 2017.

DFO. 2016b. Stock assessment and Management Advice for British Columbia Pacific Herring: 2016 Status and 2017 Forecast. Page Canadian Science Advisory Secretariat.

DFO. 2016c. Sustainable Fisheries Framework. Modified 10/25/2016. Accessed from <http://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/overview-cadre-eng.htm> on 10/17/2017.

DFO. 2017a. 2016/2017 roe herring plan season review. Presented at Herring Industry Advisory Board meeting, Vancouver, Canada, May 10 2017.

DFO. 2017b. the selection and role of limit reference points for Pacific herring (Clupea pallasii) in British Columbia, Canada. Canadian Science Advisory Secretariat, Science Advisory Report 2017:030.

Dickey-Collas, M., R. D. M. Nash, T. Brunel, C. J. G. Van Damme, C. T. Marshall, M. R. Payne, A. Corten, A. J. Geffen, M. A. Peck, E. M. C. Hatfield, N. T. Hintzen, K. Enberg, L. T. Kell, and E. J. Simmonds. 2010. Lessons learned from stock collapse and recovery of North Sea herring: A review. ICES Journal of Marine Science 67(9):1875–1886.

Dietz, T. 2013. Bringing values and deliberation to science communication. Proceedings of the National Academy of Sciences 110(Supplement_3):14081–14087.

Dietz, T., A. Fitzgerald, and R. Shwom. 2005. Environmental Values. Annual Review of Environment and Resources 30(1):335–372.

Douglas, M. 1970. Natural Symbols. Psychology Press. 177p.

Ecotrust Canada, and Ecotrust. 2004. Catch-22: conservation, communities and the privatization of B.C. fisheries(November):41.

Ecotrust Canada, and T. Buck Suzuki Environmental Foundation. 2015. Caught Up in Catch Shares.

Failing, L., R. Gregory, and P. Higgins. 2013. Science, Uncertainty, and Values in Ecological Restoration: A Case Study in Structured Decision-Making and Adaptive Management. Restoration Ecology 21(4):422–430.

Fehr, E. 2009. On the Economics and Biology of Trust. Journal of the European Economic Association 7(2–3):235–266.

Fox, C. H., A. L. Jacob, C. T. Darimont, and P. C. Paquet. 2016. Pacific herring and fisheries management in Canada: A new era or repeated history? Ocean & Coastal Management 125:47–48.

Funtowicz, S. O., and J. R. Ravetz. 1993. Science for the post-normal age. Futures 25(7):739–755.

Funtowicz, S., and J. Ravetz. 2003. Post-Normal Science. Ecological Economics(Feb):1–10.

Gearin, P. J., S. R. Melin, R. L. Delong, M. E. Gosho, and S. J. Jeffries. 2017. Migration Patterns of Adult Male California Sea Lions (Zalophus californianus). Page U.S. Dep. Commer., NOAA Tech. Memo.

Government of Canada, and Council of the Haida Nation. 1993. Gwaii Haanas Agreement. Pages 1–10.

Government of Canada, and Council of the Haida Nation. 2010. Gwaii Haanas Marine Agreement. Pages 1–11.

Graham, J., J. Haidt, S. Koleva, M. Motyl, R. Iyer, S. P. Wojcik, and P. H. Ditto. 2012. Moral foundations theory: The pragmatic validity of moral pluralism.

Greba, L. 2015. Kitasoo/Xaixais Perspectives on Herring. Presented at Pacific Herring Summit, Richmond, Canada, 2015. Accessed at <http://oceanmodelingforum.org/wp-content/uploads/2015/06/03_Greba-herring-summit-presentation-Kitasoo.pdf> on 8/27/2017.

Gregory, R., L. Failing, and M. Harstone. 2008. Meaningful Resource Consultations with First Peoples: Notes from British Columbia. Environment: Science and Policy for Sustainable Development 50(1):36–45.

Haas, A. R., D. N. Edwards, and U. R. Sumaila. 2016. Corporate concentration and processor control: Insights from the salmon and herring fisheries in British Columbia. Marine Policy 68:83–90.

Harvey, G. K. A., T. A. Nelson, C. H. Fox, and P. C. Paquet. 2017. Quantifying marine mammal hotspots in British Columbia, Canada. Ecosphere 8(7):e01884.

Hauser, L. 2015. Pacific Herring in Space and Time: scientific evidence for population structure in a highly dynamic species. Presented at Pacific Herring Summit, Richmond, Canada, 2015. Accessed at <http://oceanmodelingforum.org/wp-content/uploads/2015/06/13_Hauser-Herring-Summit-Talk.pdf> on 8/27/2017.

Hay, D. E., and P. B. Mccarter. 2013. Herring Spawning Areas of British Columbia Herring: a review, geographical analysis and classification.

Hilborn, R. 2002. The dark side of reference points. Bulletin of Marine Science 70(2):403–408.

Hilborn, R. 2007. Managing fisheries is managing people: what has been learned?. Fish and Fisheries 8: 285–296.

Hilborn, R., R. O. Amoroso, E. Bogazzi, O. P. Jensen, A. M. Parma, C. Szuwalski, and C. J. Walters. 2017. When does fishing forage species affect their predators? Fisheries Research 191:211–221.

Hilborn, R., R. O. Amoroso, E. Bogazzi, O. P. Jensen, A. M. Parma, C. Szuwalski, C. J. Walters. 2017. Response to Pikitch et al., In Fisheries Research, https://doi.org/10.1016/j.fishres.2017.07.025.

Hume, M. 2015. Heiltsuk First Nation Claims Victory over Disputed Herring Fishery. The Globe and Mail. Accessed from <http://www.theglobeandmail.com/news/british-columbia/heiltsuk-first-nation-claims-victory-over-disputed-herring-fishery/article23757390/> on 8/27/2017.

Hume, M. 2016. Oil cleanup from sunken tug on B.C. central coast criticized as storm looms. The Globe and Mail. Accessed from < https://beta.theglobeandmail.com/news/british-columbia/some-diesel-fuel-safely-pumped-from-sunken-tug-on-bc-central-coast/article32426007/?ref=http://www.theglobeandmail.com&> on 8/27/17.

IHHPC. 2010. Terms of Reference.

Incardona, J. P., M. G. Carls, L. Holland, T. L. Linbo, D. H. Baldwin, M. S. Myers, K. A. Peck, M. Tagal, S. D. Rice, and N. L. Scholz. 2015. Very low embryonic crude oil exposures cause lasting cardiac defects in salmon and herring. Nature Scientific Reports:1–13.

Jentoft, S., B. J. McCay, and D. C. Wilson. 1998. Social theory and fisheries co-management. Marine Policy 22(4):423–436.

Jones, R. 2015. Haida Gwaii Herring: Historical Trends and Sustainability Concerns. Presented at Pacific Herring Summit, Richmond, Canada, 2015. Accessed from < http://oceanmodelingforum.org/wp-content/uploads/2015/06/01_Jones.pdf> on 8/27/2017.

Jones, R., C. Rigg, and L. Lee. 2010. Haida marine planning: First nations as a partner in marine conservation. Ecology and Society 15(1):12.

Jones, R., C. Rigg, and E. Pinkerton. 2017. Strategies for assertion of conservation and local management rights: A Haida Gwaii herring story. Marine Policy(September):0–1.

Kahan, D. M. 2007. The Cognitively Illiberal State. Stan. L. Rev. 60(1):101–140.

Kahan, D. 2010. Fixing the communications failure. Nature 463(7279):296–297.

Kahan, D. M., D. Braman, J. Gastil, P. Slovic, and C. K. Mertz. 2007. Culture and identity-protective cognition: Explaining the white-male effect in risk perception. Journal of Empirical Legal Studies 4(3):465–505.

Kahan, D., P. Slovic, D. Braman, and J. Gastil. 2006. Fear of Democracy: a Cultural Evaluation of Sunstein on Risk. Harvard Law Review 119(4):1071–1109.

Kaiser, M. (2006). Practical Ethics in Search of a Toolbox: Ethics of Science and Technology at the Crossroads. Pp. 35-44 in J. Gunning and H. Søren (eds.). Ethics, Law and Society Vol. II Ashgate Publishing Ltd: Cardiff.

