AN ABSTRACT OF THE THESIS OF

Astrea Strawn for the degree of Master of Science in Marine Resource Management presented on February 19, 2019.

Title: Impacts of Policy and Environmental Change: Understanding Factors of Vulnerability and Resilience in the Face of Change in Oregon Fishing Communities

Abstract approved: _____

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Commercial fisheries are coupled human-natural systems that cross state borders and integrate private, public, academic sectors and interests. These systems integrate complicated relationships between coastal socioeconomics, resource management and environmental realms. Previous findings from West Coast-based studies have identified aging trends in commercial fisheries participation, commonly referred to as the "graying of the fleet." In Oregon alone economic, biological and regulatory factors differ greatly among major commercial fisheries, suggesting that differing "graying" trends in participation between fisheries is plausible. Direct examination of participation differences between fisheries, as well as the factors that contribute to the connection between potential differences and graying remains a gap in fisheries-related social science research. This study approached these gaps through semi-structured interviews that examined human connections to commercial fisheries from the perspective of Oregon port community members and individuals directly engaged in Oregon's fishing industry. This study found that that port community members (community of place) and fishing community members (community of interest) did perceive differences in aging trends

among four commercial fisheries: Albacore tuna (*Thunnus alalunga*), salmon (*Oncorhynchus spp*), groundfish and Dungeness crab (*Cancer magister*). While significant participation barriers were cited in each of these fisheries, all species-specific aging trends were tied to compounded human, biological and ecological factors.

Qualitative analysis of the four fisheries showed disproportionally strong interest in participating in the Dungeness crab (crab) fishery. Strong ties between port communities and the fishery in economic and socio-cultural realms were identified as well, suggesting a level of community reliance on the fishery. The most significant barrier to crab fishery participation is related to an increase in annual harmful algal bloom (HAB)-related crab fishery closures that have altered when and where fishermen are able to fish every season since 2015. Because HAB events are expected to increase as climate change progresses, these closures could significantly reduce access to the fishery over time. Findings suggest high reliance on the fishery with few opportunities to minimize risk through diversification in winter months; these factors may lower crab fishery resilience in the face of increased HABs. This study contributes to a growing body of research that examines factors of vulnerability, resilience and adaptive capacity in both coastal communities of place and interest in response to changing ocean conditions and fisheries management measure. Results from this study are timely as they contribute to other research initiatives investigating how projected closures around a HAB increase will impact management, fishing reliant communities and the commercial seafood market.

Impacts of Policy and Environmental Change: Understanding Factors of Vulnerability and Resilience in the Face of Change in Oregon Fishing Communities

by
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Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Astrea Strawn, Author

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CONTRIBUTION OF AUTHORS

Caitlin Magel, Kelsey Swieca, Elizabeth Lee and Andrew Jensen contributed to background information/introduction portions of Chapter 3 (manuscript 2) in partial fulfillment of the NRT Interdisciplinary paper requirement.

TABLE OF CONTENTS

Page

CHAPTER ONE: Introduction, Literature review……1
Literature Review……2
References……14

CHAPTER TWO: FIRST MANUSCRIPT [Differential Aging Trends Among four Major Commercial Fisheries in Oregon]
Abstract……18
Introduction……19
Background……20
Research Questions……24
Methods……24
Results and Discussion……26
Conclusion……38
References……40

CHAPTER THREE: SECOND MANUSCRIPT [An examination of perceived connections between the Dungeness crab fishery and Oregon fishing communities]
Abstract……44
Introduction……45
Background……54
Research Questions……51
Methods……51
Results and Discussion……52
Conclusion……59
Acknowledgements……62
References……63

CHAPTER FOUR: CONCLUSION
Introduction……66
Manuscript 1……66
Manuscript 2……68
Future Need and Recommendations……70
References……72

LIST OF FIGURES

Figure Page

1.1 Social indicator framework……..…...…..4

1.2 Ecosystem Based Management……..…….…….…...…...5

1.3 Vulnerability and resilience time series model…….……..…10

1.4 Reliance vs vulnerability graph…….…….….12

2.1 Economic contributions by fishery…….23

2.2 Aging trends in commercial fishery participation…….……..24

2.3 Participation and revenue data for whiting and groundfish……37

LIST OF TABLES

Table Page

1.1 Dungeness crab indices chart ……...…… 12

Chapter 1: Introduction, Literature Review

Introduction

Format of Thesis

This document is structured under the OSU manuscript document format. Chapter one functions as a general introduction to provide context for the entire thesis. Chapter two and three are structured as standalone manuscripts and chapter four offers additional results and in-depth discussion on project significance.

Chapter 2 (manuscript 1) expands directly on Oregon-based "graying of the fleet" research program out of Oregon State University (OSU) and the Northwest Fisheries Science Center (NWFSC). The chapter seeks to examine unique factors among four major fisheries prosecuted in Oregon that contribute to differential aging trends among participants. Chapter 3 builds off of Oregon-specific findings uncovered by a 2017/2018 transdisciplinary group project through the NRT: *Risk and Uncertainty Quantification in Marine Sciences* minor housed at Oregon State University. The chapter examines connections between the Dungeness crab (crab) fishery and Oregon fishing-dependent communities from the perspectives of stakeholders in an effort to better understand factors of community vulnerability and resilience.

Results from both manuscripts contribute to a growing body of research that examines factors of vulnerability and resilience in fishing-dependent communities in the face of policy, management and environmental change. The examination of these factors is essential to anticipate the ability of a given area to absorb and adapt to change.

Scope of work

West Coast commercial fisheries and the port communities that rely on them are accustomed to change and risk inherent to economic and environmental fluctuations of the industry. However, drastic changes that stem from management and environmental shifts over

recent decades have resulted in fisheries experiencing additional changes that may be creating ripple effects across both industry and communities alike (Cramer *et al* 2018).

The two studies conducted in this thesis examine themes of community resilience and vulnerability around changes in Oregon-based commercial fisheries. Drivers of change behind current and future access and participation are investigated through the perspectives of fishing industry members (community of interest) and coastal community members (community of place). Manuscript 1 builds on extensive studies focused on aging trends in Alaska's commercial fishing industry, emerging work from NOAA on human impacts of the West Coast groundfish fishery transition and aging trends in Oregon's commercial fishing industry conducted through Oregon State University (OSU). Manuscript 2 builds off of findings from a 2017/2018 transdisciplinary group project in the NRT: Risk and Uncertainty Quantification in Marine Sciences fellowship at OSU that examined the potential for climate change-driven distribution shift of Dungeness crab and socio-economic impacts of associated excess change. The timing of this transdisciplinary project was particularly relevant in the wake of increased crab fishery closures due to toxic levels of domoic acid (DA) in harmful algal blooms (HABs) that have prompted investigation by NOAA, the Northwest Fisheries Science Center and West Coast academic institutions.

Findings from both manuscripts contribute to a growing body of research that examines human and community impacts of changes in commercial fisheries in a time of shifting social dynamics in rural coastal areas. The need for this research is outlined in federal directives that call for a greater understanding of how management decisions impact communities in fishing- dependent areas, and also highlighted through the federal shift towards ecosystem-based management (EBM) through which regulatory agencies are beginning to examine commercial fisheries as a coupled human-natural system.

United States Fishery Policy

The governing laws of US fisheries are housed under the Magnuson Stevens Fisheries and Conservation Act (MSA), which was passed in 1976 with the principal goal of taking control of internationally exploited fisheries in US waters. After the MSA eliminated unauthorized international fishing efforts in domestic waters, its scope has continued to

evolve over time to reflect changing goals of US fisheries policy and management. As a result of this evolution, a current goal of the MSA is to ensure sustainable stocks through conserving current commercial fisheries and rebuilding depleted stocks (16 U.S.C. 1801 - 1891(d)). One strategy that the US has used to rebuild depleted stocks in federal fisheries is the quota system, a method that privatizes a fishery by allotting transferrable segments of the total allowable catch to various holders. The goal of quota systems (also called ITQs, catch shares and/or rationalization) is to reduce the "race to fish" by giving ownership rights to individual holders (Moon & Conway 2016; Russell *et al* 2014). Although this system can increase stakeholder accountability and profits, as well as increase net benefits of a given fishery, privatization, particularly in the form of transferrable allotments, creates consolidation of resource ownership (Cramer *et al* 2018; Moon & Conway 2016; Bonzon *et al* 2010; Carothers & Chambers 2012).

The commodification of fishery resources through rationalization, and their impacts on human systems have been a focus of study, particularly in Alaska where quota systems were implemented decades ago (Carothers, 2008; Carothers 2010; Donkersloot & Carothers 2016). Findings from these studies show significant negative social and economic impacts on fishing-dependent Alaskan communities and declines in federally managed fishery participants in response to rationalization (Carothers 2011; 2015; Donkersloot & Carothers 2016). These impacts have informed policy change in the state and pushed the introduction of House Bill 188 to create fishery trusts and improve the adaptive capacity of the state's fishing communities (Alaska State Legislature 2018).

Many West Coast commercial fisheries have experienced significant management shifts over recent decades, perhaps the most significant of which was the 2011 groundfish fishery transition to a quota system in response to a crash that peaked in the early 2000's. Quota systems allocate a percentage of the total allowable catch exclusively to an individual quota holder and are often put in place to rectify damages from overharvesting (Steiner et al 2019). In the case of groundfish, the quota system was implemented in accordance with their Fishery Management Plan with the goals of reducing bycatch and fishery capacity in response to compiled environmental, fishery and management issues that drove the fishery into economic disaster in the year 2000 (PFMC 2016). Within two years of the groundfish quota

program, catch decreased exponentially as vessels exercised increased caution in order to avoid over harvesting quota-restricted species. By 2014 quota allowances and catch rates began to expand in response to some stocks beginning to rebuild, even so, fishery participants have expressed frustration around increased regulation, reduced opportunity and poor communication from management entities (PFMC 2016; Moon & Conway 2016; Gilden & Conway 2010).

A 1996 iteration of the MSA introduced 10 National Standards, one of which, National Standard 8, was created in an effort to consider community impacts of management changes and policy decisions. More specifically, the standard called for ways to sustain participation within fishing communities while minimizing adverse economic effects that arose as a side effect of regulation and management changes ((16 U.S.C. §1851(2)(8)); Marshall *et al* 2007). In accordance with National Standard 8 NOAA requires Fishery Impact Statements (FIS) for any management or regulatory changes to examine potential environmental, social or economic effects (Calhoun 2015; NEPA; 42 U.S.C. § 4321). These statements are obtained through Environmental Impact Statements (EIS) under the National Environmental Policy Act (NEPA 1969) and accompanying social impact statements (SIA) (Calhoun 2016; Colburn & Clay 2012). Figure 1.1 depicts a general SIA model that shows interrelationships between external forces, management decision making and impacts on human systems (i.e. fishing communities) (Pollnac *et al* 2006).

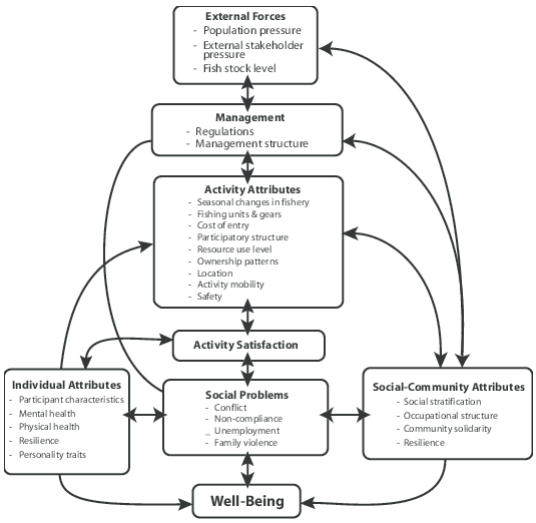

Figure 1.1: Social indicators of fishing community vulnerability and resilience (Pollnac 2006; Jepson & Colburn 2013)

Aging studies around commercial fishery participation and ties to vulnerability and resilience in communities of fishermen and coastal port communities have expanded from primarily Alaskan communities to fishing communities across the continental US (Caracciolo 2017; Donkersloot & Carothers 2016; Russell *et al* 2014; Russell *et al* 2016). Results from these existing studies show advancing age demographics among commercial fishery participants,

raising questions to the long term sustainability of both the industry and its participants (Russell *et al* 2014; Cramer *et al* 2018).

