Indigenous community preferences for food and ceremonial fishery outcomes: Quantifying the importance of harvestable biomass and spatial distribution via a discrete choice experiment

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Claire Menendez

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Examining Committee:	**Chair:** Jessica Gill Master of Resource Management Candidate
	Sean Cox Senior Supervisor Professor
	Anne Salomon Supervisor Associate Professor
	Len Hunt Supervisor Adjunct Professor
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Ethics Statement

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

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or

b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University

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Abstract

Fisheries are inherently complex, with important interactions among biological dynamics, the environment, and the socio-economic systems in which they are embedded. Managing fisheries for both short- and long-term sustainability requires taking a management-oriented paradigm focused on meeting goals and objectives that are important and acceptable to all fisheries participants. Indigenous communities regularly feel that they are under-represented in fisheries decision-making, and that their cultural and livelihood objectives are ignored. Governments want to integrate Indigenous criteria into their definition of fisheries management success, but to date there is a lack of tools and processes to help Indigenous communities quantify their objectives in a way that can effectively inform the DFO process. Using a case study on the West Coast of Vancouver Island (WCVI), this project examines how a simple survey with a discrete choice experiment (DCE) can be used to help quantify Indigenous objectives. I worked with the Nuu-chah-nulth Indigenous community to design and implement a DCE to determine their preferences for the outcomes of a food and ceremonial fishery. The DCE provided quantitative information to show positive preferences for increased layers of spawn on bough and quality of spawning area, and negative preferences for increasing number of spawning areas and increasing travel time. Additionally, we found evidence of a shifting preference baseline in the Nuu-chah-nulth community, highlighting a loss of traditional Nuu-chah-nulth knowledge caused by low herring abundances along the WCVI. DCE results are supported by qualitative comments from the Nuu-chah-nulth community, making us confident that the DCE was able to effectively represent community preferences. Overall, we found that DCE’s can help Indigenous communities translate their general fishery goals into specific measureable objectives, allowing their goals and values to be better represented and included in fisheries management decision-making.

Keywords: Discrete choice experiment; Fisheries Management; Indigenous; Objectives

For my Parents,

Who continually inspire me to take chances and believe in myself.

Thank you for your never ending support and love

.

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DCE	Discrete Choice Experiment
DFO	Fisheries and Oceans Canada
SOB	Spawn on Bough
WCVI	West Coast of Vancouver Island

Chapter 1. Introduction

Contemporary fisheries management typically takes a model-oriented approach that places quantitative science and modelling at the centre of decision-making (Cox & Benson, 2016, De La Mare, 1998). The model-oriented approach uses stock abundance and catch monitoring data to address biological questions about fish stock status and productivity, the historical impacts of fishing, and forecasted short-term stock responses to harvest choices (Hilborn &Walters, 1992). Fishery management processes and outcomes have improved substantially for many large-scale commercial fisheries that have adopted a model-oriented approach (Mora et al. 2009), because harvest decisions increasingly account for uncertainties about fish population dynamics and monitoring data. Indeed, the model-oriented approach helps fishery managers achieve several essential tenets of the precautionary approach to capture fisheries (FAO 1996).

At the same time, fisheries are inherently complex, with important interactions among biological dynamics, the environment, and the socio-economic systems in which they are embedded (Plaganyi et al. 2013, Rindorf et al. 2017). The model-oriented approach is usually so focused on modelling and estimating the details of stock dynamics and data that socio-economic dynamics get ignored and, consequently, so do other key tenets of the precautionary approach, such as long-term management goals like the needs of future generations and avoidance of irreversible change.

Managing fisheries for both short- and long-term sustainability requires a decision-making plan that, if consistently repeated over time will lead to sustainable outcomes regardless of time scale. Unlike the model-oriented approach, this management-oriented paradigm (MoP) instead focuses on strategic management goals to (i) establish biological, social, and economic objectives, (ii) develop a suite of alternative plans or decision-making procedures, (iii) ranking the procedures in terms of their expected ability to achieve the objectives, and (iv) implementing the plan consistently over time. The management-oriented paradigm is well-established in several large-scale fisheries around the world and is held as the "gold standard" of effective and precautionary fisheries management. Nevertheless, the MoP also comes with some formidable challenges; chief among these is the need to establish quantitative objectives that are important and acceptable to all fishery participants (Cox & Benson 2016).

Indigenous communities regularly feel that they are under-represented in fisheries decision-making. Although the precautionary approach to fisheries management requires consideration of future generations and preventing irreparable harm, two principles that Indigenous Nations regularly prioritize to guide their decision making, Indigenous cultural and livelihood objectives are frequently ignored in-lieu of the economic objectives of commercial fisheries (Plaganyi et al. 2013, Artelle et al. 2018). Current fishery objectives normally focus on maximizing biological yield, which tends to favour large-scale commercial interests over other community, social, and ecosystem preferences (Adams et al. 2014). Maximizing yield is also the simplest objective to understand and control. More complex objectives that combine social-ecological interactions have been difficult to quantify. Indigenous communities have many of these complex and interacting fisheries objectives related to subsistence fishing, commercial economic profits, ecological sustainability, and maintaining cultural practices (Plaganyi et al. 2013, Artelle et al. 2018). While mounting evidence suggests that management interventions linking social and ecological processes lead to outcomes that outperform those that do not (Gutiérrez et al. 2011, Schultz et al. 2015, Cinner et al. 2016, Gill et al. 2017), achieving an integrated understanding of the coupled dynamics of social-ecological systems remains a challenge for researchers and managers (Lertzman 2009, Salomon et al 2018).

In recent decades there has been an effort to build new relationships among Indigenous Nations and Provincial and Federal governments (Salmon et al 2018). Despite efforts to engage in new respectful relationships, Indigenous communities still feel that their values and objectives are not being represented in resource management decisions (Artelle et al. 2018). Consultation and engagement processes between Federal, Provincial and Indigenous governments have struggled to determine specific quantitative Indigenous objectives for fisheries management. In these conversations Government agencies such as Fisheries and Oceans Canada (DFO) use specific criteria to define what they see as successful fisheries management. Indigenous communities do not always agree with the criteria that government agencies use, and want management decisions to better reflect their goals and experiences. In comparison to the DFO, Indigenous communities can communicate what their broad fisheries objectives are, but do not have clear methodologies in place to translate these general goals into specific measurable objectives. Governments want to integrate Indigenous criteria into their definition of management success, but to date there is a lack of tools and processes to help Indigenous communities quantify their objectives in a way that can effectively inform the DFO process. For a management-oriented paradigm to be successful, their need to be methodologies in place to help Indigenous communities quantitatively express their objectives, allowing their goals and values to be better represented and included in fisheries management decision-making.

The goal of this research is to explore the use of a quantitative stated choice survey as a methodology to determine quantitative Indigenous objectives. In this study, I test the ability of a discrete choice experiment (DCE) to quantify Nuu-chah-nulth preferences for the food and ceremonial herring fishery outcomes on the West Coast of Vancouver Island (WCVI). Through this case study, I hope to better understand how DCE's can be used to help Indigenous communities quantify their preferences for fisheries management.

The next sections of this chapter will give a brief description and contextualization around Indigenous values and objectives in fisheries management, present the research case study, and introduce discrete choice experiment methodology.

1.1. Indigenous Values and Objectives in British Columbia Fisheries Management

Indigenous communities in British Columbia have sustainably managed their traditional fisheries for generations. (Trosper 2002, Turner & Berkes 2006). They have a variety of deeply rooted spiritual and cultural practices that promote the sustainable use of marine resources within their territories, such as clear property rights contingent on proper management, and systems of publically enforced reciprocity (Trosper 2002). Since the colonization of the West Coast by the British Crown in the early 1800's, Government legislation has systematically removed the ability of Indigenous communities to follow their traditional management practices (von der Porten, Lepofsky, McGregor, & Silver 2016). However, in recent years' Indigenous people in British Columbia have been re-asserting their rights to access and manage their traditional resources (FNFC 2007, Jones & Pinkerton 2016, von der Porten et al. 2016). They have been working through the courts, as well as through public policy avenues to engage as equal partners in fisheries decision-making. Working to develop management structures that recognize and meet the inherent rights of Indigenous people to self-governance will require complex systemic changes. However, better understanding the preferences and needs of Indigenous communities is a key first step in recognizing these rights..

It should be noted that some Indigenous objectives cannot be quantified to fit into fisheries models (Satterfield, Gregory, Klain, Roberts, & Chan 2012). For example, revitalizing spiritual connection and love for a place are important objectives for Indigenous communities, but quantifying and measuring a concept like love involves distilling it down to an indicator that no longer accurately represents the original intention. However, that does not make the objective any less important or valid than easily quantifiable objectives, such as the number of tonnes caught per year.

However, there are many instances when it is possible to translate the perspectives and preferences of Indigenous peoples into quantitative objectives. For example, goals related to harvestable biomass and spatial distribution of fish can be distilled into measurable, quantitative indicators. Since 2015, Fisheries and Oceans Canada (DFO) has been engaging with Indigenous communities to better understand their needs and preferences for fisheries management. Although Indigenous fisheries managers have a clear understanding of their communities' values and preferences, they have struggled to operationalize these preferences into fisheries objectives. The challenge in creating objectives has mostly been due to a lack of knowledge about quantitative indices associated with different fisheries preferences. This has led managers and researchers to look for different methods that could be used to better understand and estimate the quantitative values of Indigenous communities' preferences that will help Indigenous people assert their rights in fisheries management (Dichmont et al. 2016, Murray et al. 2016).

1.2. West Coast of Vancouver Island Pacific Herring Fishery

The British Columbia Pacific herring fishery on the West Coast of Vancouver Island (WCVI) is an example of a Canadian fishery that has struggled to achieve successful management (Cox & Benson 2016, Jones & Pinkerton 2016). The fishery is made up of two main user groups, commercial fishermen, and Nuu-chah-nulth Indigenous harvesters. The Nuu-chah-nulth are a group of 14 Nations whose traditional territories occur along the WCVI and who harvest herring for both commercial and food and ceremonial purposes. The DFO has struggled to manage the herring fishery in a sustainable way that meets the needs of the Nuu-chah-nulth and the non-Indigenous commercial fisheries, leading to frequent conflict between the Nuu-chah-nulth, the DFO, and the commercial fishing industry.

Herring on the WCVI has experienced multiple collapses over the past 50 years. A large reduction fishery starting in the 1940's led to a population collapse in 1968, drastically limiting the herring being harvested by the Nuu-chah-nulth for food and ceremonial purposes. Since the collapse in the 1960's, herring stocks have behaved erratically on the WCVI, making it challenging to sustainably allocate harvest to both commercial and food fisheries (DFO 2018). Since the early 2000's the herring population have experienced a period of low productivyt, leading to increased tension between the DFO and Nuu-chah-nulth. The Nuu-chah-nulth voluntarily gave up their commercial fishing rights due to fear of causing greater harm to an already small herring population, and greatly limited their food and ceremonial harvesting. In 2011, the DFO created a new herring stock assessment model to better characterize uncertainty in herring stocks on the WCVI (Martell, Schweigert, Haist, Cleary 2011) While the DFO saw this as a positive step in creating more sustainable herring management, it alienated the Nuu-chah-nulth Nations, as they felt that the new model was doing a worse job at producing stock biomass estimates that matched their personal observations in their traditional territory (Jones & Pinkerton 2016). Controversy around herring management came to a climax in 2013 when the Cabinet Minister opened the commercial herring fisheries on the WCVI despite DFO scientists and the Nuu-chah-nulth advising against the opening. The Nuu-chah-nulth took the DFO to court over this decision, and ended up receiving a court injunction to close the commercial fishery for the 2013-2014 fishing season (Jones & Pinkerton 2016).

1.2.1. Nuu-chah-nulth Herring Fisheries

Harvesting Pacific herring has always been a significant part of Nuu-chah-nulth culture. Spawn-on-bough and whole herring have been collected since time immemorial for cultural gatherings like Potlach's, for general consumption, and to trade between different Nations. Spawn-on-bough harvesting involves suspending hemlock or cedar boughs in the water during a herring spawn, and collecting roe and milt that attaches to the boughs as spawn occurs (Uu-a-thluk 2018). Spawn is either peeled off and stored, or consumed directly off of the boughs.

Much of the current conflict in the WCVI Pacific herring fishery is because the fishery lacks agreed upon measurable objectives to guide harvest strategies (Cleary & Taylor 2015). In 2015, the DFO and the Nuu-chah-nulth began a process to re-develop the management system for herring along the WCVI with a focus on creating clear operational objectives that represent the needs of the Nuu-chah-nulth and the commercial fishery (DFO 2017). They continue to work through a Management Strategy Evaluation (MSE) process to determine objectives for the fishery, and develop a new management structure that best meets these objectives. MSE is a structured decision-making process that specifically moves fisheries decision making away from focusing on fisheries modelling, to focusing on the wider management context (Cox & Benson 2016). MSE uses simulation modelling to test different management procedures against objectives to find the management procedure that best meets the objectives of the groups involved in the fishery.