Kitasoo/Xai'xais. 2017. Kitasoo/Xai'xais management plan for Pacific herring. Accesseed from <http://klemtu.com/resource-stewardship/marine-use-planning-management/> on 8/27/17.

Kluckhohn, F. R. and F. L. Strodtbeck. 1961. Variations in value orientations. Row, Peterson, Evanston, Illinois.

Krejcie, R. V, and D. Morgan. 1970. Determining Sample Size for Research Activities. Educational and psychological measurement 30:607–610.

Kumar, R., S. Surma, T. J. Pitcher, D. Varkey, M. Lam, C. Ainsworth, and E. Pakhomov. 2016. An Ecosystem Model of the Ocean Around Haida Columbia : Ecopath , Ecosim and Ecospace. Fisheries Centre Research Reports 24(2).

Lam, M. E. 2014. Building ecoliteracy with traditional ecological knowledge: Do, listen, and learn. Frontiers in Ecology and the Environment 12(4):250–251.

Lam, M. 2015. Opinion: Herring fishery needs integrated management plan. Vancouver Sun, 11.09.2015. Accessed from <www.vancouversun.com/technology/opinion+herring+fishery+needs+integrated+management+plan/11505147/story.html> on 8/27/2017.

Lam, M.E. 2016. Straddling the Science-Policy Interface with Values in Fisheries. Presentation at Post-normal times? New Thinking about Science and Policy Advice. Bergen, Norway. October 21, 2016.

Lam, ME. 2017. Values and Ecosystem-based Management Approach. Presentation at Expert Workshop on Values-based Approaches to Resource Management, Vancouver, BC, Canada, April 2017.

Lam, M. E., and D. Pauly. 2010. Who is right to fish? Evolving a social contract for ethical fisheries. Ecology and Society 15(3): 16. [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art16/

Lam, M.E., T.J. Pitcher, S. Surma, J. Scott, L. Ward, A. SG. J. White, K. Millar, E. A. Pakhomov, and M. Kaiser. *Submitted 2017*. Value- and Ecosystem-based Management Approach to Pacific Herring Dynamics and Fishery Policy. Submitted October 2017 to Marine Ecology Progress Series.

Levin, P. S., T. B. Francis, and N. G. Taylor. 2016. Thirty-two essential questions for understanding the social–ecological system of forage fish: the case of Pacific Herring. Ecosystem Health and Sustainability 2(4):n/a-n/a.

Levine, J., K. M. a. Chan, and T. Satterfield. 2015. From rational actor to efficient complexity manager: Exorcising the ghost of Homo economicus with a unified synthesis of cognition research. Ecological Economics 114:22–32.

Marshall, M. N. 1996. Sampling for qualitative research. Family Practice 13(6):522–525.

Martell, S. J. D., J. F. Schweigert, V. Haist, and J. S. Cleary. 2012. Moving towards the sustainable fisheries framework for Pacific herring: data, models, and alternative assumptions; stock asssessment and management advice for the British Columbia Pacific herring stocks: 2011 assessment and 2012 forecasts. Page Canadian Science Advisory Secretariat.

McDaniels, T. L., R. Gregory, J. Arvai, and R. Chuenpagdee. 2003. Decision structuring to alleviate embedding in environmental valuation. Ecological Economics 46(1):33–46.

McKechnie, I., D. Lepofsky, M. L. Moss, V. L. Butler, T. J. Orchard, G. Coupland, F. Foster, M. Caldwell, and K. Lertzman. 2014. Archaeological Data Provide Alternative Hypotheses on Pacific Herring (Clupea pallasii) Distribution, Abundance, and Variability. Proceedings of the National Academy of Sciences of the United States of America 111(9):E807–E816.

Mepham, B., and S. Tomkins. 2006. Ethical Matrix Manual(February):45.

Moss, M. L. 2015. The nutritional value of Pacific herring: An ancient cultural keystone species on the Northwest Coast of North America. Journal of Archaeological Science: Reports 5:649–655.

NMFS. 2014. Status Review of Southeast Alaska Herring (Clupea pallasi), Threats Evaluation and Extinction Risk Analysis. Report to National Marine Fisheries Service, Office of Protected Resources.

O'Donnell, K., T. Hesselgrave, E. Macdonald, J. McIsaac, D. Nobles, T. Sutcliffe, D. Fernandes, and B. Reid-Kuecks. 2013. Understanding values in Canada's North Pacific: Capturing Values from Commercial Fisheries.

Okamoto, D., M. Hessing-Lewis, and A. K. Salomon. 2016. Forage Fish Management and Conservation in the Salish Sea. Presented at Salish Sea Ecosystem Conference, Vancouver, Canada, 2016. Accessed at <http://cedar.wwu.edu/ssec/2016ssec/species_food_webs/87/> on 8/27/2017.

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

Peter Wall Institute for Advanced Studies (PWIAS). 2016. Fishing for solutions in Haida Gwaii. Accessed from < https://pwias.ubc.ca/wall-papers/fishing-solutions-in-haida-gwaii> on October 19 2017.

Petrou, E., D. Lepofsky, D. Yang, R. Kopperl, and L. Hauser. 2016. Ecological and cultural context of Pacific herring in the Salish Sea. Presented at Salish Sea Ecosystem Conference, Vancouver, Canada, 2016. Accessed at <http://cedar.wwu.edu/ssec/2016ssec/species_food_webs/38/> on 8/27/2017.

Pikitch, E., P. D. Boersma, I. L. Boyd, D. O. Conover, P. Cury, T. Essington, S. S. Heppell, E. D. Houde, M. Mangel, D. Pauly, É. Plagányi, K. Sainsbury, and R. S. Steneck. 2012. Little fish, big impact: managing a crucial link in ocean food webs. Page Lenfest Ocean Program. Washington, DC.

Pikitch, E., P. Dee Boersma, Ian L. Boyd, David O. Conover, Philippe Cury, Timothy E. Essington, Selina S. Heppell, Edward D. Houde, Marc Mangel, Daniel Pauly, Eva Plaganyi, Keith Sainsbury, Robert S. Steneck. 2017. The strong connection between forage fish and their predators: A response to Hilborn et al. (2017), In Fisheries Research. https://doi.org/10.1016/j.fishres.2017.07.022.

Pinkerton, E., E. Angel, N. Ladell, P. Williams, M. Nicolson, J. Thorkelson, and H. Clifton. 2014. Local and regional strategies for rebuilding fisheries management institutions in coastal British Columbia: what components of comanagement are most critical? Ecology and Society 19(2).

Pinkerton, E., and D. N. Edwards. 2009. The elephant in the room: The hidden costs of leasing individual transferable fishing quotas. Marine Policy 33(4):707–713.

Pitcher, T. J., R. Kumar, M. E. Lam, S. Surma, and D. Varkey. 2016. Spatial Modelling of the Haida Gwaii Ecosystem: Contributions to Haida Gwaii Marine Spatial Planning. Fisheries Centre Research Reports 24(1):1–79.

Pitcher, T., M. Lam, M. Kaiser, A. (SGaana J. White, and E. Pakhomov. 2017. Hard of Herring. Pages 112–119in P. Tortell, M. Young, and P. Nemetz, editors.Reflections of Canada: Illuminating our opportunities and challenges at 150+ years. Peter Wall Insititute of Advanced Studies, Vancouver, Canada.

PNCIMA Initiative. 2017. Pacific North Coast Integrated Management Area Plan.

Preikshot, D., R. J. Beamish, and C. M. Neville. 2013. A dynamic model describing ecosystem-level changes in the strait of georgia from 1960 to 2010. Progress in Oceanography 115:28–40.

R. v. Gladstone. 1996. . Pages 723–820.

Raman S, Hobson-West P, Lam ME, Millar K (2018) Science matters and the public interest: the role of minority engagement. In: Nerlich B, Hartley S, Raman S, Smith A (eds) Science and the politics of openness: here be monsters. Manchester University Press, Manchester, p 230-250. Schwartz, S. H. 1994. Are There Universal Aspects in the Structure and Contents of Human Values? Journal of Social Issues 50(4):19–45.

Schweigert, J. F., J. L. Boldt, L. Flostrand, and J. S. Cleary. 2010. A review of factors limiting recovery of Pacific herring stocks in Canada. ICES Journal of Marine Science 67:1903–1913.