Ecosystem-Based Management

The Ecosystem-Based Management (EBM) framework was built to consider connections within and between systems and is rooted in four key concepts: *Connections between humans and the natural world, explicit tradeoffs, adaptive capacity, and place* (Clay & Olson 2008; Lester *et al* 2010). When applied to fisheries regulation and management, this is referred to as Ecosystem Based Fisheries Management (EBFM). The core objectives of EBFM are to avoid ecosystem degradation and irreversible change to species and environmental processes without disrupting socioeconomic benefits. This can be achieved by understanding ecosystem factors and processes so impacts of human actions can be foreseen and avoided. EBFM approaches these goals using a coupled human-natural system perspective in decision making and an emphasis on sustainability through building social wellbeing and fishery-reliant community resilience (Jepson & Colburn 2013; Pikitch *et al* 2004). Although there are many definitions of community resilience, in EBM it is described as a system's ability to modify itself in the face of a changing environment (Folke *et al* 2002).

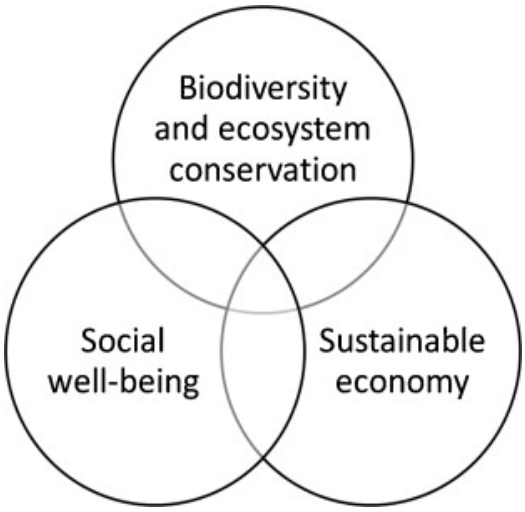

Figure 1.2: Ecosystem based management visual (Larila-Pant et al 2015).

Factors of resilience and risk in a community determine its adaptive capacity. Another EBM-specific definition that describes a system's ability to modify itself in the face of a changing environment (Folke *et al* 2002).

Changes in the commercial fishing industry, including management shifts, stock recruitment and environmental phenomena can directly impact levels of risk in a fishing-dependent community (Lyons *et al* 2016). Economic drivers in Oregon's coastal communities are largely natural resource (fishing, logging) and tourism based, so access change to commercial fisheries could significantly impact resilience and adaptive capacity of

these communities. Regulatory shifts towards EBM require that decisions makers consider how policy and management change will impact coastal communities in Oregon and beyond.

Approaches to Social Science in Commercial Fisheries Management

As directed by NOAA, the US government aims to build resilience in coastal communities, economies and marine ecosystems. Because the resilience and adaptive capacity of a given community depends on its ability to both anticipate and absorb the effects of change, research frameworks must be in place, not only to understand the health of fishery stocks, but also health of individuals and communities that rely on them (Jepson & Colburn 2007).

Quantitative Approach

As directed in movement towards EBM and National Standard 8, NOAA has shifted its basis for fisheries management away from purely quantitative stock assessments towards a system that integrates consideration the health of communities reliant on fisheries (Clay & Olson 2008). Although sustainable development-related indices are used regularly across the US as a quick assessment method, the need for indices unique to port communities have been ignored until recently. In response to this gap, NOAA has created two quantitative models (East Coast and West Coast) for Social Impact Assessments (SIAs) to examine the wellbeing of fishing communities through the relationship between resilience and vulnerability (Jepson & Colburn 2013).

In a 2013 study, Jepson and Colburn (NMFS) an SIA for fishing communities using a set of 14 social indicator indices. The study assessed 20 Northeast and Southeast US port communities using secondary data available from government and some private sources. Norman *et al* (2007) of NOAA and the Northwest Fisheries Science Center developed a community profile framework for the West Coast using census and other data from the year 2000. The framework developed by Normal *et al* functions as a baseline for understanding management and policy impacts on West Coast fishing communities through quantitative assessments that examine communities in four categories:

1. Individuals and location

2. Infrastructure of a community

3. A community's involvement with the commercial fishing industry on the West Coast

4. Involvement in North Pacific fisheries (Norman *et al* 2007)

Both models can be used to assess factors of vulnerability and resilience across communities and across regions in response to changes in the ocean environment, stock health and fisheries management changes. Although specific indices differ, both models use secondary data which is more time and cost effective than collecting primary data. However these models are constrained by limited access to up-to-date information, therefor they may not reflect abrupt changes due to shifts in the ecosystem, economy or management realms.

Qualitative Approach

Another gap in Quantitative assessments capabilities is the inability to capture the complexity of social structures at play in a coupled human-natural system. Qualitative research methods can fill this gap by utilizing theoretical or interpretive frameworks as a lens to examine research questions concerning a human or social problem. These methods can (arguably) offer more in depth, timely information than quantitative methods (Cresswell & Poth 2018; Colburn & Clay). Although quantitative methods and results may be more approachable to the resource management community, (Colburn & Clay 2012) a holistic understanding of social structures in fishing-dependent communities may be achieved through a mixed-methods approach that integrates both qualitative and quantitative methods. Successful mixed method implementation requires stakeholders, fisheries managers and scientists to agree on the unique contribution that qualitative research can offer to social science (Caracciolo 2017; Calhoun 2015; Harper *et al* 2013).

"Graying of the Fleet"

Social science researchers who examined impacts of rationalization on Alaskan fishing communities were among the first to discover an increase in the average age of commercial fishery participants (Cramer *et al* 2018; Carothers 2008; Carothers 2010; Koslow 1982). Participation age increases in Alaskan fisheries and out-migration of fishery rights ownership have continued over time as a reaction to management shifts towards

rationalization (in federal fisheries) and limited entry systems (in state fisheries). A ten-year age increase in participants between 1980 and 2014 is tied to rising social and economic issues and a loss of local knowledge in rural Alaskan communities (Cramer *et al* 2018; Carothers 2015; Cullenburg *et al* 2017).

Until recently, the majority of US-based "graying" studies were based in Alaska, but the 2011 rationalization of the West Coast groundfish fleets prompted an examination of community impacts in response to change. Although a cross-discipline, mixed methods approach is not yet streamlined in US fisheries management, NOAA integrated a qualitative approach to assess impacts of policy change on fishing communities in response to the 2011 rationalization. In this study, Russell *et al* (2014) of the Northwest Fisheries Science Center conducted surveys and interviews across the US West Coast to capture perceptions of the rationalization both directly before and after the management shift. Although it functioned only as an initial report, data showed that interview participants perceived changes in fisheries participation, social relationships within the industry, and trends towards "graying" in fishery participation. Findings continue to emerge out of this research program, are offering valuable insight into community response to change (Russell *et al* 2014). Similar to aging trends found in Alaskan fisheries, the initial report suggests that the rationalization of groundfish has significantly increased barriers to entry and may result in reduced interest in joining a fishery with high regulation and relatively low economic reward (Cramer *et al* 2018; Russell *et al* 2014).

Communities Examined

Because these studies examined perceptions of change in the commercial fishing industry and wider connections to port communities, it was important to integrate diverse stakeholder groups that related differently to the industry. Interview participants were referred to as either a member of the "community of interest" (COI), which refers to fishermen and their family members; or member of the "community of place" (COP), which described individuals that lived in port communities that house commercial fishing fleets. By separating these two subpopulations, factors of community vulnerability and resilience were examined as components of the larger coupled human-natural system (Cramer *et al* 2018; Conway 2001).

Oregon's Fishing-Dependent Coastal Communities (community of place)

The MSA characterizes fishing-dependent communities as:
A community that is substantially dependent on, or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew, and fish processors that are based in such communities (16 U.S.C. 1801 - 1891(d)).

Oregon's commercial fishing industry represents an important social and economic driver for coastal communities. There are a total of 13 ports across coastal Oregon, many of which fall under the MSA characterization of a "fishing-dependent community" (Pomeroy & Dalton 2003). The largest Oregon ports (from North to South) are Astoria, Newport and Charleston/ Coos Bay; all other host varying levels of commercial fishing throughout the year. Although the majority of Oregon's fishing businesses are categorized as small scale, the industry provides over $500 million per year in personal income to over 1,000 coastal residents in the form of fishing jobs, processing and other support industries and are thus significant in Oregon's coastal economy (Pomeroy & Dalton 2003; State of Oregon Employment Dept. 2018).

Oregon Fishing Industry (community of interest)

A diverse set of fisheries are prosecuted in the state; the most common being Dungeness crab (Crab), groundfish (90+ species), Pacific whiting, pink shrimp, Albacore tuna, Pacific sardines, Pacific halibut and salmon. Although trawl and troll gears are the most commonly used, commercial vessels utilize a range of other gears including pots/traps, longline and purse seines to prosecute these fisheries (Kounen 2018). Management methods also differ greatly among Oregon's commercial fisheries, with varying entry requirements ranging from quota systems, to limited entry, to open access. Each of these fisheries operate over different timeframes (seasons), (except for groundfish, which operates year-round). Therefore, fishing businesses often rely on multiple fisheries or other work opportunities to fulfill year-round economic needs (Moon & Conway 2016). The crab fishery stands out as the most economically important fishery prosecuted in the state of Oregon and is one of the few

fisheries that operates in winter months. Vessels that prosecute other fisheries in warmer months often fish for crab to supplement income during the "off season." The economic and seasonal roles of this fishery, paired with its relative ease of entry, make it particularly important as a "connector fishery" all along the entire US West Coast (Fuller *et al* 2017).

Conceptualizing Vulnerability and Resilience

Because they emphasize linkages between human and natural systems, NOAA uses resilience and vulnerability indicators to evaluate how well a given community will respond and adapt to change (Jepson & Colburn 2013; Clay & Olson 2008). NOAA created the framework depicted in figure 1.3 as a predictive tool to test potential impacts of change on a given community (Jepson & Colburn 2013). Similar to other natural resource-dependent communities, factors of resilience and vulnerability in Oregon fishing communities are closely tied to the strength of commercial fishing fleet (Cramer *et al* 2018; Jepson & Colburn 2013). Studies discussed in the following chapters examine fishery strength in terms of access and/or participation as a function of community resilience in Oregon port communities. While resilience can be defined in a number of different ways, this thesis utilizes a definition by Folke (2016): "*... Persistence, adaptability, and transformability of complex adaptive social-ecological systems...*"

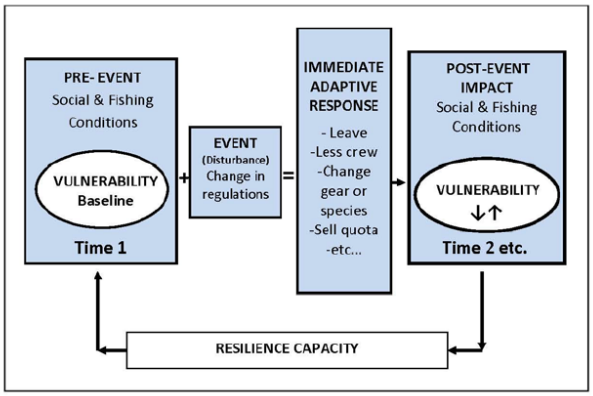

Figure 1.3: Vulnerability and resilience time series model (Jepson & Colburn 2013).

Studies that examine resilience in paired human-natural systems have increased exponentially over recent decades with the realization that ecosystems and human systems are so intimately linked that cannot be effectively managed separately (Folke *et al* 2002b; Folk 2016). When applied to access and participation shifts in commercial fisheries, resilience studies examine a community's (of place or of interest) ability to adapt and (if needed) change in reaction to dynamic shifts in the political, biological and ecological dimensions of the commercial fishing industry (Folke 2016). Studies discussed here examine

indicators of resilience including diversity, ability to self-organize, the presence of differing perspectives and overall flexibility (Carpenter *et al* 2006; Folke 2016).