A major struggle with current management for WCVI Pacific herring, is that although fishery model estimates are predicting biomass increases, the experiences of the Nuu-chah-nulth does not support the DFO belief that herring populations are rebuilding and reaching levels that could support a commercial fishery. Uu-a-thluk, the Nuu-chah-nulth management group in charge of fisheries for the Nations, and DFO managers have been struggling to understand what the Pacific herring ecosystem needs to look like for the Nuu-chah-nulth to consider the herring population healthy enough to support a commercial fishery. Nuu-chah-nulth objectives for the WCVI herring fishery encompass more than reaching a specific herring abundance level, to also include meeting marine ecosystem goals, and food and ceremonial fishery needs. While Uu-a-thluk understands that food and ceremonial fishery outcomes play a large role in Nuu-chah-nulth objectives for Pacific herring management, they have not been able to determine specific quantitative indicators to know when the food and ceremonial fishery is meeting the needs of the Nuu-chah-nulth community

1.3. Determining Indigenous Preferences for Fishery Outcomes via Discrete Choice Experiments

Discrete choice experiments (DCE) are increasingly applied within natural resource management as tools to elicit the preferences of individuals for management outcomes (Bacalso, Juario, & Armada 2013). DCE, which is a type of stated preference survey, is used to estimate preferences from choices among hypothetical alternatives such as a hypothetical fishery (Sanko 2001). The DCE method is based on utility maximization and random utility theories (Manski 1977). Utility maximization theory assumes that when confronted with a set of alternatives, an individual will choose the one that will maximize their utility or well-being. Random utility theory describes the uncertainty that researchers have about understanding how individuals make choices; thus, random utility theory results in stochastic and not deterministics predictive models of choice (Manski 1977).

In a DCE, individuals choose between discrete sets of two or more alternatives by trading off information about attributes, such as cost and expected catch rate, that describe each alternative (Ryan, Watson, & Entwistle 2008*)*. Based on the choices of alternatives, researchers can estimate preferences for attributes and attribute levels, such as expected catch rates of 1, 2, and 4 fish per hour. Individuals' repeated choices among alternatives in different choice sets permits researchers to estimate preferences for attributes that allow one to assess trade-offs that individuals make between different attributes (Wattage 2005). For any attribute, the preferences along with coding of the attribute allows researchers to express the preferences as part-worth utility functions, which demonstrate the relative importance of various attributes and their levels in influencing the choice selection by an individual (Philcox, Knowler, & Haider 2010). The relative importance of the attribute is conditioned by the levels that are considered for an attribute. For example, the choice of a fishing site is much more influenced by a range of costs from $10 to $1000 than a range from $10 to $20.Part-worth utilities are combined to determine the total utility of a scenario, providing researchers with estimates of the community's overall satisfaction with a particular outcome.

Discrete choice experiments have been used in a variety of resource management situations to determine objectives and management strategies. For example, DCEs have been used to determine recreational anglers' preferences for harvest regulations and management decisions in Canada and Europe (Aas, Haider, & Hunt 2000, Hunt 2005, Hunt, Gonder, & Haider 2010), to assess farmers' preferences for management actions to modernise agriculture in Uganda (James 2010), and to estimate the public's preference for waste management options in Macao (Jin, Wang, & Ran 2006).

1.3.1. Discrete Choice Experiments in an Indigenous Context

DCEs have multiple benefits that could help Indigenous fisheries managers better understand the preferences of their community, such as providing information about the communities preferred quantitative levels for different objectives. However, these methods have rarely been used to elicit the preferences of Indigenous communities within a resource management context. The use of any Western quantitative methods to understand Indigenous preferences should be done with an awareness of the potential inappropriateness of these methods in an Indigenous context. Many Indigenous scholars call for the use of traditional Indigenous methodologies, such as story-telling, to gather information about Indigenous communities, in-lieu of Western research methods (Simpson 2004, Louis 2007).

As well, there may also be difficulties in using DCEs in an Indigenous community due to small sample sizes. Discrete choice experiments normally require fairly large sample sizes (400+ participants) to obtain sufficient power to detect statistically significant results (Sanko 2001). Indigenous communities are typically sparsely populated and some community members may not be able to complete the survey, which could result in small sample sizes and concerns about the reliability of model estimate.

There are also general barriers to engaging in any type of survey or research in Indigenous communities as a non-Indigenous researcher. Past negative experiences have left Indigenous communities skeptical of academic researchers (Adams et al 2014). This distrust can make it challenging to build relationships within Indigenous communities, and develop acceptance and interest in the research (Smith 1999). Highly quantitative Western research and surveys can be especially challenging to implement, as they are generally outside the scope and knowledge systems of many community members, increasing their distrust and skepticism about the project.

Chapter 2. Methods

2.1. Study Area

This research was conducted on the unceded traditional territory of the Nuu-chah-nulth First Nations, which are a group of 14 Indigenous Nations found along the West Coast of Vancouver Island, with traditional territory ranging from Jordan River to the Brooks Peninsula (Fig. 2.1). The Nuu-chah-nulth Nations include: Ditidaht, Huu-ay-aht, Hupacasath, Tse-shaht, Uchucklesaht, Ahousaht, Hesquiaht, Tla-o-oqui-aht, Toquaht, Yuu-cluth-aht, Ehattesaht, Kyuquot/Cheklesaht, Mowacaht/Muchalaht, and Nuchatlaht. In this study, the Nuu-chah-nulth community is defined as the collective grouping of all 14 Nuu-chah-nulth Nations.

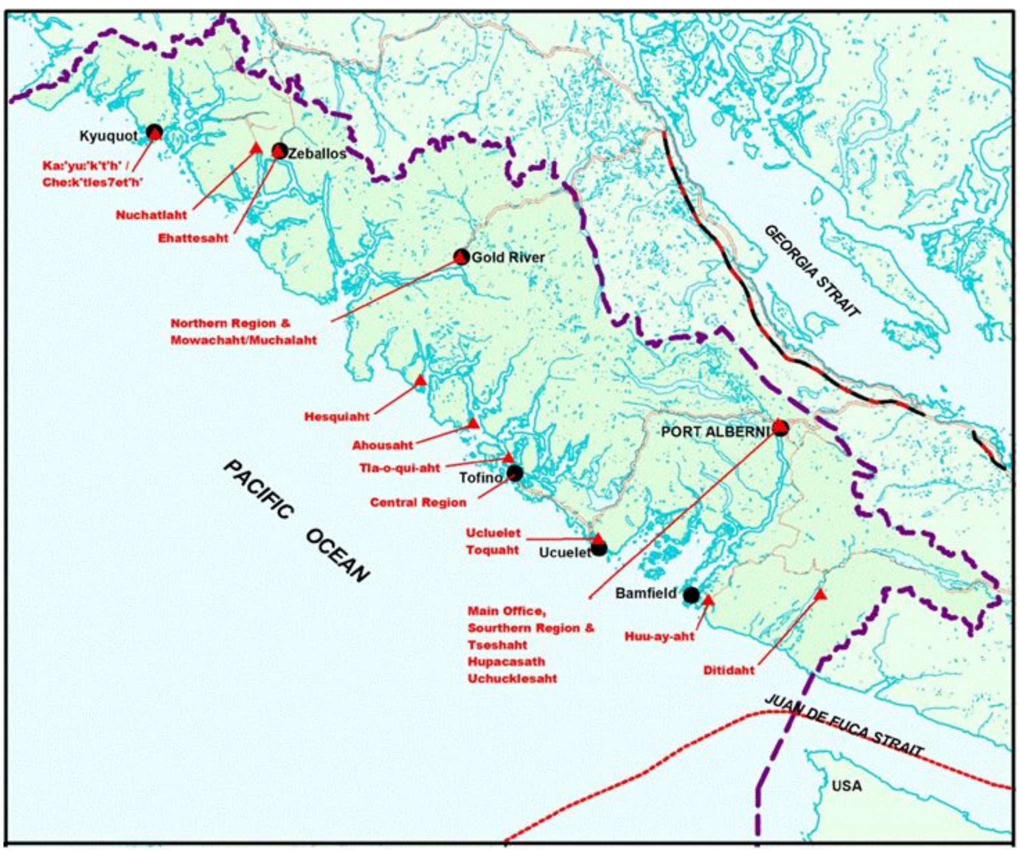

Figure 2.1. Location of the 14 Nuu-chah-nulth Nations along the West Coast of Vancouver Island. The purple dashed line denotes the entire Nuu-chah-nulth communities traditional territory.

Note. Map provided by Nuu-chah-nulth Tribal Council Staff

Currently, the Nuu-chah-nulth have approximately 10,000 members, with most people living on or near their traditional territory. The 14 Nations follow both a hereditary and elected governance system, with each Nation having a group of Ha'wiih (Hereditary Chiefs), and an elected Chief and Council. All 14 Nations are connected through the Nuu-chah-nulth Tribal Council, which provides support programs to the Nations, including fisheries management.

2.2. Community-Collaborative Research

Indigenous communities have a complicated history with academic research, with previous negative experiences making it challenging to develop trusting and positive relationships between academics and communities (Castelden, Morgan, & Neimanis 2010). In recent years, academic researchers have recognized the need to change their behaviour and research approaches to engage respectfully with Indigenous communities (Drawson, Toombs, & Mushquash 2017, Riddell, Salamanca, Pepler, Cardinal, & McIvor 2017). For this project, a research partnership was developed with the Nuu-chah-nulth community guided by the best practices of community-collaborative research (CCR), which involves engaging local communities and individuals in the research process with the goal of sharing or co-generating knowledge to understand complex problems and bring about change through policy (Tondu et al. 2014). CCR focuses on respecting and understanding community needs, building trust within the community, and making genuine collaborative efforts to engage with the community and promote knowledge exchange. Through a CCR research approach, I developed a respectful research partnership between myself and the Nuu-chah-nulth community, meaningfully involving community members in my research. I partnered with Uu-a-thluk, to engage with Nuu-chah-nulth community members to design and implement a survey, and to validate the research results.

Engaging with Indigenous communities in a way that follows their preferred and traditional protocols is important to show respect for, and an understanding of, the communities culture and values. I worked with Uu-a-thluk fisheries managers to follow the appropriate protocols while engaging with the Nuu-chah-nulth community. I initially presented my research proposal to the Council of Ha'wiih, a gathering of hereditary chiefs and community representatives, to request permission to conduct research within the Nuu-chah-nulth communities. Subsequent consent from the hereditary chiefs legitimized the research project within the Nuu-chah-nulth community.

A focus of CCR is to co-generate knowledge, and develop research partnerships that are beneficial for all parties involved (Adams et al 2014, Tondu et al. 2014). Engaging with Uu-a-thluk managers and Nuu-chah-nulth community members allowed me to design a survey that would help the Nuu-chah-nulth with their fisheries management goals, and also answer my larger scale methodological questions. Uu-a-thluk staff, a group of Nuu-chah-nulth community members, and myself developed a survey that would be relevant and understandable to the Nuu-chah-nulth community.

Involving community members as much as possible in the research process helps to develop trust, respect and engagement with the research (Castleden, Morgan, & Lamb 2012). I worked with the Uu-a-thluk biologists from the Nuu-chah-nulth Nations, to implement the survey to the community. It was beneficial to have Nuu-chah-nulth Nation biologists implement the surveys, because community members already knew and trusted these individuals. It also provided the fisheries biologists with an opportunity to learn more about their Nations' cultural connection to herring.

Involving community members in disseminating results ensures that results are being accurately interpreted and represented (Riddell et al 2017). Community members can validate hypotheses about patterns in the data, and have local knowledge to inform data interpretation. I presented my results to Uu-a-thluk fisheries staff and Nuu-chah-nulth community members to ensure they agreed with and understood the results, and to also help work through different hypotheses about why we may have found various results.

2.3. Discrete Choice Experiment

2.3.1. Survey Design

I collaborated with the Uu-a-thluk to design and implement the survey "*Nuu-chah-nulth herring (?usmit) perspectives*". The goal of the survey was to understand and quantify Nuu-chah-nulth preferences for outcomes of the food and ceremonial herring fishery on the WCVI. The survey contained three sections. In the first section, respondents were asked to provide information on their socio-demographic characteristics and experience with commercial and food and ceremonial herring fisheries. The second section contained the discrete choice experiment (DCE), which asked individuals to choose between herring food and ceremonial spawn fishery scenarios. The third section of the survey asked questions about the wider marine ecosystem, and requested qualitative comments on characteristics that they thought were important in food and ceremonial herring spawn fishery.

The survey was designed over 8 months by myself and the Herring Committee, a group made up of Uu-a-thluk managers and Nuu-chah-nulth community members. We used information from previous consultations between the DFO and Nuu-chah-nulth on herring fishery objectives to frame the survey, and to identify the types of information that would be the most helpful to Uu-a-thluk managers. A preliminary questionnaire was administered to community members to better understand the herring ecosystem from a Nuu-chah-nulth perspective. The final survey and discrete choice experiment were then designed using information from these questionnaires and input from the Herring Committee. The final survey was tested and refined using feedback from a focus group of 5 Uu-a-thluk fisheries staff, 2 of which were Nuu-cha-nulth Nation members, and 2 Nuu-chah-nulth Nation members.

2.3.2. Final DCE Design

The DCE was designed with 4 attributes, each with 4 different levels, where the attributes were: number of spawning areas, quality of the spawning area, time travelled to a spawning area, and number of spawn layers on boughs (Table 2.1). The number of layers of spawn on bough was used to determine preferences for harvestable biomass, and preferences for spatial distribution were described using the number of spawning areas, the quality of spawning areas, and the time travelled to a spawning area. Definitions for the attributes were provided to respondents prior to beginning the survey, and could be referred to while completing the survey.