Schweigert, J., and D. Ware. 2001. Metapopulation structure and dynamics of British Columbia herring:28.

Schweigert, J., and D. Ware. 2001. Metapopulation structure and dynamics of British Columbia herring:28.

Secher, Kristian. 2014a. Court overrules DFO decision to reopen herring fisheries. The Tyee, February 26. Accessed from <https://thetyee.ca/Blogs/TheHook/2014/02/26/Herring_Overrules> on 8/27/2017.

Secher, Kristian. 2014b. BC fishermen stuck in middle of DFO legal battle. The Tyee, March 1. Accessed from <https://thetyee.ca/News/2014/03/01/DFO_Legal_Battle> on 8/27/2017.

Shallard, M. 2015. Herring (Wanai) and Well-being : Accounting for Heiltsuk values to inform future resource management and economic development opportunities by.

Siple, M. C., and T. B. Francis. 2016. Population diversity in Pacific herring of the Puget Sound, USA. Oecologia 180(1):111–125.

Slimak, M. W., and T. Dietz. 2006. Personal values, beliefs, and ecological risk perception. Risk Analysis 26(6):1689–1705.

Slovic, P. 1992. Perception of risk: Reflections on the psychometric paradigm. Pages 117–152in S. Krimsky and D. Golding, editors.Social theories of risk. Praeger, New York.

Smith, W. D. 2017. Discerning connectivity and natal fidelity of Pacific herring (Clupea pallasi): Inferences on population structure from otolith chemistry. Presented at PICES International Symposium: Drivers of Dynamics of Small Pelagic Fish Resources, Victoria, Canada, 2017.

Sokol-Hessner, P., and E. A. Phelps. 2015. Affect, decision-making, and value: neural and psychological mechanisms. Pages 197–222Handbook of Value. Oxford University Press.

Song, A. M., and R. Chuenpagdee. 2015. Eliciting Values and Principles of Fishery Stakeholders in South Korea: A Methodological Exploration. Society & Natural Resources 1920(June):1–17.

Statistics Canada. 2017. Census profile: Skeena-Queen Charlotte. Accessed from < http://www12. statcan.gc.ca/census-recensement/2011/dp-pd/prof/details/page.cfm? Lang=E&Geo1=CD&Code1= 5947&Geo2=PR&Code2=01&Data=Count&SearchText=Skeena-Queen%20Charlotte&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=5947&TABID=1> on 9/25/2017.

Surma, S., and T. J. Pitcher. 2015. Predicting the effects of whale population recovery on Northeast Pacific food webs and fisheries: an ecosystem modelling approach. Fisheries Oceanography 24(3):291–305.

Surma, S., R. Kumar, T. J. Pitcher and R. I. Perry. In review. A comparative re-evaluation of unfished spawning biomasses for Northeast Pacific herring stocks.

Surma, S, Pitcher, TJ, Kumar, R, Varkey, D, Pakhomov, EA, and Lam, ME. Herring supports Northeast Pacific predators and fisheries: insights from ecosystem modelling and management strategy evaluation. Submitted to PLoS ONE.

Thornton, T. F. 2015. The Ideology and Practice of Pacific Herring Cultivation among the Tlingit and Haida. Human Ecology 43(2):213–223.

von der Porten, S., D. Lepofsky, D. McGregor, and J. Silver. 2016. Recommendations for marine herring policy change in Canada: Aligning with Indigenous legal and inherent rights. Marine Policy 74:68–76.

Walters, C. 1986. Adaptive Management of Renewable Resources. Page Biological Resource Management.

Walters, C. J. and S. J. D. Martell. 2004. Fisheries ecology and management. Princeton University Press, Princeton. 399pp.

Washington, M. 2015. Tlagut. Presented at Pacific Herring Summit, Richmond, Canada, 2015. Accessed from < http://oceanmodelingforum.org/wp-content/uploads/2015/06/09_Washington.pdf> on 8/27/2017.

Ware, D.M. 1991. Climate, predators and prey: behaviour of a linked oscillating system, p. 279-291. In Long-term variability of pelagic fish populations and their environment. T. Kawasaki et al. [ed.] Pergamon Press, Tokyo, 402p.

Ware, D. M., and C. Tovey. 2004. Pacific Herring Spawn Disappearance and Recolonization Events. Canadian Science Advisory Secretariat 8.

Ware, D., and J. F. Schweigert. 2002. Metapopulation dynamics of British Columbia herring during cool and warm climate regimes. Canada.Dept.of Fisheries and Oceans; Canadian Science Advisory Secretariat:36-.

Washington, M. 2015. Tlagut. Presented at Pacific Herring Summit, Richmond, Canada, 2015. Accessed from < http://oceanmodelingforum.org/wp-content/uploads/2015/06/09_Washington.pdf> on 8/27/2017.

Weatherdon, L. V., Y. Ota, M. C. Jones, D. A. Close, and W. W. L. Cheung. 2016. Projected scenarios for coastal first nations' fisheries catch potential under climate change: Management challenges and opportunities. PLoS ONE 11(1):1–28.

Weinberg, A. M. 1972. Science and trans-science - Springer. Minerva 10(2):209–222.

Wiles, G. J. 2015. Washington State Periodic Status Review for the Steller Sea Lion. Olympia, Washington.

Zar, J.H. 2010. Biostatistical analysis. 5th Ed. Pearson Prentice Hall, Upper Saddle River, New Jersey. 944pp.

Appendix A: Pacific herring fisheries in British Columbia

A.1 Pacific herring natural history

A.1.1 Life history

Pacific herring (*Clupea pallasii*) are distributed throughout the northern Pacific, from northern California to Bristol Bay, Alaska, and from the Russian Far East south to northern Japan. Pacific herring are small pelagic fish that spawn annually in coastal waters, with females depositing their eggs upon substrate such as kelp or tree branches in the intertidal zone and males releasing milt en masse within these areas. After hatching, herring larvae and then juveniles spend usually 3 years in shallow waters before migrating to oceanic feeding grounds, though some resident fish remain nearshore throughout the year (Beacham et al. 2008). In early spring, mature adults return to the coast to spawn. Hay and McCarter (2013) compiled records of herring spawning sites throughout British Columbia's (BC) coast, estimating that 300-600km of coastline were intensively used as spawn sites annually.

A.1.2 Stock structure

In BC waters, five major and two minor stocks of herring are recognized by Fisheries and Oceans Canada (DFO), the federal management authority over herring and other marine fisheries (DFO 2016a; Figure A1). Beacham et al. (2008) identify four genetically distinct populations co-occurring within the defined stock areas: 1) a Primary spawning stock distributed throughout Northern and Southern BC, 2) a late-spawning Northern stock, 3) a late-spawning Southern stock, and 4) a Mainland Inlet-spawning stock, distributed from Johnstone Strait north through the Central Coast. The Northern, Southern, and Mainland Inlet-spawning stocks co-occur with the Primary spawners; different timings of spawning are the main mechanism distinguishing the stocks (Beacham et al. 2008). Spawning aggregations in many places along the coast re-occur predictably on an annual basis, though local disappearances and re-colonizations are common (Ware and Tovey 2004).

There is debate whether these spawning aggregations comprise genetically distinct "stocklets" (Beacham et al. 2008). Research in Puget Sound, Washington, USA indicates that geographically distinct subpopulations of herring exist and confer stability to the overall population through their asynchronous spawning (Siple and Francis 2016); in the North Sea, Dickey-Collas et al. (2010) review evidence of sub-stock structure within populations of Atlantic herring (*Clupea harengus*), the dynamics of which could apply to Pacific herring stocks also. Intermixing of stocks appears to be driven largely by population size, with highly productive populations "subsidizing" less productive ones and thereby maintaining spawn

site fidelity (Schweigert and Ware 2001, Ware and Schweigert 2002). Thus, low overall biomass of herring stocks may be a primary cause of local stocklet disappearances. Ongoing modelling and genetic research aims to address the stocklet question with greater precision (Hauser 2015, Petrou et al. 2016, Cleary et al. 2016).