Neil Adger (2006) describes vulnerability as "*A state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt.*" In coupled human-natural systems like Oregon's fishing communities, a loss of adaptive capacity reduces overall resilience. The factors that contribute to this loss are characterized as points of vulnerability (Berkes *et al* 2003; Folke 2006). The following studies described in this thesis will examine factors contributing to resilience and vulnerability of communities of interest and place across the Oregon coast.

Problem Solving for Complex Environmental Issues

Transdisciplinary work

The National Science Foundation Research Traineeship (NRT) housed at Oregon State University is an innovative program designed to train future natural resource scientists and managers. The traineeship is novel both in its transdisciplinary structure and its goal to tackle complex marine issues associated with climate change through a holistic approach. Traineeship cohorts are split into small groups that focus on a specific relevant marine issue. The traineeship acts as both a one-year fellowship and a minor that includes a field camp, minor coursework, an internship, a transdisciplinary report detailing the team process and an interdisciplinary thesis chapter (Oregon State University 2018).

The social science aspect fit into the larger NRT project collaboration entitled ***Connecting crabs, currents, and coastal communities:*** *A transdisciplinary approach to examining the impacts of a potential Dungeness crab distribution shift under changing ocean conditions* (hereafter referred to as the "crab team"). This project examined environmental shifts associated with climate change that could result in crab distribution shifts. Crab is a particularly economically important fishery and is a significant employer among West Coast fishing fleets. Therefore, any fishery access shifts associated with changing ocean conditions could propagate through ecological and social systems, affecting policy, academia, fishing industries, and the greater wellbeing of the coastal communities.

The "crab team" employed a mixed method social science approach to determine if and how a Dungeness crab distribution shift could impact coastal communities. The quantitative portion utilized two NOAA/Northwest Fisheries Science Center datasets developed by Norman *et al* (2007); one captured fishery-specific reliance indices, while the other captured port community vulnerability indices (CSVI). The team combined these indices to form a "susceptibility index" that described potential community impacts of a decrease in the availability of Dungeness crab. Scores for each community were compared to the expected future Dungeness crab latitudinal distribution to examine the compounded risk of exposure and community susceptibility across the US West Coast (See figure 1.4). Sea surface temperature-related distribution shifts of crab are not expected to impact Oregon waters, so vulnerability indices are not referred to further in this manuscript.

State	City	GEOID (Census)	Latitude	Longitude	Engagement Score	Reliance Score	Composite Social Vulnerability	CSVI Category
California	Crescent City	617022	41.76651	-124.19895	2.73882	0.46495	-2.39868	Low
	Eureka	623042	40.7933	-124.15535	2.45858	0.01989	2.13734	Moderate
	Fort Bragg	625058	39.44107	-123.80362	3.46765	0.65073	3.32795	Moderate
	Bodega Bay	607260	38.31941	-123.03062	3.90626	8.8368	-4.03962	Low
	San Francisco	667000	37.72724	-123.03223	6.24454	-0.09825	-2.49473	Low
	Monterey	648872	36.60129	-121.88256	1.7069	-0.02705	-2.60594	Low
	Morro Bay	649362	35.36749	-120.86764	6.00058	0.80897	-1.12063	Low
Oregon	Astoria	4103150	46.18726	-123.81457	4.25835	0.62053	1.03756	Moderate
	Garibaldi	4128000	45.56077	-123.91134	1.51233	2.92301	4.92135	High
	Newport	4152450	44.62087	-124.04304	7.94372	1.06936	1.86331	Moderate
	Winchester	4183050	43.67726	-124.17772	2.01063	8.95116	1.17718	Moderate
	Coos Bay	4115250	43.38116	-124.23273	5.9004	0.43285	2.92868	Moderate
	Port Orford	4159250	42.74928	-124.49812	1.9846	2.51144	8.97602	High
	Brookings	4108650	42.0689	-124.29995	1.86637	0.33162	-0.00472	Moderate
Washington	Ilwaco	5333000	46.31269	-124.02673	4.72751	7.5398	3.73981	High
	Chinook	5312315	46.2755	-123.94223	0.84491	4.19337	-0.63008	Low
	Westport	5377630	46.8901	-124.1041	24.12016	21.0395	3.4118	High
	Tokeland	5371680	46.70878	-123.98339	0.8577	5.66844	3.75441	High
	La Push	3030	47.9081	-124.6352	0.13259	0.57835	NA	NA

Table 1.1: Dungeness crab indices chart created 2017/2018 NRT "crab team" (Unpublished data).

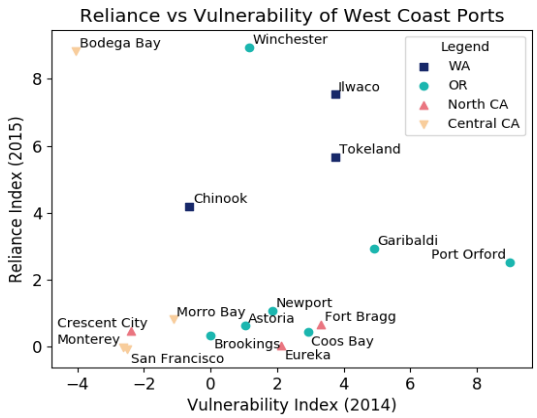

Figure 1.5: Reliance vs. vulnerability graph developed by NRT Crab Team, 2017/2018 (Unpublished data)

Figure 1.5 shows reliance vs. vulnerability scores in major port communities. The Oregon fishing communities Port Orford and Garibaldi showed the highest levels of vulnerability, but only moderate levels of reliance on the crab fishery. While the port of Winchester showed extremely high reliance on the crab fishery, but relatively low vulnerability as a community. The largest fishing communities in Oregon (Newport, Coos Bay and Astoria) showed relatively low reliance on the crab fishery, and low to moderate community vulnerability. Vulnerability levels refer to pre-existing community conditions that

could impact how a community is able to respond to change (Jepson & Colburn 2016). So a community like Port Orford may have a more difficult time adapting to any change in crab fishery access than communities like Coos Bay with lower overall vulnerability scores.

Interdisciplinary chapter

Manuscript 2 (Chapter 3) of this thesis is structured as an extension of the 2017/2018 transdisciplinary "crab team" project that focused exclusively on perceptions of change among Oregon fishermen and those living in communities that host commercial fishing ports. The manuscript acts as a link between the NRT transdisciplinary "crab project" and the examination of differential aging trends among Oregon's commercial fisheries explored in chapter 2 (manuscript 1). While the questions laid out by the NRT "crab team" examined environmental and biological shifts linked to climate change and their impacts on West Coast fishing communities, the questions examined in manuscript 2 look at factors of vulnerability and resilience in Oregon fishing communities.

Transdisciplinary project findings from the "crab team" showed little risk of a crab distribution shift impacting Oregon waters, but perspectives from community members interviewed uncovered other barriers to fishery prosecution that are also expected to increase as climate change progresses. Instead of distribution shift, current and future access change to the Oregon crab fishery was largely tied to an increase in harmful algal blooms (HABs) that produce the diatom *pseudo nitzchia,* which can contain domoic acid (DA). While consumption of this diatom does not impact crab health, secondary consumption of DA through crab can be harmful or deadly to mammals and birds. An increase in DA toxicity, initially tied to an unusually pervasive algal bloom in the 2015 season, has prompted massive fishery closures every season since 2015 resulting in the need for adaptive management action to effectively track biotoxin status across the coast (ODFW 2017; Ritzman *et al* 2018).

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Chapter Two: First Manuscript

Differential graying trends between four major Oregon fisheries: A deeper look at "graying" trends in Oregon's commercial fishing fleet.

Abstract

Previous research on U.S. West Coast commercial fisheries participation has shown significant aging shifts across the board, a trend referred to as the "graying of the fleet." In Oregon, economic, biological and regulatory factors that contribute to this trend differ greatly among major commercial fisheries, therefore it is reasonable to expect differential "graying" as a reflection of conditions within the fishery. This Oregon-based study found that port community members (community of place) and fishing community members (community of interest) perceived differences in aging trends among the four major commercial fisheries examined: Albacore tuna (*Thunnus alalunga*), salmon (Oncorhynchus *spp*), groundfish (90 species) and Dungeness crab (*Cancer magister*). While significant barriers to entry (a major factor in aging trends) were cited in each fishery, differential aging trends were tied to unique human, biological and ecological factors. In conjunction with differences in aging trends, participants cited differential factors of community importance among major commercial fisheries. These community ties suggest that graying differences between fisheries could result in varying levels of community impacts across Oregon port communities. Findings from this study uncover a perceived trend towards the reduction of fishing portfolio diversification among Oregon's commercial fishing businesses. A loss of catch diversity increases risk for fishermen and reduces factors of resilience in these businesses and the fishing-dependent communities in which they are housed. In a time of unprecedented environmental change, the integration of stakeholder perspectives could be vital in understanding a community's ability to reorganize, adapt and thrive.

Introduction

Results from previous studies show that the average age of commercial fishermen in the United States has risen to the mid 50's, almost a decade older than previous cohorts (Cramer *et al* 2018; Carraciolo 2017). This phenomenon and its ripple effects on communities

have been studied extensively in Alaska, but research efforts on aging trends within Oregon fisheries are incomplete. The "Graying of the Fleet" study out of Oregon State University (OSU) fills this gap in knowledge by examining factors that play into aging trends specific to fisheries in Oregon. As a multi-year, qualitative project, this research explores perceived causes and ripple effects of "graying" on the community of place (coastal communities) and the community of interest (individuals involved in the fishing industry) by gathering perspectives from members of both communities (Caracciolo 2017).

Previously conducted "graying" studies in Alaska have pinpointed changes in fishery access as a major driver for aging trends and changes in permit/quota ownership among fishermen in the state. Most Alaskan fishery stocks are healthy and relatively sustainable, so access shifts are closely correlated with shifts in management rather than availability of fish. Management shifts towards fishery privatization began in the 1970's with limited entry permitting in state fisheries and a shift towards quota systems in federal fisheries in the 1990's (Carothers 2015). Privatization of fisheries resources in Alaska have resulted in a separation between those who own fishing rights and the communities that house fishermen and ports. The market structure of fishing rights under these systems has led to an out migration of permit and quota holders, leaving fewer available positions for young people entering the industry. The fishermen who are able to purchase fishery rights are faced with increased risk because of elevated cost of entry and decreased opportunity to diversity across many fisheries (Cullenberg *et al* 2017). Results from Alaska based "graying" studies have identified privatization of fishery resources as a major driver of social change in Alaskan port communities (Carothers 2015).

Although both social structures and specific fisheries targeted differ between Alaska and Oregon, coastal communities in both states have experienced the effects of fishery commodification over recent decades. Management shifts, environmental and economic changes in Oregon have altered access to what were historically common pool resources (Cramer *et al* 2018). Similar to Alaska-based findings, changes in Oregon commercial fishery management have created barriers to entry, reduced the number of people with fishery rights and altered social relationships within fisheries and the port communities in which they are housed (Cramer *et al* 2018).

Background

Policy framework

The governing laws of US fisheries are housed under the Magnuson Stevens Fisheries and Conservation Act (MSA). An act passed in 1976 with the principal goal of taking control of fisheries prosecuted in US waters. However, goals of the MSA have evolved considerably over time as the United States has eliminated unauthorized international fishing efforts. A current goal of the MSA is to ensure sustainable stocks through conserving fisheries and rebuilding depleted stocks. One strategy that the US has used to rebuild depleted stocks in federal fisheries is the quota system, a method that privatizes a fishery by allotting transferrable segments of the total allowable catch to various holders. The goal of quota systems (also called individual transferrable quotas (ITQs), catch shares and/or rationalization) is to reduce the "race to fish" by giving ownership rights to individual holders (Carothers, C., Chambers, C. 2012; Moon & Conway 2016; Russell *et al* 2016). Although this system can increase stakeholder accountability, increase profits and increase overall net benefits of a given fishery, privatization, particularly in the form of transferrable allotments, creates consolidation of resource ownership (Bonzon *et al* 2010; Carothers & Chambers 2012; Moon & Conway 2016; Cramer *et al* 2018).