Table 2.1 Attributes and levels used in the discrete choice experiment

Attribute	Explanation	Level 1	Level 2	Level 3	Level 4
Number of Spawn Areas	Describes the number of spawn areas distributed throughout the pre-specified geographic region. Spawn areas were not shown on a map or distributed in any specific area	2	5	8	11
Quality of Spawn Area	Herring spawning areas varying with respect to abiotic factors that impact an individuals' safety while harvesting and the quality of the harvested spawn on bough	Poor: Exposed, wavy, sandy bottom, spawn will be sandy and gritty	Mediocre: Partially exposed, wavy, mostly sand and mud, spawn will be mostly sandy	Good: Partially protected, some choppy waves, mostly good spawning substrate, spawn will be mostly clean	Excellent: Protected, calm, good spawning substrate, spawn will be clean
Travel time to Spawn Area	Describes the amount of time an individual would spend boating to a destination to harvest spawn.	Up to 8 hours of travel	Up to 4 hours of travel	Up to 2 hours of travel	Can access spawn without a motorized boat.
Number of Layers of Spawn on Bough	Describes the number of spawn layers found on hemlock or cedar boughs suspended in the water by harvesters	3 layers	6 layers	9 layers	11 layers

2.3.3. Hypotheses about DCE Attribute Preferences

Preliminary hypotheses about DCE attribute preferences were generated through conversations with Uu-a-thluk fisheries staff and subsequently reviewed by the Herring Committee (Fig. 2.2). We believed that individuals would prefer more spawning areas, as this would signify a larger herring population size. We also hypothesized that individuals would have increasingly negative preferences for longer travel times. Increasing travel time creates logistical issues from crossing into other Nation's territories, increases safety risks from travelling beyond protected inlets, and makes it more challenging to reach a spawn when it first starts, therefore decreasing chances of getting a large biomass of spawn on bough. It was also hypothesized that individuals would have greater satisfaction from good and excellent quality spawning areas, as these areas would provide better quality spawn and safer harvesting locations. We believed that individuals would have a linear increase in satisfaction with increasing layers of spawn on bough until a certain thickness. At this point, satisfaction would plateau and potentially decrease. Comments from Nuu-chah-nulth harvesters as well as research on the Central Coast of BC have described a decrease in spawn quality once layers reach a certain thickness (Gauvreau et al. 2017). High layers of spawn on bough can cause eggs to rot or peel off boughs (Gauvreau et al. 2017).

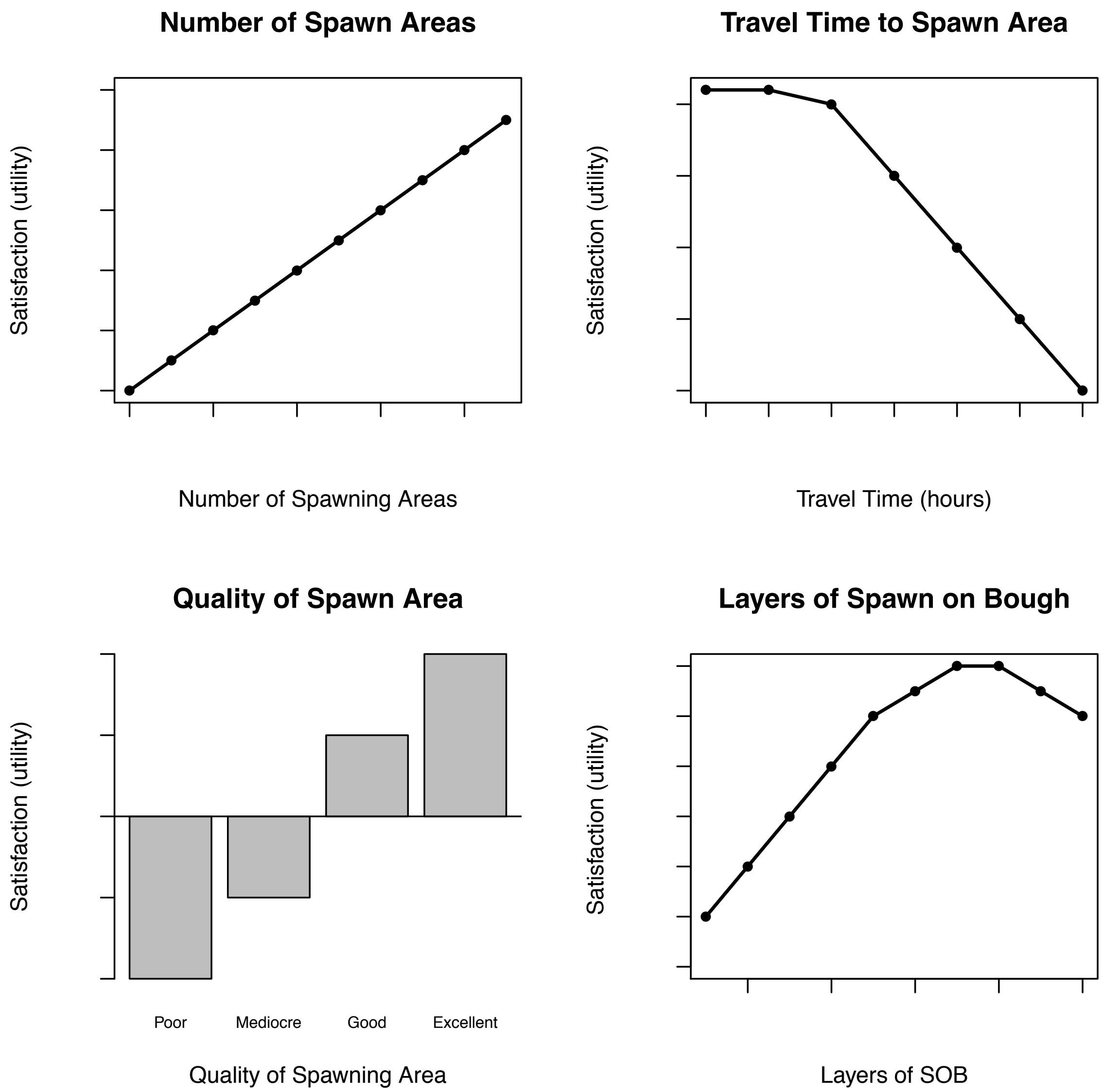

Figure 2.2. Hypotheses about the directionality of preferences for the four attributes used in the DCE.

2.3.4. Experimental Design

I created a full-factorial, orthogonal design using SAS 9.4. Priors were not used to code the DCE because of time constraints and the limited number of people who were able to complete a pre-survey without impacting the sample size for the actual survey. The final design involved 24 choice sets arising from three groupings of 72 hypothetical herring spawn situations. The choice sets were divided into 4 blocks, with 6 choice sets per block. Respondents were randomly assigned a block and choice sets appeared in a random order within the block to limit the potential effect of choice set order on respondents' preferences.

Each choice sets involved making a single choice from 3 hypothetical herring spawn scenarios. Typically, in a DCE, a status quo scenario is used to allow comparison between preferences for hypothetical situations and the present situation. However, we did not include a status quo scenario in this DCE because the Herring Committee felt that current perceptions of herring fishery status were too variable among individuals to allow an even comparison.

2.3.5. Survey Implementation

Respondents were chosen on a convenience basis, with the survey being delivered online via social media and newsletters, and in-person by Uu-a-thluk fisheries managers. Individuals who completed the hardcopy version were led through the survey by Uu-a-thluk staff or myself. The online version of the survey was made available to all Nuu-chah-nulth community members through the Uu-a-thluk website, Facebook page and newsletter, and individual Nation's social media pages and newsletters.

Respondent socio-demographic characteristics including age, gender, Nation, and level of participation in community issues were used to determine the representativeness of responses. An attempt was made to specifically target younger individuals, individuals who do not regularly attend meetings, and individuals who may not actively take part in the herring fishery, as they were recognized as the least likely to have participated in previous discussions about setting goals and objectives for the herring fishery.

After one month of fielding the questionnaire, very few individuals had responded. Therefore, revisions were made to the online survey, which included shortening the introduction, and including more description with survey questions. More information was added to the marine ecosystem questions to clarify the connection between herring abundance and other marine animal populations. More description was also added to the definition of spawn area quality, as individuals with limited herring experience were not realizing that sandy substrates causes gritty spawn. These changes were made based on recommendations from Uu-a-thluk fisheries managers, who were implementing the surveys to community members in person. An incentive was also added to complete the survey, with individuals being put into a draw to win 1 of 3 $250 cash prizes after completing the survey.

2.4. Survey Analysis

2.4.1. DCE Model Estimation Theory

Choice experiments have a theoretical basis in utility maximization theory and random utility theory (Sanko 2001), which assume that, while individuals make decisions that maximize their utility on average, survey responses have substantial random components because surveys cannot capture all of the reasons why individuals make decisions. Combining these theories leads to a model for utility U_{in} of alternative *i* for respondent *n* is of the form,

$$U_{in} = V_{in} + \varepsilon_{in} \quad \text{Equation 1}$$

where V_{in} is the observable component and ε_{in} is unobservable random error (Philcox et al 2010), which is assumed to be independently and identically distributed (IID) from a Type 1 Extreme Value distribution (Hensher 2005).

The observable component of utility is described by a linear combination of attributes, i.e.,

$$V_{in} = \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k \quad \text{Equation 2}$$

where $\beta_i \; i = 1,2, \ldots k$ are the responses coefficients estimated by the choice survey.

A choice experiment assumes that individual *n* will choose alternative *i* over alternative *j* if U_{in} > U_{jn}. Therefore, the probability that person *n* will choose alternative *i* over alternative *j* is:

$$Prob(i|C) = Prob\{V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}\}; \forall j \in C \qquad \text{Equation 3}$$

where *C* is the complete set of all possible alternatives from which the individuals can choose. The probability of choosing alternative *i* is estimated as:

$$Prob(i) = \frac{exp^{(\mu+\beta_i X_{ni})}}{\sum_{j=1}^{j=J} exp^{(\mu+\beta_i X_{nj})}} \qquad \text{Equation 4}$$

which is the standard conditional logit model.

Aggregating the responses of individuals to the DCE provides probability estimates of each alternative being chosen, allowing estimation of the utility for each alternative and its attributes.

2.4.2. DCE Parameter Estimation

Utility parameters were estimated using LatentGold Choice 5.2, via conditional logit regression (Vermunt & Madginson 2005). For the final model form, linear parameters were estimated for the two numeric attributes (number of spawn areas and layers of spawn on bough). Both linear and quadratic parameters were estimated for the numeric attribute, travel time to spawn areas, and categorical parameters were estimated for the nominal attribute (Quality of spawn area). Linear and quadratic parameters were estimated to reduce the number of parameters to be estimated by the model while permitting flexibility in the relationship between the attribute and utility (e.g., permitting a linear or a non-linear relationship). All attributes except quality of spawning area were modelled as both linear and quadratic, and the quadratic parameter estimate was removed if it was not statistically significantly different from zero.

A model form in which the data was split into two latent classes was also tested, along with the single class models. In a latent-class model, respondents are probabilistically assigned to classes, which have different utility functions. The latent-class model is specified by the following equation:

$$Prob_{ni|c} = \frac{exp^{(\mu + B_c X_{ni})}}{\sum_{j=1}^{J} exp^{(\mu + B_c X_{nj})}} \qquad \text{Equation 5}$$

$Prob_{ni|c}$ is the probability that an individual, *n*, chooses alternative *i,* given that this individual belongs to class, *c.* Individuals are assigned to classes probabilistically, using the conditional logit form:

$$Prob_{nc} = \frac{exp^{(Z_n \phi)}}{\sum_{c=1}^{C} exp^{(Z_n \phi)}} \qquad \text{Equation 6}$$

Z_n is a vector of individual respondent characteristics included as explanatory variables, and estimates of ϕ indicate which of these covariates characterise different preferences groups.

Respondents were grouped into two significantly different latent classes; however the second class had only 12 individuals, making the sample size for the second class too small to appropriately fit a model to the data. Therefore, the latent class model was discarded from the results.

The final model form was selected by choosing the model with the best statistical performance, and that was also stable and interpretable. Statistical performance of the model was determined by combining the AIC and BIC scores, and choosing the model with the lowest combined score (Vermunt and Madginson, 2005). The model with the best statistical performance was the latent class model; however, due to the small sample size noted above, the second class was seen as non-interpretable and was discarded. The model with the second best statistical performance was the single class model with a combination of nominal, linear, and quadratic coefficients. This model was retained as the final model for further analysis, as it has high statistical performance, and is interpretable.

Analysis of respondent characteristics

Respondent characteristics were included in parameter estimation as known classes to determine whether these socio-demographic characteristics were related to observed differences in estimated utility. Respondent characteristics included: 1) the survey version completed (hardcopy or online), 2) the age of respondent (over or under 50 years old), 3) the respondents level of participation in community issues (active or not active), 4) the respondents self-ranked level of knowledge of Pacific herring harvesting and stewardship (low, moderate, and high). These characteristics were chosen because they were highlighted by the Herring Committee as groupings of individuals that may have variations in preferences. It has also been shown in previous studies that socio-demographic characteristics can influence respondent preferences, both because of differences in biases while completing the survey, and different life experiences that impact their choices (Hearne & Salinas, 2002, Apostolakis & Jaffry, 2005). We did not develop specific directional hypotheses for differences in respondent characteristics, these groups were simply highlighted as groups that may show some heterogeneity in preferences for herring food and ceremonial fishery outcomes.

Survey version completed

Surveys were completed both online and in-person through a hardcopy. Individuals who completed the survey online completed the survey on their own, with no explanation beyond the instructions given in the survey, while individuals completing the hardcopy of the survey interacted with Uu-a-thluk staff or myself while completing the survey. Individuals were able to ask for clarification about questions, and some individuals were led through the entire survey. It was necessary to provide this level of support to some individuals to allow them to complete the survey, as they faced literacy or physical barriers to completing the survey themselves.

Research exploring stated preference surveys shows that individuals' responses to choice tasks can vary depending on the method used to respond to a survey (Caussade, Ortuzar, Rizzi, & Hensher 2005). Therefore, it was important to test whether the form of completing the survey was significantly impacting individuals' preferences.