A.1.3 Ecosystem changes and historical baselines

Herring occupy a central niche in North Pacific ecosystems, channeling energy from zooplankton to higher trophic levels (Ainsworth 2006, Pitcher et al. 2016; Figure A.2). Archaeological evidence suggests stocks were much larger and perhaps less variable centuries ago (McKechnie et al. 2014). Current herring populations are fractions of former abundances, likely a result of past overfishing in the 20th Century (Jones 2015, Schweigert et al. 2010; see Figure 3). However, the three smallest stocks off Haida Gwaii, BC's Central Coast, and Vancouver Island's west coast have not borne significant fishing effort for over a decade, suggesting that ecosystem effects are most responsible for inhibiting stock recovery (Schweigert et al. 2010). These effects include bottom-up, climate-linked ecosystem regime changes (Ware 1991, Beamish et al. 2004, Preikshot et al. 2013), as well as top-down impacts of predation (Beamish et al. 2004, NMFS 2014, Surma and Pitcher 2015). In addition, anthropogenic climate change could compound the ecosystem effects of natural climate oscillations (Weatherdon et al. 2016), while minute concentrations of hydrocarbon pollution may also increase mortality in herring larvae (Incardona et al. 2015).

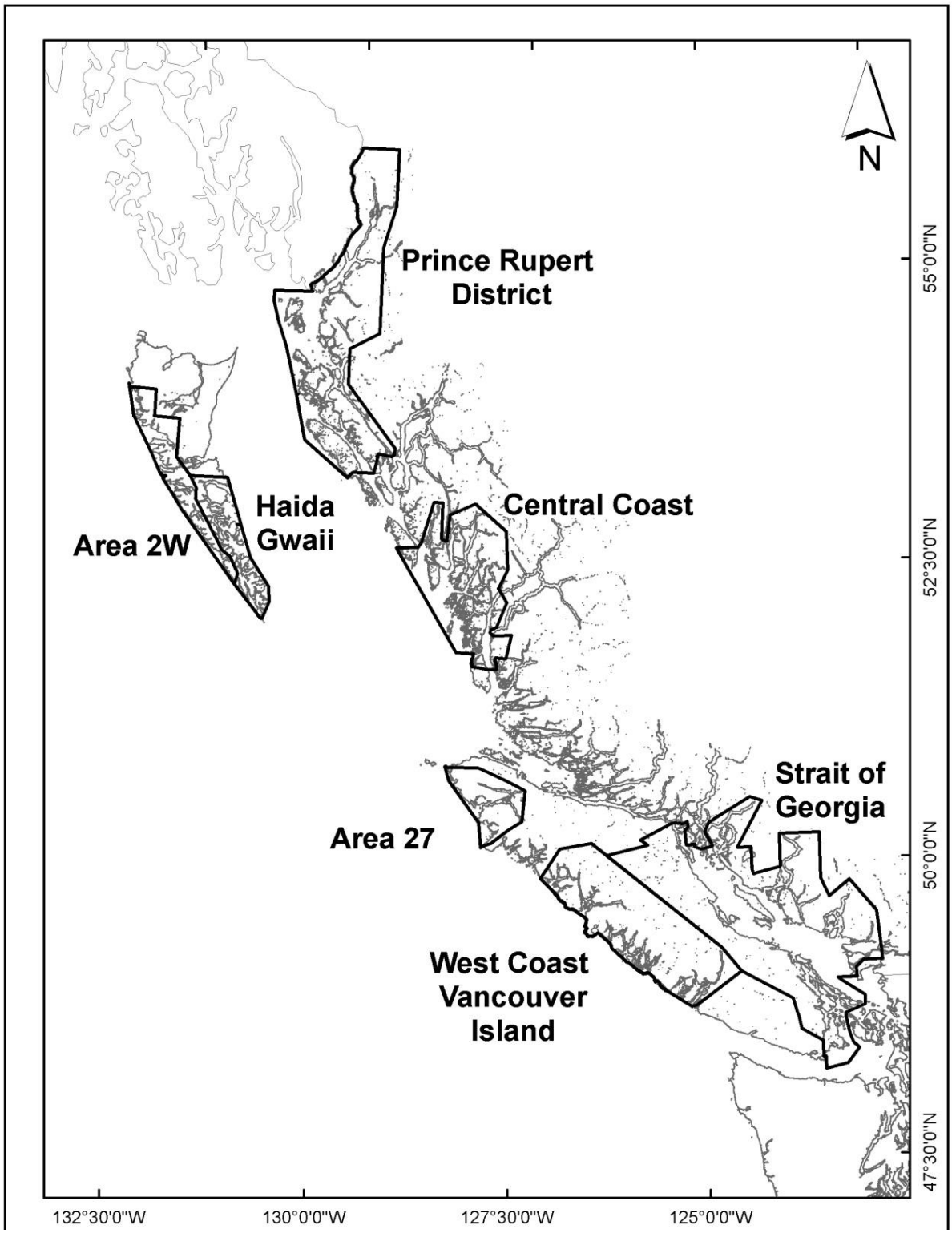

Figure A.1: The five major and two minor stock management areas defined by DFO (from DFO 2016). Major stock areas: Strait of Georgia (SOG), West Coast Vancouver Island (WCVI), Central Coast (CC), Prince Rupert District (PR) and Hadia Gwaii (HG). Minor stock areas: Area 27 and Area 2W.

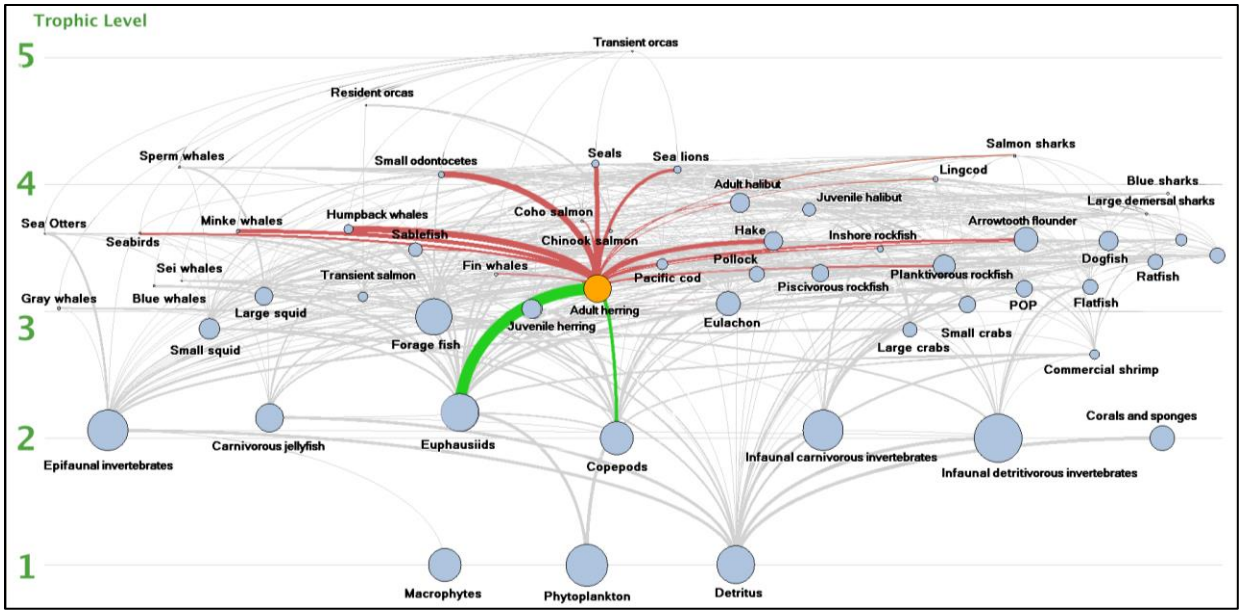

Figure A.2: Food web diagram of the Northern BC marine ecosystem. Y-axis represents trophic level, X-axis is dimensionless. Size of circles represent relative biomass of each functional group, thickness of lines connecting circles represents relative energy flux between functional groups. From Lam et al. (*submitted*).