The commodification of fishery resources through rationalization have been a focus of study by NOAA, particularly in Alaska where quota systems were implemented decades ago (Donkersloot & Carothers 2016; Moon & Conway 2016; Russell *et al* 2014). Findings from these studies show significant negative impacts on fishing-dependent Alaskan communities and declines in federally-managed fishery participation in response to rationalization (Carothers 2011; 2015; Cramer *et al* 2018; Donkersloot & Carothers 2016). These findings have informed policy change and pushed the introduction of House Bill 188 to create fishery trusts and improve the adaptive capacity of the state's fishing communities (H.B. 188, 2018 Biennium, 30th Legislature. (AK. 2018)).

A 1996 iteration of the MSA introduced 10 National Standards, one of which, National Standard 8 was an effort to consider community impacts of management changes and policy decisions. More specifically, the standard called for ways to sustain participation

within fishing communities while minimizing adverse economic effects that have arisen as a side effect of regulation and management changes ((16 U.S.C. §1851(2)(8)); Marshall *et al* 2007). In accordance with National Standard 8, NOAA requires Fishery Impact Statements (FIS) for any management or regulatory changes to examine potential environmental, social or economic effects (Calhoun 2015). These statements are generally obtained through Environmental Impact Statements (EIS) under the National Environmental Policy Act (NEPA) and accompanying social impact statements (SIA) (Colburn & Clay 2012).

Aging studies around commercial fishery participation and its ties to vulnerability and resilience in communities of fishermen and coastal port communities have expanded from Alaska to both the West and East Coasts (Caracciolo 2017; Colburn & Clay 2012 Russell *et al* 2014). Although many West Coast commercial fisheries have experienced significant management shifts over recent decades, perhaps the most significant of which was the 2011 federally managed groundfish fishery transition to a quota system. This management shift was made in response to environmental, fishery and management issues that drove the fishery into economic disaster in the year 2000 and resulted in a 40% removal of vessels in a 2003 buyback program (Steiner et al 2019). Since quota implementation, some groundfish stocks have improved exponentially, and employment opportunities have somewhat stabilized (See fig. 2.1) (Steiner *et al* 2019), fishery participants have expressed frustration around increased regulation, reduced opportunity and poor communication from management entities (Gilden & Conway 2010; Moon & Conway 2016; Russell *et al* 2014; Russell *et al* 2016).

Ecosystem-based management

The inherent connections between human and natural systems are recognized by both US sector-based management and natural resource regulatory agencies in a recent movement away from sector-based management, towards Ecosystem-Based Management (EBM). The EBM framework is rooted in four key concepts: Connections between humans and the natural world, explicit tradeoffs, adaptive capacity focus on place and anticipating and embracing change (McLeod & Leslie 2012). When applied to fisheries regulation and management, this framework calls for a coupled human-natural system perspective in decision-making and an emphasis on sustainability through building social wellbeing and fishery-reliant community

resilience (Jepson & Colburn 2013; Colburn & Clay 2012). Although there are many definitions of community resilience, the EBM definition describes it as a system's ability to modify itself in the face of a changing environment (Folke *et al* 2002). Factors of resilience and risk in a community determine its adaptive capacity, another EBM-specific definition that describes a system's ability to modify itself in the face of a changing environment (Folke *et al* 2002).

Changes in the commercial fishing industry including management shifts, stock recruitment and environmental phenomena can directly impact levels of risk in a fishing-dependent community (Lyons *et al* 2016). Economic drivers in Oregon coastal communities are largely natural resource (fishing, logging) and tourism based, so access change to fisheries could significantly impact resilience and adaptive capacity. Regulatory shift towards EBM require that decision-makers consider how policy and management change will impact these coastal communities in Oregon and beyond.

Oregon Fisheries and Coastal Communities

Oregon fishing businesses have long been categorized as small scale and family run; this suggests close ties between fishery health (including both ecological and human aspects) and community health (social and economic aspects.) Along with fishing family businesses, support industry workers and even non fishing-related community members are closely tied to fishery access since positions tied to the commercial fishing industry represent an important employment and income opportunity for coastal Oregon residents (Russell *et al* 2014). Vessels sell the majority of landings to one of 32 seafood processors in Oregon, an industry valued at $40 million/year in wages alone. Between fishermen and processors, the current average of direct employment around the industry is 1,172 individuals (State of Oregon Employment dept. 2018).

Full time commercial fishermen in Oregon rely on multiple fisheries throughout the year; fishery choice depends on gear and vessel, cost of entry, season and ease of entry. The average revenue of commercial fishing vessels fluctuates drastically by year, but has been on an upward trend since the mid 1990's. (See fig. 2.1)

Trolling (salmon, tuna), trawling (groundfish and pink shrimp) and traps (crab) are the most common commercial fishing methods used in Oregon. Fishing vessels with trolling gear often target many species and/or supplement with onshore jobs in order to piece together a lucrative business. Whereas (previous to the groundfish crash of 2000) trawling vessels were able to bring in adequate income by targeting only one fishery (Moon & Conway 2015). Of the 100+ species targeted in the state, fisheries with the highest employment rates are crab, salmon, and albacore tuna (See Fig. 2.1) (State of Oregon Employment Dept. 2018).

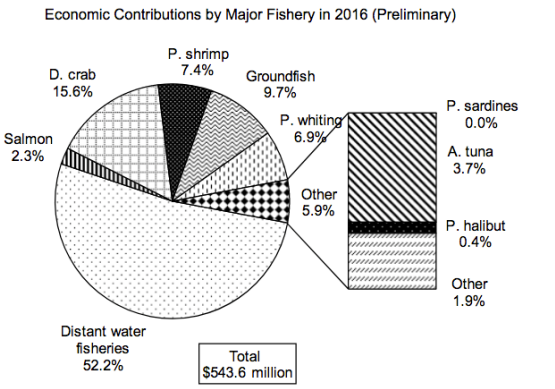

Figure 2.1: Economic contributions by fishery (Oregon Employment Department 2018).

Apart from distant water fisheries, Dungeness crab, groundfish and pink shrimp are usually the most predominant economic contributors of all commercial fisheries prosecuted in the state (Fig. 2.2). Groundfish and salmon fisheries were historically far more economically important fisheries before both experienced collapse in the 1990's. Groundfish stocks have stabilized in response to a collection of management actions including fleet reduction, bycatch reduction implementation and privatization (quota system transition) since 2011, but salmon stocks, which operate under a more complex management structure, have remained low since a complete West Coast closure of the salmon troll fishery from 2008 to 2009 due to a combination of environmental and human-related stressors on the stocks.

Guiding Research Questions

Previous research connected to Oregon's "Graying of the fleet" have identified aging trends in the state's commercial fishery participation (see fig. 2.2). This phenomenon is likely tied to significant changes in environmental, regulatory and economic factors related to fisheries and their marine habitats. These factors may have differential impacts on each of Oregon's commercial fisheries, thus two guiding research questions in this study aim to examine how differing inputs impact participation.

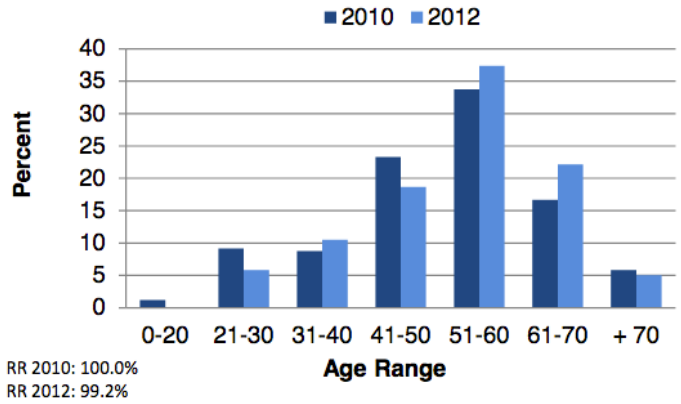

Figure 2.2: Aging trends in commercial West Coast fishery participation in 2010 vs 2013 (Russell et al 2014).

Question 1: *Do aging trends (and entry trends) differ between Oregon's major commercial fisheries?*

Question 2: *What factors affect the decision to enter or continue in some fisheries over others?*

Methods

This study was conducted using a mixed methods approach (Auerbach & Silverstein 2003) utilizing both primary qualitative data and secondary data as part of a larger NOAA/ Sea Grant project. Between 2014 and 2018, researchers gathered qualitative data using combined semi-structured interviews and oral histories with fishermen and fishing community members in Oregon coastal communities (Caracciolo 2017). Interview participants were identified using a modified snowball sampling method (Auerbach & Silverstein 2003) and interviews took place in the homes, vessels, or office spaces in communities where participants lived and worked.

A total of 72 interviews executed from 2014 to 2018 across Oregon coastal communities were analyzed (Carraciolo 2017). Interviews featured commercial fishermen of

various positions (i.e. crew, owner, skipper) and port community members. Of those interviewed, 54 currently engage, have engaged, or are directly related to an individual who engages in commercial fisheries. Even though the average age of commercial fishermen is increasing (see fig 2.2) effort was made to interview individuals from diverse age groups.

Each interview was transcribed via the Express Scribe application and was analyzed using a grounded theory approach in the program MAXQDA 12. The grounded theory method utilized an inductive coding methodology; each transcript underwent three rounds of coding to identify repeating ideas and themes (Auerbach & Silverstein 2003). Themes identified in coding were used to produce relevant narratives, and examined through an interpretive framework as a lens to examine research questions concerning a human or social problem (Cresswell & Poth 2018).

Research Validity and Bias

Validity in qualitative research has long been controversial. Some qualitative scholars denounce the concept of validity, trading the term for "t*rustworthiness, authenticity, and quality,*" while others have chosen to rework the definition of validity so it more aptly applies to qualitative research (Maxwell 2013). This thesis follows a definition used by Maxwell (2013) that accepts the concept of validity, without suggesting that there is a specific "objective truth" in which to compare results.

Some subjectivity that stems from how a researcher interprets data is an inevitable aspect of qualitative research (Auerbach & Silverstein 2003). However, steps were taken to avoid data selection based off of researcher bias (preconceived goals, theories, etc.) that might compromise validity of project findings (Maxwell 2013). A validity test checklist laid out in Maxwell (2013) was returned to throughout the data gathering and analyzation process to identify validity threats, ways to deal with those threats and rationale for using those strategies.

Validity in Data Collection and Analysis

1. Data richness was achieved by collecting in depth, intensive interview data over a longer period of time (Maxwell 2013). In depth interviews and oral histories were collected across port communities by a number of researchers, over a four year span. This method ensured varied data that could form a full picture of perceived changes in the Oregon fishing industry and associated community impacts (Maxwell 2013).
2. The threat of researcher bias was reduced through the use of a pre-determined, IRB approved research question itinerary that included open ended research prompts and questions. This itinerary was utilized by all researchers involved in the research program to reduce the impacts of leading questions that could impact participant response (Carraciolo 2016).
3. Systematic bias in the data collection period was avoided by selecting participants from diverse groups (age, position on vessels, fishery prosecuted, etc.) to represent communities of place and interest in each coastal community (Maxwell 2013).
4. Triangulation was achieved by collecting data from a wide range of locations and diversified interview participants. This method can reduce both biases and associations that can develop from small data pools (Maxwell 2013).
5. Cross coding of transcriptions between researchers reduced researcher bias in the analysis stage. These comparisons reduced two major validity threats; specifically selecting data that fit with preconceived goals or theories, and selecting data just because it "stands out" (Maxwell 2013).
6. Throughout the data analysis period, comparisons were made between emerging findings and those from past projects within the same research program and from similar studies. These comparisons aided in the identification of relevant and significant themes and further reduced validity threats addressed above (Maxwell 2013).

Results and Discussion

Oregon-based fishermen pursue a number of commercial fisheries, however, tuna, groundfish, crab and salmon fisheries were discussed most often in interviews and are therefore the focus on the results. The pink shrimp (*Pandalus jordani)*, whiting (*Merluccius*

productus) and Pacific halibut (*Hippoglossus stenolepis*) fisheries were brought up in some interviews, but were not discussed enough to form indicative themes around perceived aging trends.