Age of Respondents

Uu-a-thluk and the Herring Committee believe that younger community members may have different preferences than older Nuu-chah-nulth community members. Since the WCVI herring stock collapse in 1968, herring fisheries and populations have been in a period of low productivity (DFO 2018). Many Nuu-chah-nulth Nations have had prolonged periods of little to no herring spawn in their territory. Community leaders have expressed concern about younger generations in the Nuu-chah-nulth community having less opportunities to harvest and learn about herring, and the impact this might be having on knowledge transmission across generations. Other Indigenous communities in British Columbia have experienced a loss of traditional harvest knowledge due to a lack of access traditional harvesting areas (Turner & Turner 2008), and Uu-a-thluk is interested in whether this cultural knowledge loss is happening within the Nuu-chah-nulth community.

Along with a lack of access to herring spawn, individuals under the age of 50 have grown up in a very different world than those over the age of 50. Most of this younger generation have not personally experienced residential schools (TRC 2018), and have grown up in a more technologically and physically connected world (Turner & Turner 2008). Younger individuals are leaving their Nation's territory to go to school and get jobs, which is providing them with different opportunities than previous generations (Turner & Turner 2008). A lack of opportunity to take part in Pacific herring harvest, as well as changing opportunities and experiences for younger generations (Waldram, Herring, & Young 2006) could mean that they have different preferences for food and ceremonial fishery outcomes than older individuals.

Respondents level of participation in community issues

Individuals who actively participate in the management and harvest of a resource are likely to have different preferences than those who do not. Hunt et al. (2010) found in their research that individuals who actively participate in a fishery have different preferences than a random, representative sample of a community. The Herring Committee is made up individuals appointed by the Council of Ha'wiih, and all of them have some connection to their Nation's fishery program and herring fisheries. Uu-a-thluk was interested in using this survey to collect information and preferences from the wider Nuu-chah-nulth community to ensure that the preferences and objectives that they've been working on with the Herring Committee are representative of the entire Nuu-chah-nulth community. We gathered information on level of participation in community issues to see if the survey had been able to capture the preferences of individuals who may not normally provide input into community management plans. We make the assumption that level of participation in community issues is an indicator of likelihood of participating in, or having your opinion expressed in consultation processes, with individuals actively participating in community issues being more likely to participate in some kind of consultation or engagement processes. Testing whether individuals who actively participate in community issues have significantly different preferences than those who do not actively participate allows us to see whether a section of the Nuu-chah-nulth community is being missed or miss-represented by other individuals within the Nation.

Respondents self-ranked level of knowledge of Pacific herring harvesting and stewardship

Uu-a-thluk was interested in preference differences based on the level of self-ranked knowledge because they want to understand the heterogeneity in preferences within the Nuu-chah-nulth community. They wanted to know whether individuals with low self-ranked knowledge of herring harvest and stewardship would have similar preferences as those with high self-ranked knowledge. Level of self-ranked knowledge was used as an indicator of experience with the herring ecosystem, and Uu-a-thluk are concerned that an inability to interact and experience the herring harvest will lead to changes in preferences across the community.

2.4.3. Sensitivity Analysis of Socio-Demographic Characteristics

Socio-demographic characteristics that had significantly different preferences were tested for the sensitivity of groupings. Age and level of self-ranked knowledge were tested to determine the sensitivity of results based on how individuals were grouped.

Age:

Individuals were originally split into two groups: Group 1 - respondents less than 50 years old, Group 2 - respondents 50 years and older. This split was determined based on the first large herring collapse on the WCVI, which happened 50 years ago in 1968. It was hypothesized that individuals who had experience harvesting or interacting with herring spawn before that collapse could have different preferences than individuals who had only ever harvested or interacted with herring spawn after this first collapse. The sensitivity of the results to this grouping decision was tested by changing the ages of the two groups by 1 year increments, and assessing how the preference estimates changed. 5 different age groupings were tested, as sample sizes became too small for either group when respondents were split too unevenly across the two groups.

Self-Ranked Knowledge:

Self-ranked knowledge was originally split into 3 groups: “low knowledge” as an individual self-ranking between 1-2 on scale of 1-9, “moderate knowledge” as an individual self-ranking between 3-6 on a scale of 1-9, and “high knowledge” as an individual self-ranking between 7-9 on a scale of 1-9. The sensitivity of these knowledge rankings was tested by also running models with self-ranked knowledge groupings being 1-3, 4-6, and 7-9 for little, moderate and more knowledge respectively. As well, models were run with knowledge split into only two groups, with 1-3 being little knowledge, and 4-9 being moderate to high knowledge.

2.4.4. Inter-attribute Trade-offs and Scenario Analysis

The probability of an individual choosing a scenario were determined using parameter estimates from Latent Gold and Equation 4. Probability of choice can be used to describe the “market share” or number of individuals who would choose a scenario based on its’ level of attributes. These market shares were used to do univariate and multivariate analysis of the impact attributes have on the percentage of people choosing a scenario. The percent choosing metric allow us to explore the trade-offs individuals are making between attributes to maximize their satisfaction of a situation.

Two reference scenarios were developed, the “worst” and “best” case scenario. The worst case scenario was made up of the attribute levels associated with the lowest part worth utility for each attribute; 11 spawning areas, poor spawn area quality, 8 hours of travel time, and 3 layers of spawn on bough. The best case scenario was made up of the attribute levels associated with the highest part worth utility for each attribute; 2 spawning areas, excellent spawn area quality, 0.1 hours of travel time, and 11 layers of spawn on bough. These scenarios were used as reference points for the multivariate attribute analysis.

2.5. Qualitative Survey Analysis

Qualitative responses to survey questions were analyzed using thematic analysis. Thematic analysis is a structured process used to determine themes and ideas repeated across respondents (Braun and Clarke 2006). Responds were asked to:

"*describe and rank up to 5 characteristics you consider important in determining the quality of a spawning area*", and these qualitative answers were analyzed to determine key themes. I followed the phases of thematic analysis as described by Braun and Clarke (2006). The data was read a number of times to familiarize myself with responses, while I made note of initial ideas. I then generated initial codes for the data, highlighting the basic features of each response. These codes where then collated into different possible themes. The potential themes were then reviewed by myself, and some Uu-a-thluk staff to make sure they made sense in relation to the coded extracts. Themes were then refined and given specific names. The percentage of times a theme was mentioned was determined by counting the number of coded data points that fit into that theme, divided by the total number of coded data points.

2.6. Validating Findings with the Community

After the qualitative and quantitative data analysis was complete, the results and the inferences I drew from them were discussed and validated using a focus group with Uu-a-thluk fisheries managers and community members. This focus group provided community members and managers to provide comments on the research, and express any concerns they might have with the results. Feedback from participants was gathered verbally, and through a short questionnaire.

Chapter 3. Results

3.1. Respondent Characteristics

The survey was completed in-full by 87 respondents, with at least 1 response from every Nation (Table 2). Respondents were evenly split across socio-demographic characteristics, with 47% of respondents were male and 53% of respondents were female, and ages ranging from 18 to 85. Of the 87 respondents, 47% reported actively participating in community issues and 53% either passively participated or did not participate in community issues. Respondents experience harvesting and processing Pacific herring varied from 11.5% having taken part in commercial herring fisheries, 52% having harvested or processed herring for food and ceremonial purposes, and 37% having only ever consumed herring and not participated in any aspect of the fishery. Respondents also had variable levels of self-ranked knowledge about Pacific herring harvest, processing and stewardship, with 33% self-ranking as having “Little Knowledge” (1-2 on a scale of 1-9), 40% self-ranking as “Moderate Knowledge” (3-6 on a scale of 1-9), and 27% self-ranking as “More Knowledge” (7-9 on a scale of 1-9).

3.2. DCE Analysis

3.2.1. Primary DCE Model

A model aggregating all DCE responses into one class was estimated using LatentGold Choice 5.2 (Vermunt and Madginson, 2005). This full model included estimates of linear and quadratic utility parameters for numeric attributes (number of spawn areas, travel time to spawn area, and layers of spawn on bough) and categorical utility estimates for quality of spawning area.

Results from the full model suggested a negative relationship between satisfaction and increasing number of spawning areas and increasing travel time to spawning areas (Table 3.1, Fig. 3.1. Positive relationships were estimated between satisfaction and increasing spawn area quality and increasing numbers of layers of spawn on bough (Table 3.1, Fig. 3.1).

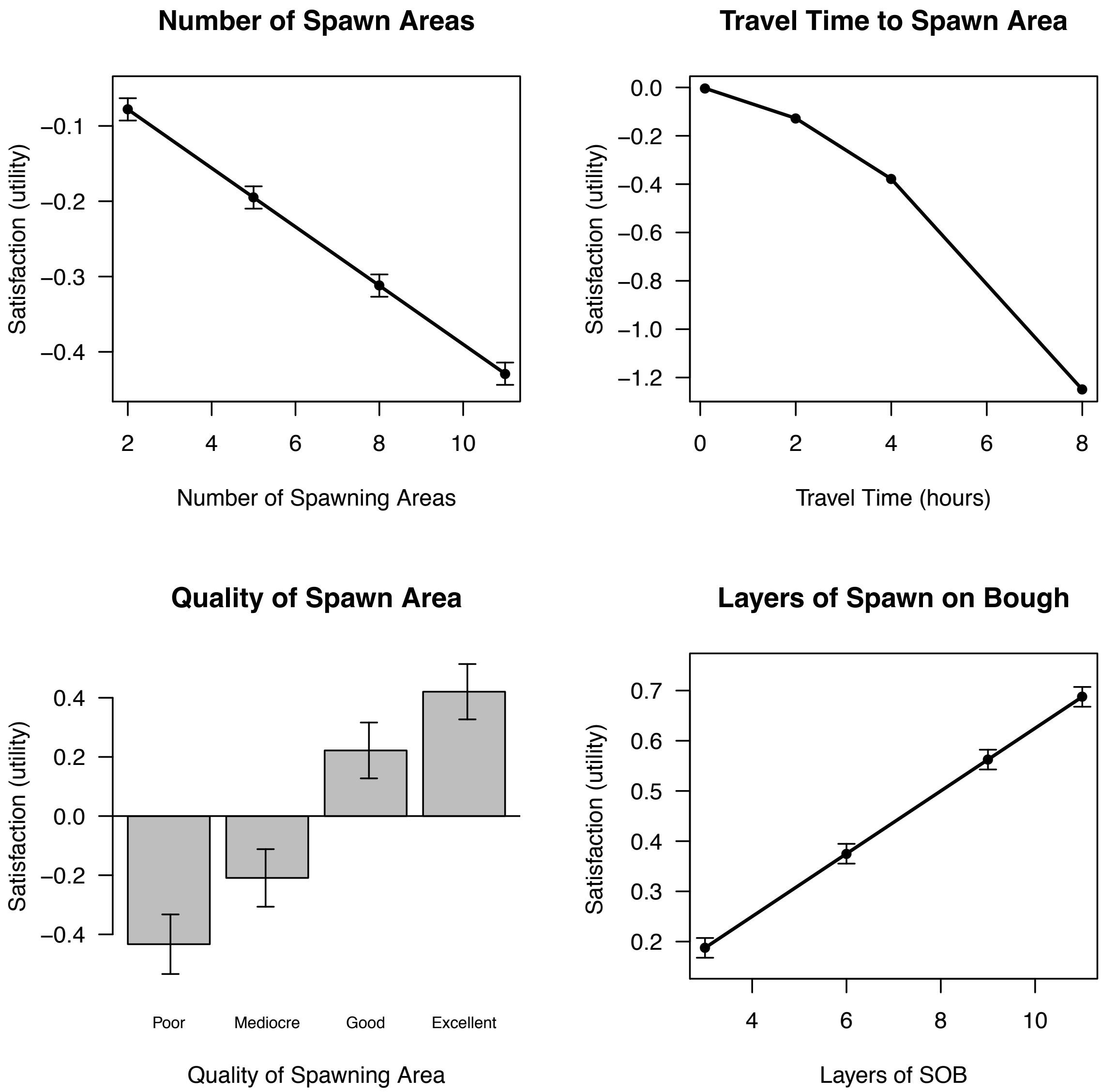

Figure 3.1. Satisfaction curves determined from the Beta parameter estimates of the primary DCE model.

Table 3.1. Beta parameter estimates for the DCE attributes based on the primary DCE model

Attribute	Parameter Estimate	Standard Error
Number Of Spawn Areas		
Linear	-0.039 *	0.0148
Travel Time		
Linear	-0.0330	0.0635
Quadratic	-0.0154 *	0.0077
Quality Of Spawn Area		
Poor	-0.4333 *	0.1007
Mediocre	-0.2092 *	0.0973
Good	0.2219 *	0.0944
Excellent	0.4205 *	0.0936
Layers Of Spawn On Bough		
Linear	0.0625 *	0.0197

3.2.2. Socio-demographics and Preferences

Separating the respondents into classes based on their socio-demographic characteristics revealed important differences in preferences for herring spawn attributes. We found a significant effect of respondents' socio-demographic characteristic on their preferences for travel time to spawning areas, and layers of spawn on bough. Travel time utility estimates were significantly different for individuals under and over 50 years old, individuals actively participating or not participating in community issues, and individuals varying in their level of knowledge of herring harvesting and stewardship. Individuals age 50 and over have a negative quadratic preference curve, with a slight increase in utility from having to travel 0 to 2 hours, and then a decrease in utility as travel time increases to 4 and 8 hours (Fig 3.2a). In contrast, individuals under age 50 have an almost linear preference curve, with utility decreasing consistently with increasing travel time. Individuals with self-ranked knowledge from 3 to 6, and 7 to 9 both have negative quadratic preference curves, with increasing utility from 0 hours of travel time to 2 hours of travel time, and then increasingly negative utilities for 4 and 8 hours of travel time (Fig. 3.2b). Individuals who fall in the "little knowledge" category, with a self-ranking of 1-2, have negative preferences for all travel times, with utility becoming less negative as travel time increases.