A.2 First Nations (FNs) and herring

The archaeological record carries evidence of continual use of herring by humans along the BC coast for around 10,000 years, with little variability in annual consumption (McKechnie et al 2014). Herring provided a plentiful source of nutrition in the early spring, as winter food stores ran out, and signaled the change in seasons for many coastal FNs (Brown and Brown 2009, Brown et al. 2011). Traditional and contemporary stories highlight the cultural importance of the resource, such as the Heiltsuk tale of how Raven introduced herring to their territories (Brown and Brown 2009). Herring were fished for bait, as well as for food products, including fresh cooked, smoked, pickled, salted or dried whole fish, as well as oil (Brown et al. 2011). Most important to coastal FNs was herring spawn-on-kelp (SOK), or spawn-on-boughs (i.e., conifer boughs), which was harvested in substantial quantities, eaten fresh and dried for consumption throughout the year; this food source holds a prominent place in the traditional diet of many peoples (Brown et al. 2011, Jones 2015, Greba 2015, Brown 2015, Washington 2015). SOK and spawn-on-bough harvesting required careful technique and adherence to common rules (Brown et al. 2011, Shallard 2015) to ensure sustainable harvest. A rich catalogue of cultivation strategies for herring also developed in the SOK harvesting techniques of Southeast Alaskan Tlingit and Haida, which reinforced spawning site fidelity in local herring sub-populations (Thornton 2015). Moss (2015) details

the nutritional importance of herring food products to the physical and cultural wellbeing of coastal FNs, noting that the degree of nutritional reliance upon the fish varied widely among communities of the Pacific Northwest, but likely facilitated demographic expansion in the area.

Coastal FNs continue to harvest herring and its spawn today. All Nations are entitled to priority access to fisheries resources for food, social and ceremonial purposes (FSC fisheries), so long as stocks are deemed large enough to support them by DFO (DFO 2016a). Aboriginal commercial fisheries also exist as a result of court decisions affirming the rights of five Nuu-chah-nulth Nations to catch and sell fish from their territorial waters (Ahousat Indian Band and Nation v Canada (Attorney General) 2013) and of the Heiltsuk Nation to sell SOK (R. v. Gladstone 1996), and many FNs individuals fish commercially as well. Haida fishers played a lead role in establishing the commercial SOK industry in BC (Brown et al. 2011; see Section A.3).

A.3 Commercial fisheries

Herring have supported commercial fisheries in BC waters since the late 1800s, first as domestic and then exported food products, before expanding into a large-scale reduction (for livestock feed, oil, and fertilizer) industry in the early 20th Century (DFO 2016a; Pitcher et al. 2017). Most fishing at this time was done with gillnets and table seines, which eventually gave way to purse seine gear. This expansion of fishing effort continued until a combination of overfishing and poor climatic conditions resulted in the collapse of stocks and the fishery's coast-wide closure in 1967 (DFO 2016a). Stocks rebuilt quickly, and DFO re-opened fishing in 1973 (DFO 2016a). Through the 1970s and '80s, production shifted from reduction to herring roe, in which herring are caught by purse seine and gillnet as they congregate by spawning grounds. The roe fetched a much higher price on the Japanese market, where *kazunoko* is a traditional luxury food (DFO 2016a). The late 1970s saw the introduction of commercial spawn-on-kelp (SOK) enterprises, which adapted FNs' traditional harvesting techniques to produce SOK for export to Japan as *kazunoko kombu*, another luxury product and gift item. Commercial SOK enterprises involve either use of closed pond or open ponds: in closed ponds, a school of herring is captured by a purse seine and then gently towed to an enclosure filled with suspended kelp fronds; in open ponding, kelp is suspended within raceways positioned where the fish are expected to spawn naturally (Brown et al. 2011). Fishing for roe and SOK persisted for decades, until low stock levels triggered roe fishing closures for Haida Gwaii in 2003, West Coast Vancouver Island in 2007, and Central Coast in 2008 (Table A.1; Jones et al. 2016).

Table A.1: Closures and openings of Haida Gwaii, Central Coast and West Coast Vancouver Island herring sac roe and spawn-on-kelp (SOK) fisheries from 1990-2016. From Jones et al. (2016).

Year	Haida Gwaii	Central Coast	West Coast Vancouver Isl.
1990	Open	Open	Open
1991	Open	Open	Open
1992	Open	Open	Open
1993	Open	Open	Open
1994	Open	Open	Open
1995	**Closed**	Open	Open
1996	**Closed**	Open	Open
1997	**Closed**	Open	Open
1998	Open	Open	Open
1999	Open	Open	Open
2000	Open	Open	Open
2001	**SOK Only**	Open	**SOK Only**
2002	Open	Open	Open
2003	**SOK Only**	Open	Open
2004	**SOK Only**	Open	Open
2005	**Closed**	Open	Open
2006	**Closed**	Open	Open
2007	**Closed**	Open	**Closed**
2008	**Closed**	**Closed**	**Closed**
2009	**Closed**	**Closed**	**Closed**
2010	**Closed**	**Closed**	**Closed**
2011	**Closed**	**Closed**	**Closed**
2012	**Closed**	**Closed**	**Closed**
2013	**Closed**	**Closed**	**Closed**
2014	Open	Open	Open
2015	Open	Open	Open
2016	**Closed**	Open	**Closed**

Figure A.3 shows recent trends in commercial landings and values; prices for roe and SOK have fallen dramatically in the past two decades. Commercial fisheries targeting whole herring for food and bait remained small but consistent throughout the late 20th Century, but have grown yearly since 2011 and accounted for 20% of BC herring fisheries' landed value in 2014 (DFO 2016a). In 2015, there were 188 communal aboriginal licenses for herring, 998 commercial roe gillnet licenses, 241 commercial roe seine licenses, 20 commercial SOK licenses, and 106 commercial food & bait licenses (DFO 2015). The BC Fish Processing Employment Survey in 2011 (BC Ministry of Agriculture 2011) found 262 jobs attributable to herring processing, generating $8.2 million in wages.

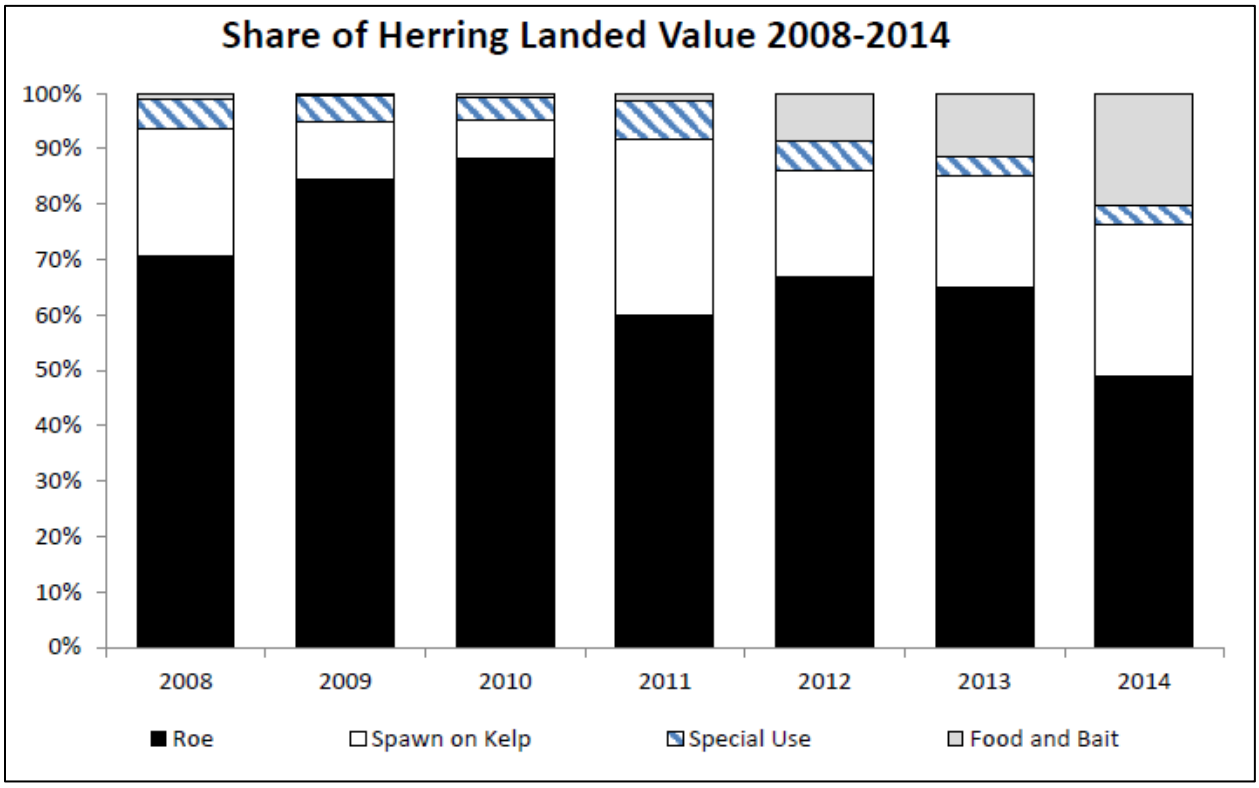

Figure A.3: Relative herring landings by BC fishery, 2008-2014. The fishery for food and bait has increased rapidly in recent years. From DFO (2016a).