Among the four major commercial fisheries studied, results did show that fishermen who participated in the study perceived differential aging trends among the four major commercial fisheries studied. Salmon and groundfish fishery participation were perceived as graying while Albacore tuna and crab were perceived as "younger" fisheries (results elaborated below). Reasons behind perceived differences in aging trends differed due to a number of factors related to management and type of work, and are discussed in more detail below. Management and regulatory-related graying factors in salmon and groundfish fisheries included cost of entry, ease of entry, ease of access and changing management responses to environmental change. In addition, interview participants expressed different levels of interest associated with joining each fishery associated with factors ranging from expected economic return, type of work and perceived longevity of a fishery.

Results reported below are organized by fishery prosecuted and major themes that arose within each fishery. The purpose for this structure is to parse out perceived differences in participation among the four major fisheries considered. Therefore, some theme titles differ between fisheries while others cross over.

The first two fisheries listed under results are Albacore tuna and crab, both of which were not perceived as exhibiting extensive graying trends. The third and fourth fisheries listed are salmon and groundfish, which did exhibit perceived graying trends.

Tuna

The Albacore tuna (*Thunnus alalunga*) is a highly migratory species, whose route passes through multiple EEZs. The fishery is managed by the Inter-American Tropical Tuna Commission in conjunction with the Western Central Pacific Fisheries Commission and the PFMC. Tuna operates as a hook and line (troll) fishery under a permit system from NMFS and is one of the last open access fisheries present in Oregon waters.

Ease of entry

In 2015, 7.6 million pounds of tuna were landed by 323 active vessels in Oregon, with a total value of $9.2 million (The Research Group, LLC 2017). Tuna is an open access fishery (not limited entry; no quota) so there may be fewer entrance barriers for incoming fishermen than other major fisheries in Oregon. As one fisherman research participant eloquently described it: *"All you need is a state license to go tuna fishing, so it is the last free, wide open fishery. It's the last buffalo hunt*."

Type of work

Interview participants expressed enjoyment around the act of catching tuna. Interview participants highlighted the fact that hook and line fishing is a physically demanding, involved process that is attractive to younger fishermen, while potentially dissuading older fishermen. Although tuna fishermen over 50 were interviewed, most were not in labor intensive deckhand positions. The following quote reflects perspectives shared by many younger fishery participants interviewed and exemplifies "type of work"-related interest in tuna fishing: *"We catch them one fish at a time, on one hook at a time. And when they're biting, it's exciting, it's fun."*

Overall, study results illustrate that this fishing method is highly physically involved. This may not be a barrier to younger fishermen, but may be for members of the older fishing generation. Interview participants also identified that, because tuna fishery as one of the few remaining open-access fisheries left in the state, it is both logistically and financially easier to enter (ODFW 2017). Given these two prominent factors expressed by participants regarding participation interest for younger fishermen, the albacore tuna fishery may not be experiencing a graying phenomenon.

<u>Dungeness crab</u>

Most years the Dungeness crab (*Metacarcinus magister*) fishery is the most lucrative single species fishery in Oregon. In 2016 the state's crab ex-vessel value was $63 million. Newport generally has the highest landing rates in the state, with Charleston and Astoria vying for second place and Brookings landings coming in at fourth. Unlike the NOAA managed groundfish industry, crab is a state managed fishery in Oregon in collaboration with

Washington and California management. This fishery has been managed by size, sex and season for over 100 years. It has been a limited entry fishery since 1996, and a pot limit (200, 300 or 500) was established in 2006, which dramatically reduced the catch capacity for larger vessels (Didier 2002).

The crabbing industry stood out as an important fishery among participants interviewed across Oregon. Although some interviewees expressed frustration around recent pot limitations, high interest in this type of work and income potential suggested heightened interest in participating in this fishery above others in the state. The socio-cultural and socio-economic contributions of the crab fleet suggest multidimensional connections between the fishery and the community of interest and place. Interview participants cited high community reliance on this fishery in particular, and compounding socio-economic impacts when access to the fishery (and the income it generates) has been reduced. Heavy community reliance on a specific fishery may leave communities vulnerable in the face of increased climate-change related closures and distribution shifts, results below highlight fishermen and community connections to the crab fishery.

Disproportionately high participation rates in the Oregon crab fishery above all others reflect findings from the 2017 fisheries connectivity study by Fuller *et al* that showed crab as the dominant fishery in connectivity networks in Oregon, meaning that many vessels that target other fisheries also target crab. Participants noted that as a winter fishery, crab offers an important economic boost to fishing families and port communities at a time when most other fisheries are closed. Apart from functioning as an economically important “side fishery”, increased dependence on crab may be attributed to waning access to the salmon fishery due to low stock recruitment and the consolidation of groundfish fishery participation after the 2011 quota transition. Given diverse factors of perceived importance that arose in this study, fishing community connections the crab fishery are investigated in manuscript 2 (chapter 3) of this study.

Type of work

Every year as winter winds, rain and waves pummel Oregon's coastline, the crab fleet sets out for their season. Although interview participants engaged in the fishery noted long hours, physical danger and unfavorable conditions, elements of excitement and satisfaction with the nature of work were also reported. When asked why the crab fishery was his favorite fishery to participate in, one fisherman exclaimed *"the excitement of it 'cause it's during the worse weather, and the reward is how hard you'll push yourself, you know? To work as many hours as you possibly can, as many days in a row as you can and in the worst weather that you dare to go."* Beyond, or perhaps in conjunction with the excitement of the fishery, a number of participants expressed a more general appreciation of the type of work, as reflected in this comment "*[You] work really hard and kinda have a chunk of money when you're done, and have some time to enjoy [it]. Like I said, I have a love for the ocean and I love the action of catching crab."*

Income potential

Another major theme was the income potential that the winter crab fishery represents. Even with pot and entry limitations, the potential for substantial income in this fishery remains a strong incentive as evidenced by perspectives from a number of members from both communities (interest; crab fishermen, and place; community members.) While there is some annual variation due to stock status, price agreements and environmental conditions, the fishery generally opens mid-winter and continues until mid-august every year (ODFW 2017). Unlike quota fisheries, the crab fishery is highly competitive at the start of the season and offers an influx of money into coastal communities. Management estimates show that approximately 75% of legally sized and gendered crab are caught within the first eight weeks of the season (Oregon Crab Commission 2018). This was validated by participants in this research when a number of fishermen shared *"first trip you fill up, that's 14-16 grand"* and *"we make our money in a month, 6 weeks, 2 months maybe. 80-90% of your (annual) income."*

However, despite high earning potential, gear and vessel costs can be a significant barrier to entry for incoming fishermen. As one vessel owner explained, purchasing a permit can be a significant barrier: *"The crab permit on this boat is probably worth one and a half*

times what the boats worth." From the perspective of one interview participant, and shared by a number of others: *"In the younger generations, if you're not in a fishing family it is almost unobtainable."* Because of the high volume of Oregon vessels participating in the fishery, participation as a seasonal deckhand may be possible without family ties to the industry, but operator owner positions may be particularly challenging without family support.

"*Younger" man's fishery*

Elements of hard work, competition and excitement in adverse conditions likely lend to the reputation among participants of Crab as a "young man's fishery," particularly for those in a deckhand position. Some participants theorized that media hype may have inspired even more interest in fishery participation, though this was likely because many of the Newport, OR interviews were collected during local filming of the Discovery Channel's <u>*Deadliest Catch: Dungeon Cove*</u> reality television show. In a 2016 interview, a Newport fisherman shared his perspective on interest in the fishery: *"You know, because of our television programs and the sensationalization of the crabbing industry, [it has] become what kids think they need to do."* Even through this "sensationalization" is likely limited to spatial and temporal factors, interview participants across the state commented on heightened interest of participation among younger fishermen: *"Their push is the crab industry. Or if they're buying boats, they are buying crab boats or needing a bigger boat that can crab."*

Environmental barriers

In an ideal year, the commercial crab fishery season begins on December 1st and ends on August 14th. Delayed season openers are common, however, for a number of environmental, biological and market-based reasons (ODFW 2018). A number of interview participants cited frustration around significant delays over recent years that were specific to Domoic Acid (DA) toxicity. *"We sat around for over a month and a half at the start of this crab season. It was a 'go' a week before the season was supposed to open. Then, all of the sudden they're like* '*oh sorry you guys ain't going, you've got domoic acid'".* This quote above refers to the 2015/2016 season, where significant delays at the beginning of the season made

way for high overall volume of catch by the end of the season, suggesting that overall annual income levels may not have been impacted as much as initially feared (ODFW 2018). Even so, the closure was responsible for a $97.5 million dollar loss in revenue. If delays and closures continue to increase in reaction to projected increases in harmful algal blooms, total annual income could be impacted. However, 2015 income data suggests that this may not be the case. Perhaps more significant impacts would be derived from the loss of income during the winter season when communities have previously relied on an economic influx from the crab fishery (NMFS 2016; Ritzman et al 2018).

Community Connections

Both fishermen and port community members emphasized socio-cultural and socio-economic connections to the fishery, particularly related to multigenerational crab fishing families and an economic influx that boosts the community in the winter. Research participants across Oregon's ports noted perceptible changes in their communities during crab season. One example of crab related economic influx was explained by a community member who stated:*"After crab season there's all these new pickup trucks around there and people buying new boats and stuff."* The season begins in the winter when only the commercial groundfish fishery is active and tourism-related community income is at a low.

When unexpected delays or closures occur in the Crab fishery, interview participants noted both community and family level repercussions. Community impacts included unemployment, buying choices and more: *"...without fishing, every time a closure happens, like domoic acid or anything like that, you can really feel it in the community because people aren't working*." Family level impacts showed a dependence on the fishery for anything extra, especially around the winter holiday season. *"Whether or not to have Christmas is dependent on the season, which can be really stressful for a lot of families."*

<u>Salmon</u>

Oregon salmon populations declined dramatically in the 1990's due to compounding environmental factors and over fishing. The fishery was once both popular to join and lucrative, as evidenced by the total income from the Oregon salmon fishery when it peaked in the 1980's at about $55.5 million (1998 USD). The financial impacts of population decline wer evident soon afterward when income from the fishery dramatically declined to $5.2 million between 1994 and 1998 (PFMC 2000). Similarly, in the 1980's total boat days recorded for salmon trollers were in the tens of thousands in each of Oregon's catch areas. These have also since dropped to under 1000. This widespread decline in stocks and access to stocks resulted in economic loss across communities (Bottom *et al* 2009; Martin 2008).

The fishery itself is pursued using the hook and line (troll) method, and focuses on Chinook (king) and some Coho (silver) species. It is currently managed through a limited entry permit system with about 1,000 permits available, only about half of which are in use.

Type of work

Interview participants noted that type of work, ease of entry and income potential historically attracted younger fishermen to commercial salmon fishing. Shorter trips, ability to work alone or with family and relative ease of moving up in rank made it a practical starter fishery for previous generations. One research participant shared: *"Salmon trolling was the entry fishery for many people my age, I just turned 63 this week."* Furthermore, Oregon salmon trollers were affordable vessels for incoming fishermen, referred to as the "mosquito fleet" by a number of interview participants. Another fisherman interviewed commented: *"I've bought a few salmon boats just from trolling alone, bought 'em from fishing them,"* which would be near impossible for vessels outfitted for other fisheries.

Decreased access through stringent regulations

The majority of themes that emerged from interviews painted the Oregon salmon fishery as a bygone opportunity, at least as a primary fishery. *"The salmon fishery was the first one to experience a level of regulation that kind of made me think 'well, better look for something else.'"* Similar perspectives to this were shared by a number of older fishermen who elected to shift their focus due to increasingly stringent regulations created to combat

dwindling salmon populations prompting some to shift to a more lucrative fishery: "*Changes in management came mostly with salmon regulations and that actually propelled us more and more towards albacore".*

Interview participants observed that the decline of the salmon fishery participation caused ripple effects outside of the fishery itself. An interviewee noted: "T*he reduction in the salmon fleet has had a huge impact…All these smaller coastal towns have really been hit hard.*" This perspective aligns with results from previous vulnerability/ resilience studies on salmon-dependent communities in the Pacific Northwest in the wake of 1990's stock declines. One 2008 study that examined Columbia River salmon gillnet fishery declines and associated community impacts found that while fishermen were able to pursue other fisheries, they felt strong emotional and financial ties to salmon and their eroding habitats (Martin 2008). Although fishermen interviewed in this project were not gillnet salmon fishermen, similarly connections to the fishery were noted.