Utility estimates for layers of spawn on bough were significantly different for individuals who were under or over age 50, and individuals who had different levels of knowledge of herring harvesting and stewardship. Individuals who are age 50 and over had a steeper positive preference curve (line) for increasing layers of spawn on bough than individuals under the age of 50 (Fig 3.2c). Individuals with self-ranked knowledge between 3 to 6 and 7 to 9 also have steep positive preference lines for layers of spawn on bough, while individuals with little knowledge of Pacific herring harvest and stewardship have a less steep, and negative preference line for layers of spawn on bough (Fib 3.2d).

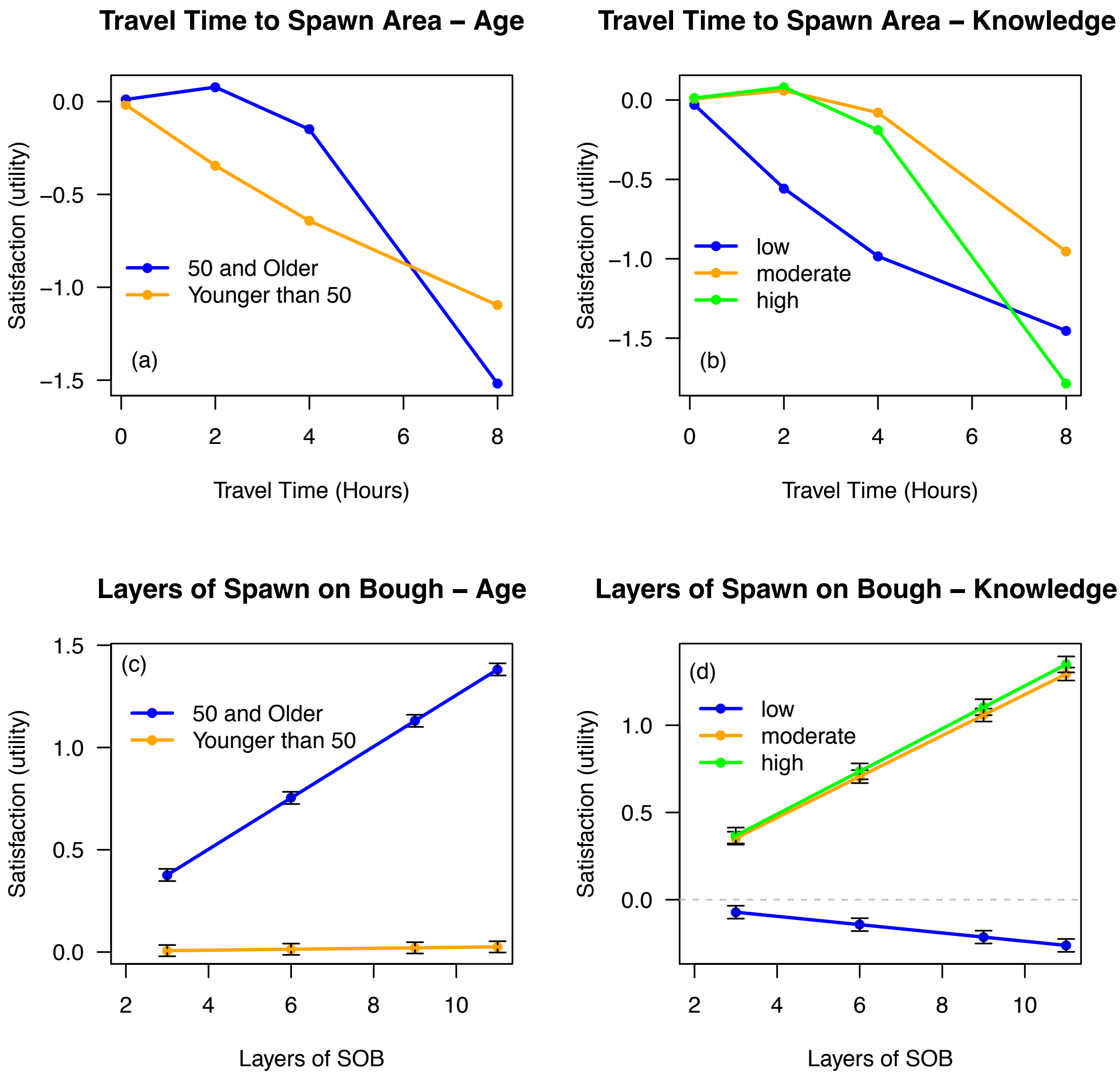

Figure 3.2. **Difference in preferences for travel time and layers of spawn on bough depending on respondent age and respondent level of self-ranked knowledge. Low knowledge is a self-ranking between 1-2 on a scale of 1-9, moderate is a self-ranking of 3-6, and high is a ranking of 7-9.**

3.2.3. Sensitivity Analysis of Socio-demographic Groupings

Age:

Individuals under 50, and 50 and over were found to have significantly different preferences for travel time to spawn area, and layers of spawn on bough. The sensitivity of these differences in preferences based on how age was grouped was tested by looking at 5 different age groupings. The sensitivity analysis age groupings were 0-46 and 48-85, 0-48 and 49 to 85, 0-50 and 51-85, 0-51 and 52-85, 0-52 and 53-85.

Differences in preferences for travel time to spawn area for each grouping of ages followed the same general pattern as the original groups of 0-49 and 50-85 (Figure 4). The younger age grouping (either 0-46, 0-48, 0-50, 0-51, or 0-52) always had a more linear negative preference for increased travel time, and older age grouping (either 48-85, 49-85, 51-85, 52-85, or 53-85) always had a negative quadratic preference for travel time. The major sensitivity of the ages that individuals were grouped as was based on the split of the older age group, with increasing the age of the older group causing steeper negative preferences for travel times (Fig. 3.3).

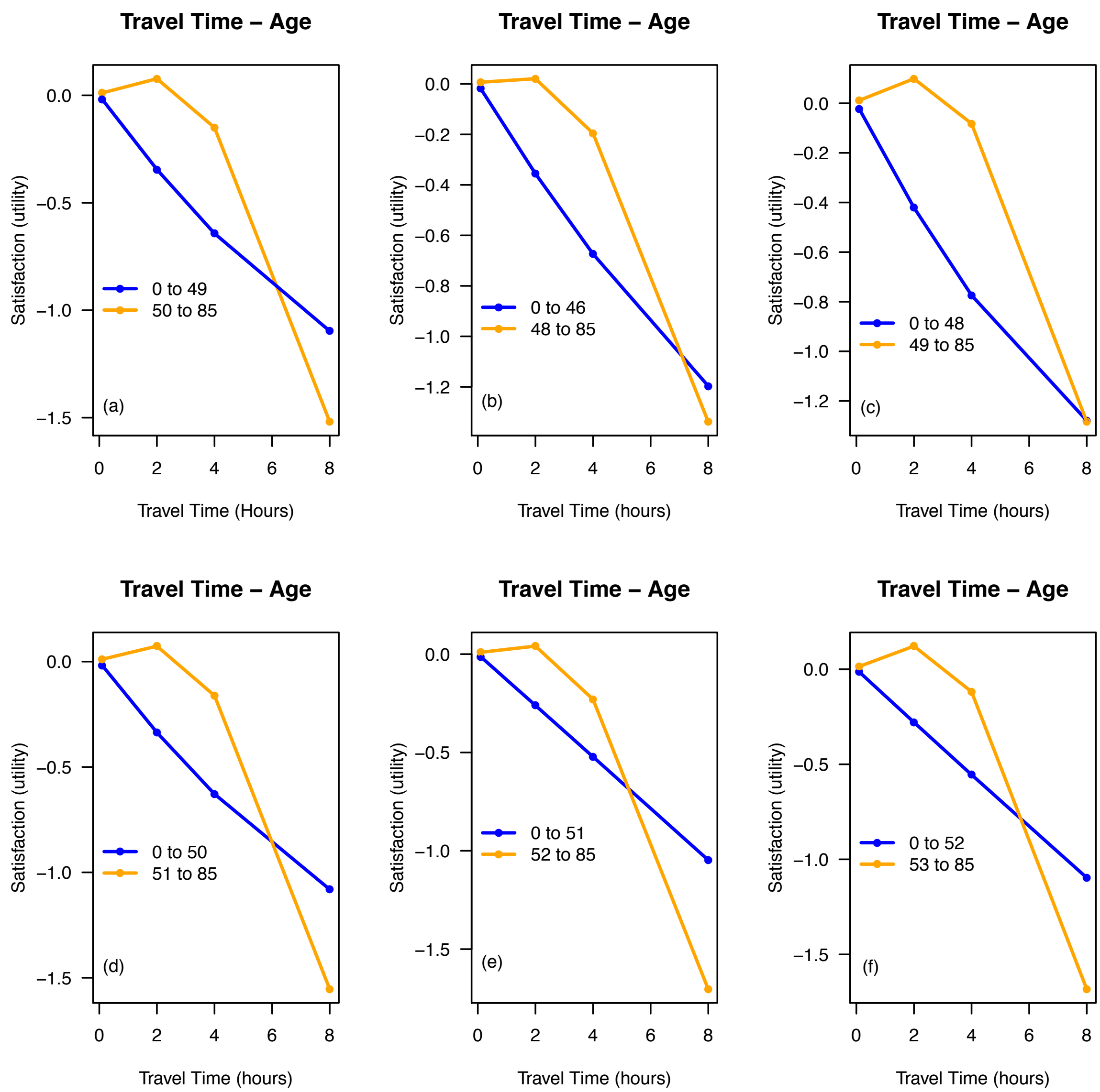

Figure 3.3. Sensitivity of differences in preference for travel time to spawn area based on how age of respondents is grouped. Figure (a) is the original age grouping, and figures (b) through (f) are the preferences based on the sensitivity analysis age groupinds.

Preferences for layers of spawn on bough were more sensitive to how age groups were split than preferences for travel time to spawn area. Once the older age group was increased to 52 and over, there was no longer a significant difference in preferences between the younger and older age categories (Fig. 3.4).

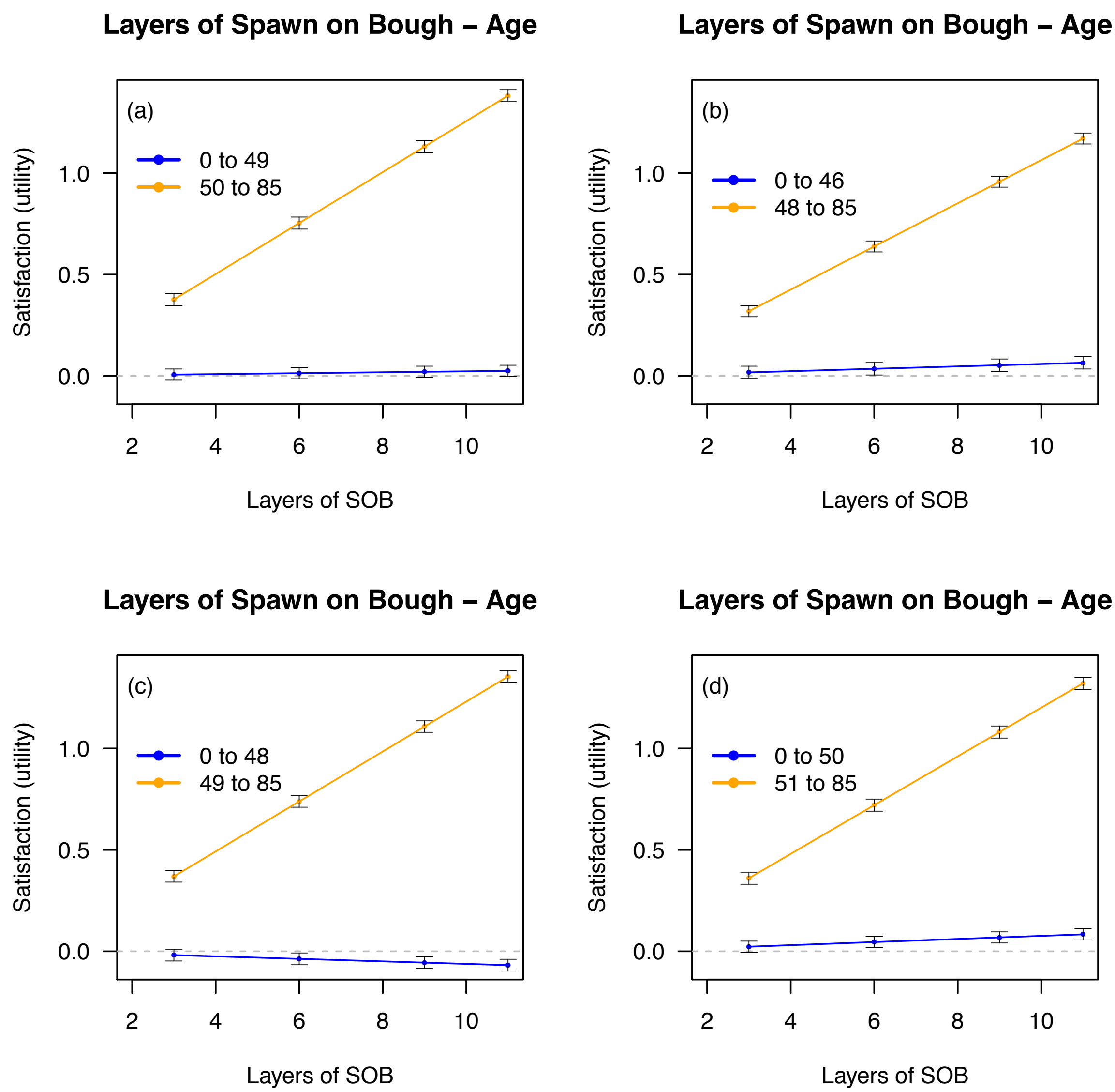

Figure 3.4. Sensitivity of differences in preferences for layers of spawn on bough based on how age of respondents is grouped. Figure (a) is the original age groupings, and figures (b) through (d) are the sensitivity analysis groupings

Self-Ranked Knowledge:

Differences in preferences for travel time were insensitive to whether low, moderate, and high knowledge was grouped as 1-2, 3-6, 7-9, or 1-3, 4-6, and 7-9, or if moderate and high knowledge are aggregated (Fig. 3.5).