A.4 Herring management

A.4.1 Governance regime

DFO is the federal management authority over Pacific herring stocks in Canadian waters (DFO 2016a). Its mandate consists of implementing federal laws pertaining to Canadian oceans and fishery resources, namely the Oceans Act, Fisheries Act, Species at Risk Act, and Coastal Fisheries Protection Act (DFO 2016a). DFO's Science branch carries out research while its Management branch designs, implements, and enforces regulatory measures to achieve broad goals laid out by legislation and to meet specific objectives for individual fisheries (DFO 2016a). Ultimate authority rests with the Fisheries Minister, who may authorize or reject management measures proposed by DFO managerial staff in annual Integrated Fisheries Management Plans (IFMPs) (DFO 2016a).

A.4.2 Research and monitoring

Data is collected each year to estimate parameters for assessing and forecasting herring stocks (see Section A.4.3.1), comprising commercial landings, an index of spawn quantity, and age composition data (DFO 2016a). Landings data is collected from verified offload weights at processing plants; spawn assessments take place along the coast annually by dive surveys; age, sex, maturity, weight and length data come from landed specimens and from herring caught by test fisheries (DFO 2016a). DFO conducts most of this research itself, though some is also carried out by the Herring Conservation Research Society (HCRS), a non-profit research group funded by the industry and connected to the Herring Industry Advisory Board (HIAB; see Section A.4.4). HCRS and DFO also conduct projects addressing the life history and ecological role of herring, such as pre-season roe quality tests (done by HCRS) and annual juvenile distribution surveys in the Strait of Georgia and Central Coast (done by DFO; DFO 2016a). Fishery monitoring for compliance is funded by commercial roe license holders, which includes hailing in/out and validating 100% of offload weights and is administered by HCRS or a contractor (DFO 2016a).

A.4.3 Management plan

Each year's Pacific IFMP is published by DFO "to identify the main objectives and requirements for the Pacific herring fishery in the Pacific Region, as well as the management measures that will be used to achieve these objectives" (DFO 2016a). It "is not a legally binding instrument[,]" and "does not fetter the [Fisheries] Minister's discretionary powers set out in the *Fisheries Act*" (DFO 2016a). It does lay out, though, the results of herring stock assessments and forecasts, used to justify specific management measures for each stock. The document also includes historical, biological, economic and cultural background on the fisheries as separate, but not formalized, considerations for decision making (DFO 2016a).

A.4.3.1 Stock assessment and management procedures

DFO currently operates an integrated statistical catch-age model (ISCAM) of Pacific herring stocks that relies upon inputs from landings, age composition, and spawn survey data to forecast the next season's biomass of each of five major and two minor stocks (DFO 2016b). Managers have established rules for determining whether and how much fishing should take place on each herring stock: if a stock's biomass currently exceeds a strict threshold of 25% of its unfished biomass (B_0), fishing is allowed at either a 10% (for stocks slightly above the threshold) or 20% (for stocks well above the threshold) harvest rate (DFO 2016b). According to the 2016/17 draft Pacific herring IFMP, the 20% harvest rate is

set as an implementation of the precautionary approach, and is "based on an analysis of stock dynamics, which indicates this level will stabilize both catch and spawning biomass while foregoing minimum yield over the long term[.]" Decision tables are generated from the ISCAM which provide probabilities of each stock's biomass falling below the 25% threshold, and of harvest rates exceeding 10% or 20%, given a value of Total Allowable Catch (TAC) for the upcoming season (DFO 2016a).

In 2011 DFO switched to a stock assessment model (AM2) which departed from the previous model (AM1) in two main regards: 1) in AM2 the parameter for scaling the spawn survey index is estimated by the model, as opposed to a fixed estimate used in AM1; 2) AM2 similarly estimated stocks' unfished biomass (SB_0) each year, rather than using a fixed estimate as in AM1 (DFO 2016b). Responding to criticism of the new model as too liberal in its estimates (e.g., Jones et al. (2016) accuse such annual updating of SB_0 of exemplifying Pauly's (1995) shifting baseline phenomenon), DFO in 2015 evaluated performance of the historical and new models against each other and against alternative management plans (DFO 2015). While simulation testing found no clearly preferred option amongst all tested criteria, results of both AM1 and AM2 have been included in stock assessments and IFMPs for 2015/16 and 2016/17. DFO also established in 2015/16 a Herring Technical Working Group (HTWG) comprised of DFO scientists and managers, science representatives from coastal FNs and from the herring industry (DFO 2016a). Table A.2 compares the attributes and limitations of AM1 and AM2, as identified by HTWG in the 2016/17 stock assessment.

Table A.2: Specifications for the current (MP1) and historical (MP2) management procedures. Model-based procedures MP1 and MP2 forecast biomass in the next year by projecting the age-structured population forward one year given fishing, natural mortality, and age-1 recruitment obtained from the stock-recruitment relationship. Adapted from DFO (2015b).

		Assessment model			Harvest control rule	
MP symbol	MP Description	Scaling parameter assumption	Prior	Forecast biomass	Cut-off	Target harvest rate
MP1	Current model-based MP with variable CUT-OFF	Estimated	Normal Mean=0.56 S.D.=0.27	1-year ahead model-based forecast	**Updated annually**: 25% of unfished biomass estimate	20%
MP2	Historical model-based MP with constant CUT-OFF	Constant q_2=1	NA	1-year ahead model-based forecast	**Constant at 2014 level**: 25% of estimated unfished biomass given data up to 2014 only	20%

The metapopulation structure and spatial dynamics of Pacific herring in BC (Section A.1.2) may affect stocks' susceptibility to fishing effort, as well. Coastal FNs lament the loss of once-reliable spawning aggregations in local waters, blaming these disappearances on overfishing of stocklets by the commercial roe fleet (Brown and Humchitt 2015, Washington 2015; see Section A.4.3.4 for further FN concerns). Benson et al. (2015) modelled the potential impacts of managing BC herring stocks as single units, finding great variety in the effects of different stock assessment parameters and fleet incentives on local populations, depending on the true structure of the metapopulation. In particular, highly connected local sub-populations appeared equally or more susceptible to depletion than discrete ones in their simulations, though parameters of productivity, migration, and fishing fleet dynamics mattered much more. Further research continues to examine the interplay of stock structure and fleet dynamics in BC herring fisheries (Okamoto et al. 2016), but management has begun to address concerns of potential local extirpations. In the 2016/17 IFMP, DFO implemented a new rule for sub-areas within the Strait of Georgia (SoG), requiring specific criteria for the strength of a spawning event for fishing to take place in that location; this is "to ensure commercial fisheries are not opened on small areas of fish or spawn, and that opportunities for First Nations FSC fisheries can be provided on a priority basis" (DFO 2016a). The IFMP also allows for other area closures in season "to address specific management concerns" such as FSC access to fish and spawn.

A.4.3.2 Ecosystem considerations

The 2016/17 IFMP addresses ecosystem considerations of Pacific herring stocks in a brief subsection, quoted here:

> *"At this time there is no information available on the appropriate conservation limits for herring based on ecosystem considerations. It is recognized that herring plays a critical role in the ecosystem and are a food source for a variety of species. The current maximum harvest rate of 20% under the herring management framework is believed to be conservative, most juveniles and a significant proportion of the adult population should remain available to support ecosystem processes. Recent research indicates that the interplay of food supply and predation impacts on herring survival and production is complex and not readily predictable (Schweigert et al. 2010). Research is ongoing to better understand these ecosystem processes and the role herring plays in maintaining the integrity and functioning of the ecosystem."*

A number of researchers from FNs, academia and environmental non-governmental organizations (ENGOs) have criticized the lack of explicit ecosystem criteria in DFO's single stock management of herring, pointing to Lenfest (Pikitch et al. 2012) recommendations to advocate for higher limit reference points (LRPs; i.e, the spawning biomass threshold for opening herring fisheries) due to herring's central role in the BC coastal ecosystem (e.g, Lam 2015, Pitcher et al. 2017). In response to such criticisms, the 2016/17 IFMP announces an initiative to include greater ecosystem considerations: "DFO Science has begun to compile data sources to engage in an ecosystem modelling initiative that will examine how ecological and physical interactions affect herring population dynamics" (DFO 2016a).