"Graying"

Participation and access barriers to the fishery appear to have led to a graying trend observed by a number of participants. One older fisherman commented: *"There's a lot of guys that are my age, and there's a lot of senior guys that are about ready to be done."* Though another (in the following quote) suggested that salmon fishing, even as limited as it is now, can act as a way to ease into the retirement process: *"There's a lot of guys that really like salmon fishing and are kinda sliding into retirement while still fishing."* Several fishermen and fishing family member interview participants shared stories from "back in the day" when salmon was a more viable (if not seasonal) career opportunity for younger individuals and families.

Overall, participants interviewed shared a common sentiment that *"Salmon is still a vital fishery to Oregon, but it's not nearly as large as it used to be."* This perspective likely relates to fishery value beyond economic input, including social and cultural ties to salmon in the Pacific Northwest. Although salmon fishermen have exhibited flexibility by adapting to different gears, smaller fishing zones and shifting to other fisheries, access reduction has increased factors of vulnerability in both economic and employment realms. Even so,

interview participants noted that salmon continues to play an important, if less tangible, role in the state.

A definition of resilience is a system's ability to adapt to change without losing key functions. In the case of West Coast salmon populations, biological resilience has been compromised through a combination of human and ecosystem shifts (Hanna 2008; Bottom *et al* 2009). The human communities that once housed healthy salmon fleets reportedly suffered socioeconomically in the wake of the 1990's fishery collapse, indicating that the strong connections between fishery and community may have increased factors of community vulnerability at the time (Bottom *et al* 2009; Smith & Clay 2010). Results from this study, however, show that over time fishermen have been able to reorganize into other fisheries and move forward, indicating that communities of interest as well as the communities of place are relatively resilient despite significant uncertainty around a historically key Oregon fishery.

Groundfish

The 2011 US West Coast groundfish fishery shift to rationalization (quota) was NOAA's attempt to further reverse declining stocks, reduce bycatch and increase economic potential (Russell et al 2014; Warlick *et al* 2018). Biological goals of the quota shift have been successful, but social impacts like increased financial barriers to entering the commercial fishing industry and fleet consolidation are more controversial (Russell *et al* 2014).

Social impacts of fishery privatization policies like quota have been examined in the United States by Alaska-based researchers like Carothers and Donkersloot (2016), West coast researchers like Russell (2014) and Cramer *et al* (2018) and others across the country. Previous studies that have examined community impacts of rationalization in Alaska have found links between quota systems and loss of opportunity for incoming fishermen. These studies cited compounding social impacts of opportunity loss that included economic loss, social problems, and lack of alternative employment options (Cramer *et al* 2018; Carothers 2015). An initial theme-based report published in 2014 by Russell *et al* examines social impacts of groundfish quota across the US West Coast the years directly before and after the 2011 implementation. Four major themes were uncovered including perceptions of graying

trends in the fishery, changing social relationships in response to rationalization, various perceptions of the program and fisheries participation (Russell *et al*, 2014).

Major themes that emerged in this study regarding groundfish fishery were related to management and fishery regulation, particularly high costs of entry and mandatory observers, both directly a result of the quota system. These findings were comparable to those from the Russell *et al* (2014) study that found perceptions of rationalization were mixed, but Collectively were considered to have caused a huge shift in the fishery. Results indicated mixed perceptions from fishermen around the ITQ Groundfish fishery structure, where more informed participants were more likely to be in support of the new system. One fisherman shared a balanced perspective of the shift: *"It's the biggest thing that's happened to our industry, ever, in my opinion, and we have had to plan for that. Now has that hurt us? Somewhat yes, somewhat no."*

Privatization

Rationalization programs are structured to increase flexibility for fishermen by eliminating the "race to fish" because quota holders are allotted a percentage of the total allowable catch. There are, however, negative social impacts associated with this privatization as described by an interview participant: *"It has also privatized what used to be a public resource. It used to be owned by everybody collectively, and there was opportunity for people who wanted to get involved in the industry to get in and start at a lower level and work their way up.*" Privatization of the resource through the quota system transition was a major groundfish related theme that emerged from this study. This is significant because it was also cited as a major source of change in COI and COP in an associated study by Cramer *et al* (2018). In both studies, research participants viewed rationalization as a factor that increased community vulnerability because it reduced both local financial capital and business ownership opportunities (Cramer *et al* 2018).

Consolidation

Efficiency is an intended effect of ITQ systems. In theory, consolidation of the fishing fleet frees "excess" fishermen to

fill other roles, but this theory fails to consider community structure and lack of career alternatives available in rural communities (Carothers & Chambers 2012). During an interview, one fisherman shared his observations of the dwindling fleet: *"I think I started in '89 doing that (groundfish trawl), there used to be 30 or 40 trawlers out of here. Now there's just a handful. So that has changed."* This sentiment is backed up by social science data collected in the groundfish fishery that shows a consolidation of vessels as an effect of the rationalization program implemented in 2011 (see fig. 2.3).

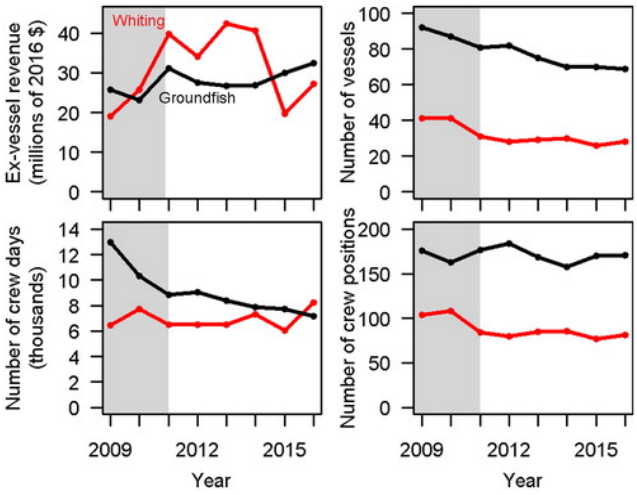

Figure 2.3: Participation and revenue data for West Coast whiting (red) and groundfish (black) (Steiner et al 2019).

Diminishing opportunity

An interview participant shared*: "The quota system has definitely changed the ability for young people to get into the business."*

Diminishing employment opportunities were a final theme that emerged related directly to the groundfish fishery. Like privatization and consolidation, lack of employment opportunity was perceived to be directly linked to the quota transition. The 2014 study found that the average groundfish fisherman has been in the fishery for about 26 years, and is nearing retirement age. These aging fishermen entered the fishery between early childhood and their mid 20's; fishermen hoping to enter the field post rationalization are likely to struggle with high cost of entry and availability of quota (Russell *et al* 2014). This theory is supported by preliminary results on the US West Cost that show fewer young entrants into the commercial fishing industry since the 2011 groundfish rationalization (see fig. 2.2) (Russell *et al* 2014).

In this research, data suggests that rationalization has created barriers to entry through privatization of the resource, higher cost of entry, and increased difficulty in obtaining rights to fish has led to the perceptions of a consolidating fleet. These perceptions are similar to findings from previous research in Alaska and the Northeast on the impacts of management transitions into quota systems (Colburn & Clay 2012; Donkersloot & Carothers 2016). In both locations studied, quota transitions resulted in reduced fishery options for industry

participants with ripple effects that invaded social and economic realms (Colburn & Clay 2012).

Synthesis of Results

Given vast differences in catch value, total landings and number of participants among the four fisheries considered in this article, sustained participation in some fisheries may be more economically important than others. If access to lucrative fisheries continues to wane due to management shifts and stock recruitment issues, commercial fishing businesses will rely more heavily on fewer fisheries or will turn to land-based jobs to supplement income. According to results from this study, Albacore tuna and Crab fisheries are most likely to see increased participation. Interview participants cited interest in the Albacore tuna fishery because of the active nature of the fishery and its regulatory status as an open access fishery that incoming fishermen are still able to enter without exorbitant expense. Interest in crab fishery participation centered around the lucrative nature of the fishery, relative ease of entry and type of work also emerged as prominent themes. Interview participants cited factors of social, economic and cultural importance connected to the Crab fishery, and cited Domoic acid-related closures as a potential threat to security of the fishery. Because Domoic acid events are projected to increase as climate change intensifies, increased closures could result in a significant barrier to fishermen. Similar to the impacts of access shifts in the salmon fishery, the impacts of a reduced crab fishery access could trigger a myriad of socio-economic impacts across Oregon fishing communities.

Conclusion

This study utilized interview data from a multi-year study and examined graying trends across four major commercial fisheries prosecuted in Oregon. Results showed that interview participants perceived significant aging trends in both the salmon fishery and the groundfish trawl fishery, while participants viewed tuna and crab fisheries as “younger” and perhaps not graying. Considerable access reduction in both salmon and groundfish were cited as primary causes for graying. Salmon access shifts are directly associated with low and

unstable stock health due to human and ecosystem changes in play since the 1990's. Whereas groundfish access shifts can be traced back to a stock crash in 2000, with a vessel buyback program soon after, and a shift to the quota structure in 2011. The perception of tuna as a "younger" fishery is tied to its status as an open access fishery, as well as the high energy, labor intensive nature of the work. Interview participants also characterized crab as a "younger fishery" because of type of work, seasonality and income potential. Among the four fisheries, crab stood out as exceptionally socio-economically important in port communities, with high interest in participation.

Fishery portfolio diversification is a key factor for reducing overall risk in fishing businesses and the port communities in which they are housed. Fishing businesses on the US West Coast that are able to prosecute a diverse set of fisheries experience less interannual variability in income are more resilient overall (Fuller *et al* 2017; Kasperski & Holland 2013; Cline *et al* 2017). Results from this study show a trend of extrapolated decline in portfolio diversification among Oregon's commercial fishing businesses that could contribute to decreased resilience in communities of interest and place unless alternative economic opportunities are created.

Preliminary findings from this study provide a baseline of information on perceived connections and interest in participation among four major fisheries targeted in Oregon. Themes uncovered in this study were somewhat limited by fishery, to avoid this in the future, researchers should choose interview participants that participate in other economically important fisheries like pink shrimp. Finally, to uncover long term impacts of access shift among Oregon's fisheries, a longitudinal study may be appropriate to capture changes in perceptions over time. National Standard 8 and NOAA's movement towards EBM require research and documentation of changes in fishery participation and the socio-economic effects that ripple into coastal communities. Studies like this one are essential to large scale problem solving in the commercial fishing industry as a paired human natural system because interviews integrate perceptions of stakeholders that have been historically underrepresented in policy and management decision making. Further integration of these stakeholders into the decision making process is key to increasing adaptive capacity and resilience among Oregon's commercial fisheries and fishing-dependent communities.

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16 U.S.C. §1851(2)(8)

Chapter Three: Second Manuscript

An examination of perceived connections between the Dungeness crab fishery and Oregon fishing communities

Relationship to Thesis:

Chapter 2 examined graying trends in Oregon's coastal communities through the lens of fishery targeted. In other words, whether graying trends differ between the various commercial fisheries and potential impacts of uneven interest in participation in that fishery.

This chapter focuses on potential distribution shifts of Dungeness crab in reaction to climate change, and utilizes interviews to examine ripple effects on both the fishery and coastal fishing communities, especially through the lens of graying. Although this fishery stands out as an exceptionally socioeconomically and sociocultural important fishery across port communities analyzed in this study, previous research indicates that fluctuations inherent to the industry cause annual variation in landings and value (Fuller *et al* 2017; Ritzman *et al* 2018).

The Crab fishery has experienced regulation changes over recent decades, and many interview participants in this study noted boom and bust cycles of crab populations through time. Even so, ecological evidence suggests the fishery is environmentally sustainable (ODFW 2014), and interview participants expressed high interest in continued participation in the fishery. High participant enthusiasm around joining this fishery meant that graying trends were not immediately obvious. However recent environmental trends have resulted in decreased access to the fishery since 2015, and are projected to increase in the future. In anticipation of increased access barriers due to environmental change and regulatory response, this research contributes to an emerging body of research that examines factors of vulnerability and resilience in West Coast fishing-dependent communities.