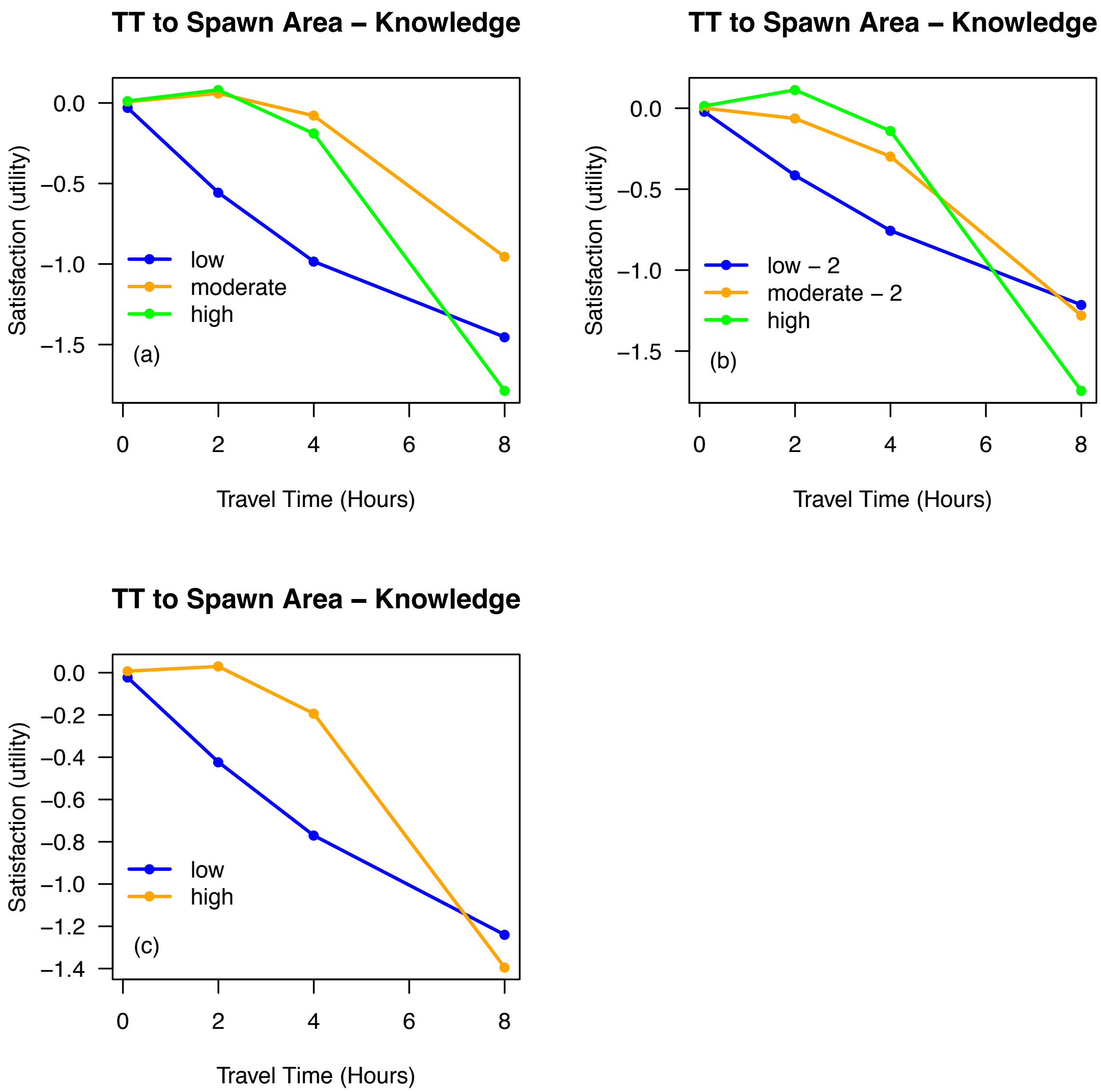

Figure 3.5. **Sensitivity of differences in preferences for travel time based on grouping of respondents self-ranked knowledge. Figure (a) is the original grouping, and figures (b) and (c) show the sensitivity analysis groupings. Low - 2 represents grouping individuals with self-ranked knowledge of 1-3, and moderate -2 represent grouping individuals with self-ranked knowledge of 4-6.**

Splitting knowledge groups into two groups, instead of 3 groups also had little influence on differences in preferences of low and high knowledge groups. Preferences for layers of spawn on bough were also insensitive to whether little, medium, and high knowledge was grouped as 1-2, 3-6, 7-9, or 1-3, 4-6, and 7-9, and aggregating the medium and high knowledge groups (Fig. 3.6).

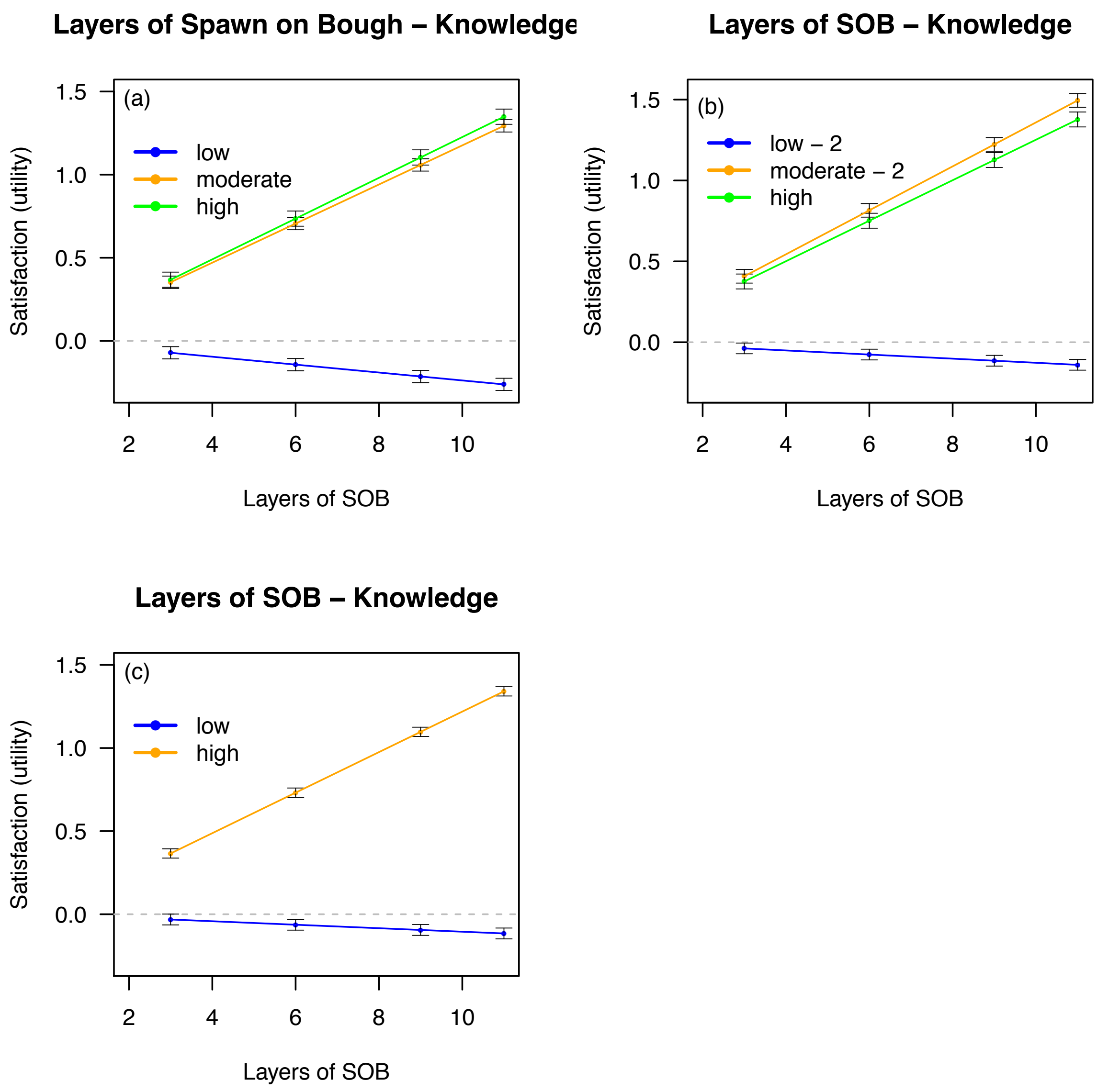

Figure 3.6. Sensitivity of difference in preferences for layers of spawn on bough based on groupings of respondents self-ranked knowledge. Figure (a) is the original knowledge grouping, and figures (b) and (c) are the sensitivity analysis knowledge groupings. Low -2 represents grouping individuals with self-ranked knowledge of 1-3, and moderate -2 represent grouping individuals with self-ranked knowledge of 4-6.

3.3. Inter-attribute Trade-offs and Scenario Analysis

Univariate attribute analysis found that the quality of spawning area had the biggest impact on the percent of people choosing a scenario. When all other attributes are held constant, increasing the quality of spawning area from mediocre to good increases the percentage of individuals choosing the “better” scenario by 12.2%. Multivariate attribute analysis for two attributes, layers of spawn on bough and travel time to spawn area are presented in this paper to provide an example of how this analysis can be used as a management decision support tool (Fig. 3.7).

Layers of SOB and Travel Time

Layers of Spawn on Bough \ Travel Time Hours	0.1	1	2	3	4	5	6	7	8
2	20.42	19.7	18.48	16.88	14.99	12.94	10.82	8.77	6.87
3	21.46	20.71	19.44	17.77	15.81	13.66	11.44	9.28	7.28
4	22.53	21.75	20.44	18.7	16.66	14.41	12.09	9.82	7.72
5	23.64	22.84	21.47	19.67	17.54	15.2	12.77	10.39	8.17
6	24.78	23.96	22.54	20.68	18.47	16.02	13.48	10.98	8.66
7	25.97	25.11	23.65	21.72	19.43	16.88	14.23	11.61	9.16
8	27.19	26.31	24.8	22.81	20.42	17.77	15.01	12.27	9.7
9	28.44	27.54	25.98	23.92	21.46	18.71	15.82	12.96	10.26
10	29.73	28.8	27.2	25.08	22.53	19.68	16.67	13.68	10.85
11	31.05	30.1	28.46	26.27	23.64	20.68	17.56	14.43	11.47

Figure 3.7. Change in percent choosing as layers of spawn on bough vary from 2 to 11 layers, and hours of travel time vary from 0.1 to 8. Numbers within the cells represent the percent of individuals choosing a scenario

3.4. Qualitative Analysis

Comments on characteristics of a good spawning area were grouped into 7 different themes (Table 3.2). “Location/abiotic conditions” and “Proximity” were the most mentioned themes, with 21.8% and 21.2% of individuals mentioning the themes respectively. Grouping “Proximity” with “Traditional Territory” into one theme “Geographic Location” makes it the most mentioned theme, with 29% of individuals mentioning the importance of where herring spawns occurs geographically (Table 3.3).

Table 3.2. The seven themes determined by the thematic analysis of the survey question “Describe 5 characteristics of a high quality spawning area”

Theme	Description
Proximity	Express preference for spawn being close to community, a short boat ride, easy to access
Location/abiotic conditions	Preferences for location-specific attributes other than distance, e.g. substrate type, protected area, close to trees and kelp, good distribution
Environment/biotic conditions	Express importance of weather, eelgrass, other animals around, water temperature, cleanliness of the area
Abundance	Describe characteristic related to the number of fish present. E.g. lots of fish, lots of spawn/eggs
Management	Statements about how the spawn area is managed. E.g. exclusive access, some things not allowed, excluding motorboats.
Traditional territory	Specifically mention spawn being in traditional territory, hahouthlee, or ancestral areas
Timing	Statement related to when spawn happens

Table 3.3. Examples of comments for the two most common themes, Geographic Location, and Location/Abiotic Conditions.

Theme	Example quote
Geographic location	We had spawn a few minutes from our villages, now we don't have any spawn
Geographic location	Traditional community location
Geographic location	Locations ancestors used; one of ways we can connect to them
Location/abiotic conditions	Away from sandy outside beaches
Location/abiotic conditions	Sheltered/protected from storms

3.5. Focus Group Comments

Uu-a-thluk fishery managers and community members generally felt that the quantitative results from this DCE analysis reflected individual preferences, and were able to provide feedback on my interpretation of the results. I collected survey feedback on the results of the survey from 5 Nuu-chah-nulth community members, with all 5 individuals agreeing on the results for preferences for quality of spawn area, travel time to spawn area, and layers of spawn on bough. Three individuals agreed with the results for preferences for number of spawn areas, and 2 individuals disagreed with these results.