A.4.3.3 Access and allocation

Herring fisheries in BC are separated into three sectors: Aboriginal, Recreational, and Commercial. Aboriginal FSC use receives first priority for allocation (after conservation of the resource); specific allocations are negotiated bilaterally between DFO and each Nation (DFO 2016a). Recreational fisheries for herring in BC are negligibly small and allow a 20kg/day limit to licensed anglers, though recreational harvest of SOK is prohibited (DFO 2016a). Commercial fisheries are limited entry and receive a total allowable catch (TAC) for each stock area, set after FSC fisheries are provided for. This TAC is then divided amongst the licenses for roe herring, SOK, food and bait, and special use fisheries in each stock area. In 2016/17, there were 252 seine and 1,267 gillnet licenses for commercial roe herring, all party-based (as opposed to vessel-based; DFO 2016a). While each license is allotted a share of the stock area TAC based upon its fishery and gear type, "pooling" of multiple fishers' licenses onto one vessel is required as a way of maximizing profitability and improving compliance (DFO 2016a). Jones et al. (2016) describe the pooling system as a *de facto* individual transferable quota (ITQ) scheme, and warn of the unintended effects such ITQs have produced in other fisheries (Ecotrust Canada and Ecotrust 2004, Pinkerton and Edwards 2009, Ecotrust Canada and T. Buck Suzuki Environmental Foundation 2015).

A.4.3.4 Cultural considerations for First Nations

The 2016/17 IFMP acknowledges the cultural importance of herring and its roe to First Nations in multiple subsections. Under its "Objectives" section, the IFMP states "DFO will continue to provide opportunities for First Nations to harvest fish for food, social, and ceremonial purposes, in a manner consistent with the Sparrow Decision […] and for treaty and aboriginal commercial fisheries." Under the "Social, Cultural, and Economic Considerations" subsection of its "Performance/Evaluation Criteria" section, the IFMP states succinctly that "DFO will consult with First Nations through established processes to develop fishing plans to authorize fisheries and conduct post-season reviews." An

appendix titled “Aboriginal Fishing Plan” describes four court-recognized instances of individual First Nations’ rights to fishery resources, and maintains that “DFO is committed to improving its relationship with Aboriginal people.”

Many coastal FNs maintain that DFO management does not adequately address their concerns over the roe fishery’s potential impact upon local availability of herring SOK and other culturally important species (Jones 2015, Greba 2015, Brown 2015, Washington 2015, Jones et al. 2016). These sources argue further that traditional, unceded rights and titles are violated by federal management of fisheries within their territorial claims, and demand greater involvement in herring management, if not full sovereignty over herring in their territories. Recent legal and extra-legal conflicts between FNs and DFO/industry are described more fully in Section A.5; processes by DFO to address FNs’ mounting complaints are described in Section A.4.4.

A.4.3.5 Socio-economic considerations

The 2016/17 IFMP describes recent economic trends in the fishery, including quantity and value of landings and exports, and employment capacity. It makes no mention, though, of socio-economic issues raised by others, such as the economic multiplier effect of fishing within and among coastal BC communities or the non-economic benefits of fishing (O’Donnell et al. 2013). The increasing concentration of license ownership among a few large processors has caused particular concern for many stakeholders. This ownership concentration, while moderate compared to other industries, may be exacerbated by geographic concentration of processing facilities and the perishability of the product, creating market-distorting effects of a traditional oligopsony (Haas et al. 2016). Others complain of unfair limits to access due to the high price of licenses, as in other BC fisheries (Ecotrust Canada and Ecotrust 2004, Pinkerton and Edwards 2009, Ecotrust Canada and T Buck Suzuki Foundation 2015).

A.4.4 Consultations/co-management

The 2016/17 herring IFMP states:

> *“DFO supports consultations that are transparent, accessible and accountable. DFO Pacific Region undertakes consultations in order to meet the duty to consult with First Nations, improve departmental decision-making processes, promote understanding of fisheries, oceans and marine transport issues, and strengthen relationships.”*

These consultations take place before and after each roe herring season, as well as throughout the year on an as-needed basis. Previously, consultations occurred separately between industry, represented by

HIAB, and individual FNs. DFO initiated the Integrated Herring Harvest Planning Committee (IHHPC) in 2010 to streamline the consultation process and offer a more representative forum for hearing all stakeholder groups' concerns (IHHPC 2010). The harvest advice HIAB submits to DFO is now reviewed within the IHHPC (DFO 2016a). Seats on the IHHPC represent HIAB, SOK and special use fishery license holders, a FN from each major stock area, the Marine Conservation Caucus (MCC), the Sport Fish Advisory Board (SFAB), the Province of BC, and DFO (the latter two representatives in an ex officio capacity; IHHPC 2010). DFO also consults bilaterally with individual FNs upon request or when required by treaty (DFO 2016a).

A unique case of federal-local cooperation rests in the Gwaii Haanas National Park Reserve and Haida Heritage Site, located in the southern portion of Haida Gwaii. The reserve and heritage site was established through the Gwaii Haanas Agreement, signed in 1993 between the Canadian government and the Council of the Haida Nation (CHN), and governed collaboratively between the CHN, Parks Canada, and DFO through a body known as the Archipelago Management Board (AMB; Government of Canada and Council of the Haida Nation 1993). As part of an extension of the agreement, the 2010 Gwaii Haanas Marine Agreement, the waters within the reserve are co-managed by the AMB, and all extractive activities subject to AMB's authority (Government of Canada and Council of the Haida Nation 2010). Section A.5.2 describes the role these agreements played in a 2015 legal dispute between CHN and DFO over roe fishery openings.

A.6 Current frameworks for improving fisheries management

A.6.1 DFO's Pacific Herring Renewal process and associated frameworks

The conflicts over roe herring fisheries in recent years have prompted greater review of management processes by DFO, as part of an initiative dubbed Pacific Herring Renewal (DFO 2016a). The goals of this renewal process include "identification of new management objectives and reference points for Pacific herring, as well as evaluating the performance of current and alternative decision rules at meeting these management objectives" (DFO 2016a). Measures, described above, include formation of the HTWG and review of alternative stock assessment model performances (Section A.4.3.1), more productive consultation with individual FNs (Section A.5.3), and further research into the science and fishery implications of herring stock structure and ecosystem function (Sections A.4.3.1 and A.4.3.2).

In addition to this herring-specific improvement process, DFO has developed broader frameworks for renovating its fisheries management across Canada. The Sustainable Fisheries Framework (DFO 2016c)

aims to apply a universal set of principles to Canadian fisheries for ensuring conservation and sustainable use of living marine resources, and outlines tools for planning and monitoring fisheries to that end. DFO began implementation of this framework in 2009 and, according to the 2016/17 Pacific herring IFMP, "work is progressing on aligning the management of Pacific herring with the Sustainable Fisheries Framework." *A New Ecosystem Science Framework in Support of Integrated Management* (DFO 2007) lays out a plan for developing a framework for incorporating ecosystem interactions in single-species management plans, but its advice has not yet been incorporated into a formal policy or statement. It is not clear whether DFO intends to explicitly incorporate its Herring Renewal initiative within the broader Sustainable Fisheries Framework.