Abstract

U.S. West Coast commercial fisheries are coupled human-natural systems that cross state borders and integrate private, public, and academic sectors. These systems are composed of complicated relationships between coastal socioeconomics, resource management, and environmental factors. Changing ocean conditions tied to climate change is anticipated to impact access to these commercial fisheries through shifts in species distribution and abundance on a scale that has not been seen in the modern age. Fishery policy makers and managers are tasked with anticipating how sea change will impact target species and connected human systems. This study builds on a larger, transdisciplinary study conducted at Oregon State University, and offers insight on human connections with the U.S. West Coast Dungeness crab fishery through semi-structured interviews with fishing community members across Oregon port communities. Themes that emerged through data analysis give insight into factors of resilience and adaptive capacity of the fishery and fishing-dependent communities across Oregon in the face of changing sea conditions and access to the fishery.

Introduction and Background

Scope of project

The National Science Foundation Research Traineeship (NRT) housed at Oregon State University is an innovative program designed to train future natural resource scientists and managers. The traineeship is novel in its transdisciplinary structure as well as its goal to tackle complex marine issues associated with climate change through a holistic approach. Traineeship cohorts are split into small groups that focus on an emerging marine issue. The traineeship is both a one year fellowship and a minor that includes a field camp, minor coursework, an internship, a transdisciplinary report detailing the team process and an interdisciplinary thesis chapter.

The need for this work was identified through findings from a 1-year transdisciplinary group project of which the author was a member. Findings contribute to a growing body of research that examines factors of resilience and vulnerability in fishing-dependent communities as directed by various US policy directives (Oregon State University 2018).

Due to the nature of the transdisciplinary project, the format of this manuscript is somewhat nontraditional. The structure of the document begins with a background section detailing the transdisciplinary group project and findings followed by a brief literature review that gives additional context to the research conducted. Together the background and literature sections show significant gaps in depth of understanding around Oregon port community connections to the Dungeness crab fishery from the perspective of stakeholders.

Findings from the Transdisciplinary team

Each NRT transdisciplinary team detailed group process and findings in a report. The crab fishery-focused team created a report titled *"**Connecting crabs, currents, and coastal communities:** A transdisciplinary approach to examining the impacts of a potential Dungeness crab distribution shift under changing ocean conditions."* In the report, the team examined the crab fishery as a coupled human-natural system, with a special focus on how communities that house crab fleets may be impacted by changing ocean conditions. The team found that sea surface temperature increase associated with climate change could result in a northward crab distribution shift. Given the interconnected nature of this fishery impacts of access change to crab were likely to propagate across ecological and social systems across the West Coast.

Findings specific to this research

The crab team utilized biological and oceanographic datasets and determined that a future 2-degree northward distribution shift of crab is likely in response to increasing sea surface temperature. However, all port communities that house crab fleets are not at equal risk of access declines due to this shift. Furthermore, some communities are better equipped to deal with access shifts than others because levels of perturbation depend on factors of community vulnerability and their reliance on the fishery. To approach the potential for differential community response to a distribution shift, the crab team utilized a NOAA community vulnerability framework designed to "rate" vulnerability and resilience of each crab port on the US West Coast. While not comprehensive, the function of this framework was designed to rapidly evaluate communities before and after significant fishery changes to

better understand factors of their resilience and adaptive capacity (Jepson & Colburn 2013; NOAA 2017). In response to a large scale harmful algal bloom (HAB) related closure in 2015, NOAA and the Northwest Fisheries Science Center altered this framework to examine the relationship between the Dungeness crab fishing industry to U.S. West Coast communities that engage in the fishery (Varney 2018 Unpublished data). Results from that study showed that community vulnerability and engagement was highly variable across ports, and many ports that showed either high vulnerability or reliance, but not both. For example, Bodega Bay, CA was highly reliant and engaged, but was not socially vulnerable. Overall, Oregon and Washington communities were more socially vulnerable than California communities (Varney 2018 Unpublished data).

Data comparisons across regions (Central California, Northern California, Oregon and Washington) showed central California as highest risk areas for distribution shift, but lowest in engagement and reliance. Neither Oregon nor Washington were at risk of a sea surface temperature (SST) driven distribution shift, but ranked higher in reliance and engagement with the fishery, with higher social vulnerability in port communities. Overall, changes in the fishery prompted by other environmental shifts (like HAB closures) may have larger impacts on Washington and Oregon port communities than those in California (Varney 2018 Unpublished data).

Social Change

The integral role of humans in fishery systems has been formally recognized in recent shifts towards ecosystem-based management in natural resource divisions (ORAP 2013). In the past two decades, social science researchers have begun to address social vulnerabilities in fishing-dependent communities through both quantitative and qualitative valuations across U.S. coast port communities (Himes-Cornell *et al* 2016; Norman *et al* 2007). Fishing communities are defined in the Magnuson-Stevens Fisheries and Conservation act as:
A community that is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew, and fish processors that are based in such communities

(16 U.S.C. 1801 - 1891(d)). On the US West Coast alone, 123 port communities fit into the "fishing-dependent" category (Norman *et al* 2017).

A push to integrate human systems is driven by federal directives established in National Standard 8 of the 1996 revision of the Magnuson-Stevens Fisheries Management and Conservation Act (MSA; 16 U.S.C. 1801 - 1891(d)), as well as the National Environmental Policy Act (NEPA). Despite these legal directives to integrate human-natural connections into management plans, it is difficult to formulate quantitative indices that reflect complex factors of resilience and vulnerability in fishing communities. While these indices are necessary, they cannot fully capture the intricacy of individual and community connections to fisheries (Himes-Cornell *et al* 2016).

Qualitative Approach

NOAA's quantitative indices, used for rapid assessment purposes, assess engagement and reliance of fishing communities. In response to the 2015 DA event, NOAA adapted these indices to assess the crab fishery and its socioeconomic connections (Varney 2017). These quantitative assessments of community vulnerability and resilience may be time and budget friendly, but fail to capture the complexity of social structures at play in a coupled human-natural system. Qualitative research utilizes theoretical or interpretive frameworks as a lens to examine research questions concerning a human or social problem, and can (arguably) offer more in depth information than quantitative methods (Cresswell & Poth 2018; Colburn & Clay). Understanding these impacts can increase a community's ability to create strategies that will increase community and fishery resilience (Ritzman *et al* 2018). Community insights can lead to more effective solutions that increase resilience in communities of place (port communities) and communities of interest (individuals and their families who are directly involved in the fishing industry) (Carraciolo 2017; Cramer *et al* 2018).

Environmental Change

Because environmental shifts related to climate change result are unpredictable, magnitude and direction of change in ocean conditions vary considerably. These changes influence directional and distributional shift in marine fauna, which tend to shift distribution

more rapidly than their terrestrial counterparts (Pinsky *et al* 2013; Sorte *et al* 2010). Climate change-related distribution shifts that could impact market-important species, including North Pacific albacore tuna (*Thunnus alalunga*) and American Lobster (*Homarus americanus*), which have been a focus of study in recent years. Results from these studies show projected northward distributional shifts linked to climate change impacts that are expected to increase over coming decades. These studies have focused on biological response to change, but human impacts of distribution shifts in market-important species are yet to be studied (Phillips *et al* 2014, Rheuban *et al* 2017).

This gap in knowledge creates a need to establish a functional framework to examine community impacts of biological and environmental shifts associated with climate change; ranging from altered food web dynamics to shifts in species distribution (Hoegh-Guldberg & Bruno 2010). Although rate and dimensions of ocean change remain uncertain, clear trends towards sea change that directly impact the US west coast are being seen across the California Current System (Checkley & Barth 2009).

Events intensified by climate change impacts like hypoxia and Harmful Algal Blooms (HABs) are also expected to increase in coming years (Ritzman *et al* 2018). Sea surface temperature (SST) increase and ocean acidification are both directly tied to climate change and create favorable conditions for HAB events that impact human and ecological wellbeing, with ripple effects that extend to coastal economies (COST 2016). A marine diatom in HABs called *Pseudo-nitzchia* can produce a neurotoxin known as domoic acid (DA) that infiltrates the marine food web via suspension feeders like Pacific razor clams (*Siliqua patula*) and bioaccumulates in fish species and Dungeness crab (COST 2016). Although DA is not harmful to these organisms, it can cause potentially fatal neurological effects to humans, mammals and birds that consume them (McKibben et al. 2017).

The impacts of West Coast HABs have been a focus of study since a massive El Niño driven mass of nutrient poor, warm water (referred to as “the blob”) emerged between Central California and Alaska in 2015, creating ideal conditions for these events. (COST 2016; Ritzman *et al* 2018). Many of the resulting blooms across the US West Coast contained high levels of DA, prompting Washington, Oregon and California state agencies to employ adaptive management measures to monitor and close razor clam and crab fisheries as needed.

Oregon's adaptive management plan included the implementation of twelve coastal fishery "zones" that could be individually monitored for levels of DA toxicity and could be independently opened or closed accordingly (ODA 2015). Unsafe levels of DA toxicity used today were set in accordance with limits set by the Canadian government in 1987 who deemed that closures should occur when DA levels exceed 20ppm in meat and/or 30ppm in viscera (COST 2016, ODA 2015). DA toxicity in crabs have surpassed these levels every year since the 2015 season, resulting in delayed openings and intermittent closures across the fishery range (ODFW 2017; Ritzman *et al* 2018).

Fishery Change

The Dungeness crab fishery is the most economically important fishery prosecuted on the US West Coast. Not only does the fishery generate high revenue, it has been identified as the most dominant fishery node on the US West Coast (Fuller *et al* 2017). This means that a disproportionately high number of fishing vessels participate in the crab fishery, often in conjunction with other fisheries (Fuller *et al* 2017).

The geographical extent of the fishery stretches from Southern California through Washington State, with large annual fluctuations in landings across all ports (PFMC 2017, Rasmuson 2013, Shanks & Roegner 2007). Each state manages their crab fishery separately, but work together as the Tri-State Dungeness Crab program (TSDC) when large scale management decisions are necessary (Lefebvre & Robertson 2010).

Not only is the crab fishery usually the highest ex vessel value of any single species fishery on the U.S. West Coast, but it also represents a significant source of employment in coastal communities (ODFW 2017). Partially due to Domoic acid-related closures the West Coast Crab industry (as a whole) experienced a $97.5 million decrease in revenue in the 2015-2016 season alone (National Marine Fisheries Service 2016). Negative impacts on fishery access, and dependent economic influx will likely intensify over time as climate change impacts continue (COST 2016).

A study in 2018 study by Ritzman *et al* used themes derived from semi structured interviews to examine economic and sociocultural impacts of 2015/2016 Crab season DA closures in the communities of Long Beach/Ilwaco, Washington and Crescent City,

California. The purpose of this study was to examine factors of community resilience as an indicator of how these communities may respond to changes in fishery access due to DA related closures. Themes from this study included community impacts such as: industry and hospitality (including tourism); barriers to accessing assistance during closures; lack of communication between managers, fishermen and community members; and community and individual disruption due to closures (Ritzman *et al,* 2018). This study was significant because it was the first qualitative study to examine perceived sociocultural and economic impacts from recent DA-related closures on the US West Coast. Such studies are important because they offer cultural insights on changing ocean conditions that could be considered when designing and building appropriate response plans.

Guiding Research Questions

Findings from quantitative indices in "crab team" report showed varied levels of engagement and reliance on the crab fishery between Oregon port communities. To better understand community impacts from decreased access to the fishery, this study investigated perceived connections to the fishery within both communities of place and of interest. Data analysis focused on economic, social and cultural connections to the fishery, and whether participants perceived DA as a threat to those connections. Question 1 examines perceived functions of the fishery in coastal communities, while question 2 investigates whether or not closures will impact these key functions.

Question 1: *What are the perceived connections between Oregon's Crab fishery and communities of interest (crab fishermen) and communities of place (port communities) as coupled human-natural systems?*

Question 2: *Do these communities show traits of resilience in the face of access shifts due to changing ocean conditions?*

Methods

Data for this study were gathered via oral history interviews conducted as part of the "Graying of the Fleet" research project headed by Flaxen Conway and Lori Cramer. Data

gathered for this study were supplemented and modeled after data gathered using semi-structured (See appendix C, D), oral history interviews (See appendix A) with fishing community members in Oregon coastal communities (Caracciolo 2017). Interview participants were identified using a modified snowball sampling method (Auerbach & Silverstein 2003) and oral history interviews took place in the homes, vessels, or communities in which participants lived and worked.