Chapter 4. Discussion

Indigenous communities currently lack tools and processes to help quantify their objectives in a way that can effectively inform the DFO processes for managing fisheries. Using a case study on the West Coast of Vancouver Island, this project examined how a survey with a discrete choice experiment can be used to help understand Indigenous preferences for the outcomes of a food and ceremonial fishery. The DCE provided quantitative information to show positive preferences for increased layers of spawn on bough and quality of spawning area, and negative preferences for increasing number of spawning areas and increasing travel time. This quantitative preference information can be used to determine community acceptance of different food and ceremonial fishery outcomes, helping managers better understand when Nuu-chah-nulth food and ceremonial herring fishery outcomes are met. Developing management procedures that promote these quantitative fishery outcomes recognizes and responds to the Nuu-chah-nulth's preferences and is a key step in recognizing the communities' values and Indigenous rights to access herring.

Survey results indicated that Nuu-chah-nulth preferred higher quality spawning areas that were sheltered and less sandy compared to unprotected sandy areas. These attributes could reflect harvesters' safety while collecting spawn, as well as the quality of the spawn collected (Gauvreau, Lepofsky, Rutherford, & Reid 2017). As expected, Nuu-chah-nulth also preferred high quality fishing areas as close as possible to their communities as indicated by strong preferences for shorter travel times to fishing areas. Shorter travel times have several advantages for Nuu-chah-nulth food and ceremonial fisheries. For instance, short transit times solve several logistical issues such as (i) lowering costs of fishing (e.g., in transit time and fuel), which is important because food and ceremonial fisheries provide no direct monetary gain; (ii) easing concerns about the safety of long transit times to fishing areas during late-winter and early-spring when sea states can be dangerous; (iii) operationally, increasing the chance of harvesters getting to the spawn early; and (iv) making it more efficient to check boughs frequently during the spawning period.

Greater travel distances to access herring spawn increases the need to cross into another Nation's territory and therefore obtain permission to fish from other Nation's

Ha'wiih. The 14 Nuu-chah-nulth Nations all have traditional territories along the coast. The Nations Ha'wiih are responsible for managing their territories resources, including fisheries (Arbour, Kuecks, & Edwards 2008). If an individual from another Nation wishes to harvest in a Nation's territory that is not their own, they require permission from the Ha'wiih of the other Nation (Arbour et al. 2008). Requests for permission to harvest are an important traditional practice to the Nuu-chah-nulth, but increases the cost and logistical aspect of harvesting herring spawn.

Nuu-chah-nulth preferences for short travel times could also reflect cultural objectives related to maintaining traditional practices and intergenerational knowledge exchange. For example, several qualitative comments indicated that having spawn close to communities, helps to promote cultural experiences: short travel times provide access to herring spawn for a greater proportion of the community:

> We had spawn a few minutes from our villages, now we don't have any spawn

> [Good spawn areas are] Locations ancestors used; one of ways we can connect to them

> I would love to have herring and herring spawn strong in our area so that I can learn how to harvest myself. My mothers' generation used to harvest but since the decline in herring - she has not been able to teach me in our traditional harvest area

The proximity of herring spawn to communities plays a key role in individual participation in the food and ceremonial herring fishery and, thus, transmission of traditional knowledge across generations (Turner and Turner 2008). The Nuu-chah-nulth are place-based peoples, with a strong traditional, cultural and spiritual relationship to the land they inhabit. Their culture and traditions have been shaped over generations by the land and resources they interact with on a daily basis (Uu-a-thluk 2018). Each Nation's communities have been built in areas that traditionally provided all of the resources necessary for their livelihoods. This place-based connection is described in traditional stories, and through place names. For example, the Nation name Hesquiaht is an English version of the Nuu-chah-nulth word, heish-heish-a, which means, "to tear asunder with the teeth." This refers to the technique of stripping herring spawn away from eel grass, which grew near Hesquiaht territory (Dewhirst 2010). The land the Nuu-chah-nulth inhabit provides them with physical resources to sustain themselves, and also creates a sense of purpose and spiritual connectedness that supports who they are as people.

A connection to the ocean and the resources it provides is a key pillar of Nuu-chah-nulth culture (Uu-a-thluk 2018). Over the years, Nuu-chah-nulth fishermen have noticed a decline and shift in the geographic location of fisheries in their territory, making it harder for community members to access their traditional resources. The Pacific herring fishery along the WCVI has changed dramatically over the past 50 years, with many Nations claiming that they no longer have spawn in the bays around their communities. For example, many qualitative comments describe changes in herring spawn distribution over time:

> [Good spawn areas are] 1 mile from village but doesn't spawn there anymore
>
> [Good spawn areas are] 40 minutes from village, but doesn't spawn there anymore
>
> Herring spawn seems to be less now. We had enough to last for a while a long time ago. Don't see much now. Don't get enough of this [herring spawn] now a days

The change in geographic location of spawn has limited people's ability to take part in the fishery, and has caused concern throughout the Nuu-chah-nulth community of decreased knowledge exchange about herring harvesting and stewardship practices between generations.

The DCE showed that the Nuu-chah-nulth prefer a small number of spawning areas over more spawning areas. The negative preferences for increased number of spawning areas was counter to our initial expectations. In particular, we expected that more spawning areas would indicate more fish and a better distribution of spawn. In qualitative survey comments, Nuu-chah-nulth community members explained that current perceptions of herring spawn associate more spawning areas with worse spawning conditions:

> Current trends we see that more [spawn] areas is often associated with more spot spawn with more trace spawn. So if you keep seeing multiple areas getting spot spawn and setting trees there and not getting much, all that work for low layers makes you angry/disappointed. Whereas less areas with big spawn events is the preference.

More spawning areas are equated to fewer spawning fish, shorter spawns, fewer egg layers and fewer opportunities to harvest eggs by the Nuu-chah-nulth harvesters. Smaller number of spawn areas are described as providing denser aggregations of fish with spawning lasting for a longer period of time and yielding a greater number of egg layers. Another Nuu-chah-nulth community member writes:

> Recent experiences with [getting] more spawning layers with less areas being concentrated on. For example, more areas of spawns might equal less layers because they [herring] are more spread out. I think results might have differed if they [respondents] thought more areas and good layers were incorporated

Nuu-chah-nulth preferences for the number of spawning areas should be interpreted with the understanding that the primary objective is to have spawning areas with high levels of harvestable biomass. Current harvesting experiences on the WCVI is that more spawning aggregations leads to lower levels of harvestable biomass, and is therefore not preferred. However, preferences for number of spawning areas would likely change if more aggregations was not associated with as much of a decrease in harvestable biomass. This is important to recognize because it is possible that spatial distribution is recovering before high local herring abundance. If this is true, then over time there may be both spatial distribution and high harvestable biomass, changing Nuu-chah-nulth preferences for the number of spawning areas.

Along with determining preferences for spatial distribution, we were also trying to better understand preferences for harvestable biomass from the food and ceremonial fishery by determining preferences for layers of spawn on bough. The layer of spawn on bough parameter estimate from the DCE was positive and linear, assuming an infinite increase in utility as layers of spawn on bough increase. However, Nuu-chah-nulth harvesters have described a decrease in spawn quality once layers reach a certain thickness (Gauvreau et al. 2017). When designing the survey, we had hypothesized that respondents' preference for egg layers would plateau or decrease in utility at with the higher numbers of layers. We did not capture this plateau, and based on research on the BC's central coast suggesting that too many egg layers will cause egg die off and rot, there should be further discussion with harvesters to understand when layers become too thick (Gauvreau et al. 2017).

The levels for layers of spawn on bough were chosen based on consultation with a small number of Nuu-chah-nulth harvesters. We chose the levels for layers to try to represent the lowest possible levels a harvester would ever harvest, a medium number of layers harvested, and the higher end of layers that a harvester would want when harvesting spawn on bough. Nuu-chah-nulth harvesters explained that they consider many things when choosing whether to harvest spawn on bough or to leave it in the water to let the eggs hatch. They are making a decision about the amount of work it will take to process the herring spawn, with more layers coming off of the boughs more easily, as well as considering the ecological impact of harvesting spawn when herring populations are at low abundances.

When validating the layers of spawn on bough results with other Nuu-chah-nulth harvesters, it became apparent that different individuals and Nations had different perspectives about the number of layers associated with low, medium and high harvest level of layers of spawn on bough. We heard from one harvester that they would not consider taking spawn until there were at least 8-10 layers of spawn on bough, with their preference being for 15 layers of spawn. Previously we had been told by another harvester that they would collect spawn when 4-6 layers were present. Differences in harvesting practices are likely due to different experiences with herring spawn over the past 10-15 years. Some Nations have had very limited spawn for a long time, with a low number of layers of spawn on bough. This may have caused a shift in what is perceived as being a "harvestable" amount of spawn. Nations with lower abundances of herring spawn still want to be able to harvest and have some herring to share with their Nation, making them willing to harvest spawn with a low number of layers' even if this means more work to process a much smaller amount of product. In comparison, Nations that have on average had higher herring biomasses in their territory have not had this shift in what they perceive to be a harvestable number of layers and expect more layers of spawn on bough before harvesting.

Based on comments from Nuu-chah-nulth harvesters, it is likely that the quantitative levels chosen for layers of spawn on bough were not very representative of what individuals would see when harvesting herring. Our lack of understanding around the number of preferred layers of spawn on bough is likely due to the small number of community members we had commenting on the final draft of our survey. Only two Nuu-chah-nulth community members with experience harvesting herring were present at the focus group to edit the DCE, which did not provide a very wide range of perspectives around harvestable levels of layers.

Further research should be done to better understand Nuu-chah-nulth preferences for harvestable biomass of the food and ceremonial Pacific herring fishery, such as applying a DCE with higher level of spawn on bough to better capture the higher number of layers some Nations experience. However, it is widely expressed that the current quantity of spawn on bough being harvested is not enough to meet the Nuu-chah-nulth communities needs for food and ceremonial purposes. Management procedures should continue to be implemented that focus on increasing the amount of harvestable biomass, and more work should be put in to quantifying how much herring spawn on bough Nation's need to meet their food and ceremonial needs.

4.1. Applying Preferences to WCVI Pacific Herring Management

Successful management of the Pacific herring fishery on the WCVI will require long-term management plans to rebuild the stock and maintain sustainable commercial and food and ceremonial fisheries. It's important to know what attributes of the food and ceremonial fishery should be prioritized to be improved, and which attributes may be of lower priority.

Looking at inter-attribute trade-offs and how different attributes influence individuals' choice of a scenario allows us to determine which attributes are having the largest impact on people's choices. Changing the level of an attribute, while holding all other levels constant will cause a change in the predicted percentage of people who would choose a scenario. The change in percentage of people choosing a scenario shows the impact of that attribute on people's choices.

Increasing the quality of spawning area from mediocre to good has the largest delta percentage increase, showing that the quality of the spawning area is the attribute that has the largest impact on respondents' choices.

It's important to note that no particular attribute on its own has an extremely high impact on people's choices, but instead all affect choices conjointly. For example, changing just one attribute to its highest level does not drastically change the number of individuals choosing that scenario. However, comparing “Best”, “Worst”, and an “In between” case scenarios has large differences in the percentage of respondents choosing a scenario, showing that all four of the attributes interact to impact people’s choices.

4.1.1. Scenario Planning and Decision Support Tool

Part-worth utilities from the DCE can be used to integrate preferences for all of the attributes into a single performance metric, the percentage of people choosing a scenario. This percent choosing metric can be used to compare preferences for any given scenario. For example, if we consider a scenario alongside the “best” and “worst” case scenarios, we can see how many individuals are choosing a third scenario, where we hold two attribute levels constant, and vary travel time and number of layers of spawn on bough. This type of decision support tool can help managers to visualize how changing the outcomes of the Pacific herring food and ceremonial fishery will impact people’s satisfaction, and to compare between scenarios and attribute levels. For example, in Figure 3.7 we can see that the highest percent choice values fall in a square along the bottom left corner, with a preferences falling between zero and three hours of travel time, and eight to eleven layers of spawn on bough. This provides managers with a range of values to aim for to maximize individuals’ satisfaction with management outcomes.

4.2. Validating DCE Results

Discrete choice experiments have rarely been used to elicit preferences of Indigenous communities within a resource management context. It is possible that a Western quantitative surveying method like a discrete choice experiment has limitations for capturing Indigenous preferences. When analyzing the DCE results, it was important to be critical of the model outputs, and make sure that the Nuu-chah-nulth community validated the DCE model outputs and my interpretation of these results.

Comments from Uu-a-thluk fisheries managers and Nuu-chah-nulth community members made us confident that the DCE was effectively representing community preferences. The direction of preferences determined by the DCE match most of our hypothesized preferences directions, giving us confidence that the DCE is capturing preferences held by the Nuu-chah-nulth. Where DCE preferences did not match the hypothesized preferences, Nuu-chah-nulth harvesters were able to provide information to explain these differences. As well, there were similarities between qualitative comments gathered about important characteristics of good herring spawn and the directionality of preferences from the DCE. Proximity of spawning locations to communities and having abiotic conditions that support good quality spawn were the two most mentioned themes in the qualitative comments. These themes match the preferences for higher quality spawn areas and less travel time to spawn areas shown by the DCE.

Qualitative comments also described a variety of characteristics of good herring spawn that were not described in the DCE. Qualitative themes described by the Nuu-chah-nulth included wider ecosystem and environmental characteristics, as well as different management practices that individuals felt would create better herring spawn areas. These management practices included creating specific Indigenous-only access areas, limiting the harvest of other species at the same time as herring spawn, and decreasing noise and disturbance while harvesting herring (Table 4.1).

Table 4.1. Examples of Nuu-chah-nutlh qualitative comments about the relationship between herring and the greater marine ecosystem, and preferred herring management practices.