A.6.2 Pacific North Coast Integrated Management Area ecosystem-based management assumptions and principles

Other frameworks for improving management of marine resources in BC have been developed by external groups. The Pacific North Coast Integrated Management Area (PNCIMA) was identified by the federal government as a Large Ocean Management Area of importance in its 2005 Oceans Action Plan; the area stretches from the Alaskan border south to the northern Strait of Georgia and northwestern coast of Vancouver Island, encompassing all or part of the five major Pacific herring stock areas (PNCIMA Initiative 2017). Federal, provincial, local and FN governments, stakeholders and other interested parties all collaborated to create the PNCIMA Plan, published in 2017, which lays out a set of high-level strategic goals for ecosystem-based management (EBM) in northern BC waters. The assumptions, principles, goals, objectives and strategies outlined in the Plan point towards a more holistic management regime for use and conservation of the marine environment, as well as greater collaboration between all levels of government, local stakeholders and constituents. This framework, while not herring-specific, could influence the course of herring management and governance if its collaborative, holistic principles are adhered to in future discussions.

Appendix B: Levin et al.'s (2016) 32 questions from the Pacific Herring Summit

The following questions come from Levin et al. (2016), and were formulated from input received at the Pacific Herring Summit in Richmond, BC in June 2015. For a discussion this work, see Section 1.3.3.

Questions about broad social, political, and economic forces

1. How have global market forces influenced the commercial Herring fishery? How have the markets changed over time?

2. What are the social, cultural, and political motivations for Herring fisheries, and how have they changed over time?

3. What is the relationship between Herring fisheries and broader issues of indigenous rights? Questions about human activities (and their effects on Herring)

4. What is the relative influence of fishing, other human activities and climate on Herring population dynamics, and how can the impacts be differentiated?

5. What are the cumulative effects of human activities (fishing, coastal development, toxins, etc.), predators and climate on Herring populations?

6. What are causes of historical disappearance of Herring, and is the current status of Herring a lingering consequence of historical impacts?

7. How does fishing affect spawn timing, and what impact does this have on population dynamics?

8. What are the ecological, economic, and cultural costs and benefits of alternative fisheries management strategies?

Climate questions

9. How does global-scale climate variability related to El Niño and the Pacific Decadal Oscillation influence Herring behavior and population dynamics?

10. How is changing climate affecting Herring populations?

Habitat questions

11. Does the quantity and/or quality of spawning habitat determine Herring productivity and population size?

12. Does the artificial supplementation of spawning habitat (i.e., by trees or boughs) result in increases in the long-term median Herring population size?

13. Are Herring using deeper spawning habitat? If so, why, and how does that affect their vulnerability to predation?

Institutional and governance questions

14. How do policies and management strategies that address the spatial distribution of fishing effort and the temporal order of fisheries better account for aboriginal rights as codified by court decisions and law?

15. What are the pros and cons of different temporal and spatial scales for adaptive Herring decision making?

16. How would different forms of knowledge alter definitions of overfishing thresholds and sustainable levels of fishing?

17. What role can institutional processes play in better facilitating the rebuilding of Herring populations?

18. How can we allocate harvest in such a way that supports ecological, economic, and cultural resilience?

Questions about Herring and the Herring food web

19. Are Herring vital rates (e.g., recruitment, mortality) or behavior positively or negatively density dependent? How has the nature of density dependence changed over time?

20. How do the processes that determine or limit Herring population size vary across spatial and temporal scales?

21. What factors affect survival of Herring eggs, larvae and young-of-the-year?

22. How has size structure changed over decadal to millennial time scales, and what are the causes and consequences of such changes?

23. What is the spatial structure of Herring populations, and what factors influence the degree of connectivity among sub-populations? Has this changed over time?

24. What factors influence interannual and interdecadal movement of spawning Herring stocks?

25. What is the role of genetic and life-history diversity in maintaining Herring populations? How has this changed over time?

26. What is the relative importance of bottom-up versus top-down processes for Herring behavior and population dynamics, and how has this varied over time?

27. What are the cross-ecosystem linkages that influence Herring, and how have they changed over time?

28. How have changes in ocean productivity, predator abundance or other factors affected the long-term median biomass of Herring?

Questions about human wellbeing

29. What thresholds of Herring abundance and distribution exist for meeting cultural objectives?

30. How do the economic and cultural benefits associated with the harvest of sac-roe, spawn-on-kelp, adult fish for bait, and adult fish for food propagate through local and regional social systems? What are the consequences of this for equity and food security?

31. What nonfishing human activities are supported by Herring, that is, what is the value of the supportive ecosystem services provided by Herring?

32. What is the trade-off between economics and human wellbeing if Herring remain in the ecosystem versus if they are harvested and removed from the system? How does this vary over the range of Pacific Herring?

Appendix C: Images and descriptions of interview materials (PWIAS Solutions Initiative project; Lam et al., submitted)

C.1 Haida Values

These "Haida values" came from the traditional Haida values and ethics identified by Jones et al. (2010). They were presented on cards to respondents in English translation, with the Haida words alongside. Each value card contained an image by April White on the front and a description of its value on the back. The concept in parentheses here refers to the principle for modern resource management the Haida Marine Working Group believed to be analogous to the value presented (Jones et al. 2010).

Respect Yahguudang or Yakguudang

Respect, for each other and all living things, is rooted in our culture. We take only what we need, we give thanks, and we acknowledge those who behave accordingly. (Precautionary approach)

"The world is as sharp as the edge of a knife." Giid tll'juus

Balance is needed in our interactions with the natural world. If we aren't careful in everything we do, we can easily reach a point of no return. Our practices and those of others must be sustainable. (Sustainable use) *[This value is abbreviated as "balance" in Figure 3.1 and Table 3.1.]*

Interconnectedness ("Everything depends on everything else.") Gina waadluxan gud ad kwaagiida

This principle is comparable to an integrated approach to management. (Integrated management)

Reciprocity (Giving and receiving) Isda ad diigii isda

Reciprocity (giving and receiving) is a respected practice in our culture, essential in our interactions with each other and the natural world. We continually give thanks to the natural world for the gifts that we receive. (Equitable sharing)

Seeking wise counsel Gina k'aadang.nga gii uu tl' k'anguudang

Our elders teach us about traditional ways and how to work in harmony. Like the forest, the roots of our people are intertwined. Together we consider new ideas and information in keeping with our culture, values, and laws. (Adaptive management/Best information)

Responsibility ‘Laa guu ga kanhllns

We accept the responsibility passed on (to us) by our ancestors to manage and care for the sea and land. We will ensure that our heritage is passed on to future generations. (Inclusive and participatory)

C.2 Western values

These “Western values” were derived from a variety of sources in the moral psychology and applied ethics literatures (Mepham et al. 2006, Graham et al. 2012), and were meant to reflect, together with the “Haida Values,” a comprehensive set of near-universal values (i.e., common to most cultures; Lam et al. *submitted*). Each value card contained an image by April White on the front and a description of its value on the back.

Sanctity

Sanctity is about accepting a sacred or spiritual element in the world.

Wellbeing

Wellbeing is about a good quality of life, a state characterized by essential features such as health, prosperity, and happiness.

Freedom

Freedom is about the ability to make your own choices on how to live your life.

Justice

Justice is about distributing benefits, risks and costs fairly.

Authority

Authority is about respecting social order and the rule of law.

Group solidarity

Group solidarity is about the sense of belonging and showing loyalty to a group.

A

Yahguudang or ***Yakguudang***
Respect

B

Glid tl'juus
"The world is as sharp as the edge of a knife."

C

Gina waadluxan gud ad kwaagilda
Interconnectedness ("Everything depends on everything else.")

D

Isda ad diigii isda
Reciprocity (Giving and Receiving)

E

Gina k'eedang.nga gii uu ll' k'anguudang
Seeking Wise Counsel

F

Laa guu ga k̲anhlins
Responsibility

A

Sanctity

D

Justice

B

Wellbeing

E

Authority

C

Freedom

F

Group Solidarity

C.3 Scenario images

These images were printed on 8.5'' x 11'' paper sheets and presented to respondents as illustrations of each of four herring management scenarios for Haida Gwaii waters: 1) A Whale of a Time, in which all commercial herring fisheries are closed in Haida Gwaii waters; 2) The Fish that Get Away, in which the commercial roe herring fishery is closed while a commercial spawn-on-kelp (SOK) fishery is managed using a harvest-control rule (HCR) based upon an unspecified biomass threshold for opening; 3) Hard of Herring, in which commercial roe herring and commercial SOK fisheries are both managed using the same HCR (this was the scenario in place at the time of all interviews); and 4) The Little Fish that Could, in which commercial roe herring and commercial SOK fisheries are managed using separate HCRs, based upon different, unspecified biomass cutoff thresholds.