Theme	Example quote
Marine ecosystem	Right now there is imbalance in the eco-system. Humans or Nuu-chah-nulth people were an important part to the eco-system. we created a balance in the food chain. Less Nuu-chah-nulth people living in their homeland means we are no longer harvesting seal and sea otters for our purposes. Therefore creating an imbalance. “Hishukmatsawak” - everything is one
Marine ecosystem	[A characteristics of a good herring spawn area is]: "Life" fin fish, ducks, marine water birds, seals, people
Management	Prefer only First Nations be allowed to collect herring, Prefer territory be protected from commercial harvest of herring, and that First Nations be given preference to access resource of herring eggs and herrings
Management	Reduce motor & engine noise from boats and planes when spawning time approaches
Management	no crab traps, no geoduck harvesting

These comments show that the preferences expressed by the DCE are not the only things driving Indigenous objectives, but are just one part of the larger picture. Discrete choice experiments are a highly structured Western surveying method. The DCE was designed to understand preferences for harvestable biomass and spatial distribution of the herring fishery and did not try to identify the more cultural aspects of the herring fishery.

4.3. Experience with Pacific Herring Influences Preferences

A priori hypotheses about differences in preferences based on socio-demographic characteristics were tested to determine whether there was evidence for heterogeneity in preferences within the Nuu-chah-nulth community. Travel time to spawn areas and layers of spawn on bough were both significantly different based on respondents age and level of self-ranked knowledge. Age and self-ranked knowledge of herring harvest and stewardship are indicators of experience with the herring ecosystem on the WCVI. Being younger inherently means that an individual has had less opportunity to participate in herring fisheries and to learn about Nuu-chah-nulth stewardship practices. Recent low herring abundance and restrictions in spawning distribution across the WCVI has further limited the ability of young people within the

Nuu-chah-nulth community to take part in harvesting and to learn about stewardship processes. For example, an 18-year-old respondent explains how low herring abundance has impacted their ability to learn about herring harvesting from their mother:

> I would love to have herring and herring spawn strong in our area so that I can learn how to harvest myself. My mothers' generation used to harvest but since the decline in herring - she has not been able to teach me in our traditional harvest area

Heterogeneity in preferences across age groups occurred within the Nuu-chah-nulth community, which raises some concern about shifting baselines regarding the herring fishery. Shifting baseline syndrome (SBS) refers to a change in human perceptions of biological systems due to loss of experience about past conditions (Papworth, Rist, Coad, & Milner-Gulland 2009). Known class estimates from the DCE showed individuals under the age of 50 have more linear decreasing preferences for travel time to spawn area compared to individuals over the age of 50, who are less sensitive to travel times in the 0 to 2-hour range (but subsequently showed negative utility for travel times greater than 4 hours). Respondents under the age of 50 also had significantly different preferences for layers of spawn on bough where, paradoxically, younger individuals had no preference for increasing layers of spawn on bough. Such differences in preferences may occur either because of generational amnesia, where knowledge is lost because younger generations are not aware of past biological condition, or personal amnesia, where an individual forgets their own experience (Papworth et al. 2009). The results from the DCE suggest potential generational amnesia occurring within the Nuu-chah-nulth community, with younger generations not knowing what to expect from the food and ceremonial herring fishery.

Recognizing that individuals who have less knowledge about the fishery have different preferences than individuals with high knowledge about herring management and stewardship is an important consideration for Pacific herring fishery managers. The impact of decreasing knowledge throughout the Nuu-chah-nulth community, and the impact this will have on individuals' preferences for the herring fishery is something Uu-a-thluk managers and community leaders have been worried about as herring populations and spawning has become more erratic, causing a decrease in knowledge due to a lack of access to herring spawn. While this has been a concern, there has been no previous evidence to show the impact that a lack of access to harvesting herring spawn has on knowledge transfer to younger generations. In our DCE, Nuu-chah-nulth preferences for travel time and layers of spawn on bough were significantly different between respondents with low knowledge of herring harvest and stewardship, and those with medium or high herring knowledge. Respondents with low knowledge had more linear preferences for travel time than medium and high knowledge individuals. Similar to the counter-intuitive preferences for travel time shown by relatively younger survey participants, low knowledge individuals showed decreasing utility as the number of layers of spawn on bough increased, which was opposite to what one would expect. Indeed, these preferences were opposite to moderate and more knowledge respondents who showed increasing utility for increasing layers of spawn on bough. These differences highlight the impact that lower herring knowledge has on preferences, and the importance of restoring herring spawn near Nuu-chah-nulth communities to increase herring knowledge throughout the community.

4.4. Pacific Herring and the Nuu-chah-nulth – A Social-Ecological system

Conversations with Nuu-chah-nulth community members and qualitative comments from the survey highlight that harvestable spawn biomass and spatial distribution of spawning activity represent both a perception of ecological system health as well as deep cultural values for the Nuu-chah-nulth. Higher amounts of harvestable biomass mean more spawn on bough for people to supplement their diets, and more spawn for cultural events. Spawn events that are closer to communities has the dual effect of allowing greater community participation in spawn on bough fishing and transmittance of Nuu-chah-nulth herring stewardship knowledge across generations. Managing with a focus on improving ecological aspects of the fishery that also impact social dimensions leads to a more robust and well-rounded management system (Gutiérrez et al. 2011, Cinner et al. 2016, Gill et al. 2017). It is challenging to achieve an integrated understanding of the couple dynamics of social-ecological systems (Salomon et al 2018), and the survey “Nuu-chah-nulth ?usmit (herring) perspectives” is an example of how qualitative and quantitative methods can be combined to begin to better understand and manage for these dynamics.

Further research will be needed to better understand the relationship between social attributes, such as the number of individuals taking part in food and ceremonial herring harvest, and ecological attributes, such as the harvestable biomass, and the proximity of spawn to communities.

4.5. Implementing the Survey "Nuu-chah-nulth ?usmit (herring) Perspectives

The overarching goal of this research was to improve our understanding of Nuu-chah-nulth preferences for herring food and ceremonial fishery outcomes using a discrete choice experiment. The models produced by DCE's have greater statistical power as you increase the sample size. While we were hoping to get between 150-200 responses, by the end of the study only we had only 87 responses, even after implementing a cash incentive. The lower number of responses was likely due to: (i) timing of the research, and (ii) limited engagement from Nuu-chah-nulth Nation fisheries staff.

Implementing the survey during the summer meant there were fewer individuals around their communities to answer the survey, and that individuals were generally busy and focused on summer resource harvesting. The timing of the survey distribution was based on my academic schedule, and not on when survey distribution would have been best for the community. Many researchers have found that there is a mismatch between when researchers can complete research in Indigenous communities, and when it makes the most sense to complete research in Indigenous communities, with researchers needing to be present at academic institutions during the fall and winter months when Indigenous people are in their communities with time to participate in research projects (Tondu et al 2014). Researchers should consider shifting academic obligations to be able to do research in the fall or winter, or consider paying community members to implement surveys during this time if the researcher themselves cannot be present.

Difficulties connecting with individual Nation's fisheries staff and getting them to actively participate in distributing the survey to their Nation also limited survey responses. Throughout the survey design process I did not have the time and opportunity to connect with the fisheries staff from each Nation. These staff have the closest connection to the Nations, and are vital channels for sharing information with the Nations. Each Nation's fisheries staff were contacted multiple times to inquire about distributing the survey to their Nation, and whether I could visit communities to help distribute the survey, but there was limited engagement back from the staff.

Many of the Nation's fisheries staff are operating at a capacity deficit, with more projects, research requests and consultations than they can handle (Castleden et al. 2012). I do not believe that they didn't engage with the survey because they were uninterested, but because they did not have the capacity to take on another project. Fisheries staff are also closely involved in the communities of the Nation they work for, with many staff being from the Nation themselves. This means that community issues, illnesses and deaths impact them and their ability to take on other projects. In the future, relationships with individual Nation fisheries staff should be developed earlier on in the research process. It would also have been beneficial to organize formal community events in each Nation that followed Nuu-chah-nulth protocol where a meal was served, and individuals were led through the survey. This would have given people an opportunity to ask questions about the research, and to clarify questions they had about the survey, in particular related to the DCE section.

While having more survey responses would have greatly increased the reliability of the results from the discrete choice models, the survey and DCE itself could also have been improved to provide better and more useful information. Based on feedback from Uu-a-thluk staff administering the survey in person, the wording and structure of some questions were changed to improve clarity and understanding. However, individuals completing the survey still commented on parts of the survey they found confusing and unclear. Specifically, many individuals found the discrete choice tasks confusing and unintuitive. Having a step-by-step description of how to complete the DCE, with a sample DCE for individuals to complete would have likely improved responses.

Having a longer time to design and implement the survey would also have improved the survey and DCE. A longer study period would have allowed us to get a more input from Nuu-chah-nulth community members about appropriate levels for the DCE, and given us the time to implement a preliminary test survey. However, with only one field season it was not possible to complete two iterations of the survey.

Despite there being a variety of ways to improve the robustness of the survey, validation of the DCE results by the Nuu-chah-nulth community and the similarity between qualitative comments from the survey and the DCE outputs leads us to believe that the DCE is still capturing the preferences of the Nuu-chah-nulth community for herring spawn outcomes on the WCVI.

Chapter 5. Conclusions and Future Research

5.1. Conclusion

To our knowledge, this is the first time a DCE has been applied in an Indigenous fisheries management context. This research provides an example of a methodology that can help Indigenous communities to translate their general fishery goals into specific measureable objectives, allowing their goals and values to be better represented and included in fisheries management decision-making. This case study on the WCVI Pacific herring fishery shows that a DCE paired with a simple qualitative survey can provide important quantitative and qualitative information about Indigenous preferences for harvestable biomass and spatial distribution outcomes. The success of the Nuu-chah-nulth food and ceremonial fishery is a key benchmark for the Nuu-chah-nulth to use when considering the success of WCVI herring management. The quantitative preferences from the DCE are the first direct measures of what a successful food and ceremonial fishery looks like to the Nuu-chah-nulth. The part-worth utilities from the DCE allow preferences for each attribute to be combined into one measureable indicator, percent choice, allowing managers to directly measure how different outcomes of the food and ceremonial fishery will impact Nuu-chah-nulth's satisfaction with management outcomes.

Along with providing quantitative preferences, the DCE also helped managers understand how changes in herring biomass and spatial distribution over the past 50 years may have impacted particular aspects of Nuu-chah-nulth culture. For instance, differences in preferences among generations provides the first direct evidence of a shifting preference baseline within the Nuu-chah-nulth community. The ability of the DCE to highlight these age and knowledge specific differences in preferences shows that a DCE can go beyond providing quantitative information for fisheries objectives, but can also highlight heterogeneity in community preferences that may signify important cultural changes.

5.2. Future Research

This research project is a preliminary look at how DCE's can be applied in an Indigenous fisheries management context. There are many ways this research can be expanded in the future. Future research recommendations are split into two categories, those which focus on applying the DCE methodology in a wider context, and those which focus on learning more about the specific WCVI herring case study.

5.2.1. Applying DCE's in a Wider Context

Discrete choice experiments are a methodology that can help Indigenous communities express their fisheries objectives in a quantitative way. However, the process of designing a DCE can be quite complex and time consuming, which may limit the ability of some Indigenous communities to implement the method. Future research should try to develop an easy-to-use guide on how to design a DCE, and the most important things to consider during the design phase. While I recognize that all Indigenous communities have their own unique values and goals, it could also be helpful to have a template with example attributes, or types of attributes, that communities could consider using in their DCE. This template could act as a starting place for communities, and help them move through the DCE design process.

5.2.2. Future Research on the WCVI Herring Fishery

The WCVI herring fishery has plenty of unanswered research questions whose answers could benefit long-term management plans. Two major research areas that could build off of the results from this case study are: (i) exploration of necessary data to be able to add the attributes from the DCE into current herring models, (ii) *exploration of spatial differences in preferences within the Nuu-chah-nulth community, and (iii) evaluating trade-offs between the different herring fishery sectors.

Many of the indicators that the Nuu-chah-nulth use to measure the success of the food and ceremonial fishery cannot be modelled by the current WCVI herring model, which presents a critical challenge for herring management on the WCVI. Currently, herring abundance estimates are made at too large a spatial scale to allow management procedures to be applied at the small spatial scales relevant to Nuu-chah-nulth communities. New data collection protocols and models need to be developed to allow management to occur at the spatial scales relevant to the Nuu-chah-nulth. There is also limited information about herring movement along the WCVI to inform spawning spatial distribution estimates. A key next step to recognizing Nuu-chah-nulth objectives in herring management is to determine what new data are needed to be able to begin creating models that can show whether different management procedures are meeting the Nuu-chah-nulth's preferred outcomes for the food and ceremonial fishery.

Conversations with Nuu-chah-nulth community members and harvesters shows that Nations in different areas along the WCVI have had different experiences with decreasing and shifting abundances in herring. The spatially shifting baseline of harvestable layers of spawn on bough is one example of these different experiences affecting opinions and preferences for the food and ceremonial herring fishery. There were not enough survey responses to be able to separate the data spatially, but further research could look at gathering more responses and looking at how preferences for food and ceremonial fisheries differ depending on individuals' geographic location.

The WCVI fishery has multiple fisheries sectors, including Nuu-chah-nulth food and ceremonial fisheries, Nuu-chah-nulth commercial spawn on kelp and whole herring fisheries, and non-Indigenous whole herring fisheries. The current primary concern of fisheries managers is understanding what objectives need to be met for the Nuu-chah-nulth to support the opening of a commercial fishery in their territory. However, once those objectives are met it will be necessary to have objectives and management procedures for the variety of different commercial fishery sectors. In the future, an expansion of the DCE method could be applied to the WCVI herring fishery to see how the Nuu-chah-nulth community makes trade-offs between the outcomes of different herring fishery sectors to achieve their social and ecological goals.

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