Semi structured interviews gathered information relevant to changes in communities, fishing industry, and ocean conditions. To assess the importance of Dungeness crab to coastal communities through human perspectives, a total of 72 interviews executed from 2014 to 2018 across Oregon coastal communities. Interviews featured commercial fishermen of various positions (i.e. crew, owner, skipper) and port community members. Of those interviewed, 54 were currently engage, have engaged, or are directly related to an individual who engages in the Dungeness crab fishery.

Interviews were transcribed verbatim using the Express Scribe application, and analyzed using MAXQDA 12 software following the grounded theory method (Auerbach & Silverstein 2003). The grounded theory method utilizes an inductive coding methodology; each transcript underwent three rounds of coding to identify repeating ideas and resulting themes (Auerbach & Silverstein 2003). Themes identified in coding were used to produce relevant narratives.

Dungeness crab-related passages from interview transcriptions in Oregon coastal communities, including Brookings, Coos Bay/Charleston, and Newport, were marked according to location during the coding process and further analyzed for relevance to the objectives of this project. In addition, relevant quotes were extracted from individual interviews and utilized to enhance the value of the quantitative socio-economic findings.

Qualitative research utilizes theoretical or interpretive frameworks as a lens to examine research questions concerning a human or social problem (Cresswell & Poth 2018). The analysis process of interviews was conducted using a grounded theory approach, an iterative process that requires multiple rounds of revisions. This process is unique because it evolves throughout the study (Creswell & Poth, 2018).

Results and Discussion

Interest in participation:

A major overarching theme that emerged from this research was a disproportionate interest in participating in the Dungeness crab fishery alone, or in conjunction with, other commercial fisheries in Oregon. This heightened interest seemed to be tied a number of factors ranging from potential income, ease of entry, seasonality, media hype and type of work that the fishery requires.

Income potential and regulation

Despite changes in regulations over past decades, the income potential in the Crab fishery has remained high. One fisherman described his introduction to the fishery two decades ago, and how that experience motivated him to stay in the industry: "*That first day I made a thousand dollars and that was it, it hooked me. That was in the early 90's, [and] that was a lot of money [at that time]".* This individual began his career near the time of the 1996 shift towards a limited entry system, a measure that restricted the number of vessels given the right to fish in a given year (Didier 2002, ODFW 2014). While this transition certainly excluded a percentage of historically active vessels, its purpose was to raise the value of catch, and thus provide a higher income for those still participating in the fishery. A decade later pot limits were established in the fishery, vessels that had historically used many hundreds or thousands of pots were suddenly restricted to 200, 300 or 500 pot permits (Rasmuson 2013).

Even with pot and entry limitations, the potential for substantial income in this fishery remains today as evidenced by perspectives from a number of Crab fishermen and community members alike. While there is some annual variation due to stock status, price agreements and environmental conditions, the fishery generally opens mid-winter and continues until mid-august every year (ODFW 2017). Unlike quota fisheries, the Crab fishery is highly competitive at the start of the season and offers an influx of money into coastal communities. Management estimates show that approximately 75% of legally sized and gendered crab are caught within the first eight weeks (Oregon Crab Commission). This was validated by participants in this research when a number of fishermen shared "*first trip you fill up, that's*

14-16 grand…", and "…we make our money in a month, 6 weeks, 2 months maybe. 80 or 90% of your (annual) income."

Younger fishermen in deckhand positions were not excluded for high income potential. Because the bulk of fishing is done at the beginning of the season, deckhand positions in this fishery may represent a method to achieve financial freedom for younger individuals. Even if these individuals may not end up as fulltime fishermen, interview participants generally considered seasonal participation to be a positive opportunity for the younger fishing generation: "*they can come fish a crab season and take that money and come to school for a year, or take that money and buy their own boat, or work on their boat with their older brother."* In rural Oregon port communities where economic opportunities may be limited and income potential may be low outside of natural resource fields, working in the crab fishery can be very attractive.

Type of work

Every year as wintertime winds, rain and waves pummel Oregon's coastline, the crab fleet sets out for their season. Although interview participants engaged in the fishery noted long hours, physical danger and unfavorable conditions, elements of excitement and satisfaction with the nature of work were also captured. When asked why the Crab fishery was his favorite fishery to participate in, one fisherman exclaimed "*the excitement of it 'cause it's during the worse weather, and the reward is how hard you'll push yourself, you know? To work as many hours as you possibly can, as many days in a row as you can and in the worst weather that you dare to go."* Beyond, or perhaps in conjunction with the excitement of the fishery, a number of participants expressed a more general appreciation of the type of work "*work really hard and kinda have a chunk of money when you're done, and have some time to enjoy. Like I said, I have a love for the ocean and I love the action of catching crab."*

"Younger fishery"

These elements of hard work, competition and excitement in adverse conditions likely lend to the reputation of Crab as a "young man's fishery," particularly for those in a deckhand position. Some participants theorized that media hype may have inspired even more interest in

fishery participation, though this was likely because Newport, OR interviews were collected during local filming of the Discovery channel's "Deadliest Catch: Dungeon Cove" reality television show. In a 2016 interview, a Newport fisherman shared his perspective on interest in the fishery: *"You know, because of our television programs and the sensationalization of the crabbing industry, [it has] become what kids think they need to do.* Even through this "sensationalization" is likely limited to spatial and temporal factors, interview participants across multiple ports commented on heightened interest of participation among younger fishermen: "*Their push is the crab industry, or if they're buying boats, they are buying crab boats, or needing a bigger boat that can crab."*

Community connections

Participants interviewed across Oregon coastal communities spoke explicitly about community connection to the Dungeness crab fishery. The nature of these connections are diverse, spanning from the connection between fishery and product, family and port community, fishery, and the culture between those specifically engaged in the industry.

Intergenerational fishery/family connection

While first generation fishermen are certainly present in Oregon ports, Crab fishery participants interviewed reported high instances of intergenerational participation in the fishery, where entire families work on one vessel or one family owns multiple vessels. In Oregon's central coast one community member described the strategy behind one local intergenerational fishing family's success: "*He just kept building his fleet and his sons run them, they own half the boats at the port now, and they are all good, high line fishermen."* Joining a family fishing business may offer a significant "leg up" for individuals entering the fishery as permit, gear and vessel costs can be a significant barrier to entry, particularly at a higher position. As one vessel owner explained, purchasing a permit can be a significant barrier: "*The crab permit on this boat is probably worth 1 and a half times what the boats worth."* From the perspective of one interview participant, and shared by a number of others: "*In the younger generations, if you're not in a fishing family it is almost unobtainable."* Because of the high volume of Oregon vessels participating in the fishery, participation as a

seasonal deckhand may be possible without family ties to the industry, but operator owner positions may be particularly challenging without family support.

The presence of intergenerational fishing families in Oregon's Crab industry show that it has not only been an environmentally sustainable fishery through time, but also economically sustainable. Conversely, intergenerational Crab fishing families may have increased levels of vulnerability as compared to families that rely on multiple fisheries or multiple industries. The more dependent a given group (or family) is on a particular fishery, the more sensitive they are to the impacts of any access shifts related to management, environmental impacts or abundance shifts (Steneck et al 2011; Fuller et al 2017).

Visible change during crab season

Community members interviewed across Oregon's ports noted perceptible changes in their towns during crab season. These observations were categorized as both economic contributions and changes in the character of the community itself. One example of crab related economic influx was explained by a community member: *"After crab season there's all these new pickup trucks around there and people buying new boats and stuff."* The Dungeness crab season begins in the winter when only the commercial groundfish fishery is active and tourism-related community income is at a seasonal low. When unexpected delays or closures do occur, interview participants noted both community and family- level repercussions. Community impacts included employment, buying choices and more: "*...And without fishing, every time a closure happens, like DA or anything like that, you can really feel it in the community because people aren't working."* Family level impacts showed a dependence on the fishery for anything extra, especially around the winter holiday season. "*Whether or not to have Christmas is dependent on the season, which can be really stressful for a lot of families."*

Findings from the 2018 Ritzman *et al* reported similar visible community connections to the fishery in Crescent City (CA). Participants from that study reported cultural ties to the fishery including consuming crab over Christmas and thanksgiving dinners, and perceptible change in community activity around the opening of the season. The authors suggested that

reduced fishery access due to closures could disrupt social and cultural structure and even identity in crab port communities.

Fishery connectivity

For individuals who do identify as full time fishermen, the Dungeness crab fishery may represent an important financial connector throughout the year. In a 2017 article, Fuller *et al* examined connectivity of commercial fisheries across the US West Coast and identified the crab as a "central" fishery along the US West Coast. Findings from Oregon-based interviews reinforce these findings, and many interview participants referred to the sustaining role of the crab fishery. Even though many Oregon fishermen participate in multiple fisheries every year, the crab fishery may be central to the success of a year-round fishing operation: "*Tuna fishing is a lot of fun, [but] it's not profitable generally, it can be but normally the crabs are kind of our anchor for the year, everything else follows that."*

In their fisheries connectivity study, Fuller *et al* stressed that fishery portfolio diversification reduces financial risk and increases resilience and adaptive capacity in fishery businesses and fishery-dependent communities alike (Fuller *et al* 2017). The study identified the crab fishery as disproportionately important in terms of economic input and cross participation with other fisheries. For example, commercial fishermen in Newport (OR) who participated in albacore, groundfish, pink shrimp and salmon troll fisheries were all likely to participate in the crab fishery as well. Conversely, those who identify as "crabbers" likely participate in other fisheries throughout the year, as determined by their vessel size and gears, as exigences in the 2017 fishery connectivity study by Fuller *et al*. Despite the "generalist" nature of Oregon's fishing vessels, "crabbing" vessels on the US West Coast generally obtain about 70% of their annual income from the crab fishery. The study concluded that significantly reduced access to this particular fishery would impact entire fishery networks and coastal communities would experience economic shocks (Fuller *et al*, 2017).

Barriers and concerns

Perspectives of Environmental Change

Dungeness crab is usually, but not always, the most economically valuable single-species fishery in the state. This value is determined by annual and seasonal variations in species abundance and market value of catch (Oregon Crab Commission). Dungeness crab abundance is cyclical by nature and a number of fishermen attributed any change in catch to natural variations: "*the crabs have kinda come back, that's a cycle though."* Overall, interview participants perspectives were hopeful and positive regarding the present and future availability of the species, and abundance was not pinpointed as a concern for the fishing community: "*there's more crab around now than there used to be, so let's hope it stays that way."*

Access to the fishery, rather than availability of catch, was pinpointed as a theme of concern from a number of interview participants. Barriers to access take the form of delayed starts and intermittent closures due to market price disagreements, environmental issues and species health.

Management response: Domoic acid

As climate change continues to warm global oceans, important commercial fisheries including the American lobster and North Pacific albacore tuna will experience distribution shifts towards the poles (Pinsky *et al* 2013; Rheuban *et al* 2017). Findings from the NRT "crab" determined that SST-related Crab distribution shifts may impact the California fishery, but distribution will likely not change in Oregon. However, access restriction across the US West Coast is projected to increase due to as climate change continues (Ritzman *et al* 2018). There have been few studies on the socio-cultural impacts of HAB-related closures (Jewett *et al* 2008). This and other similar studies address a pressing need to examine factors that may contribute to resilience and adaptive capacity in fisheries and communities that rely on them in the face of climate change.

The commercial Dungeness crab fishery season begins on December 1st and ends in August, but delayed season openers are common for a number of environmental, biological and market-based reasons (DFW 2014). However, a number of interview participants cited

frustration around significant delays over recent years that were specific to DA toxicity. *"we sat around for over a month and a half at the start of this crab season, and it was a go a week before the season was supposed to open then all of the sudden they're like "oh sorry you guys ain't going, you've got DA"*

The quote above refers to the 2015/2016 season, where significant delays at the beginning of the season made way for high overall volume of catch by the end of the season, suggesting that overall annual income levels may not have been impacted (ODFW 2017). If delays and closures increase in reaction to DA toxicity in Dungeness crab the amount income may not be compromised as much as the time of year that the income has historically been obtained. On a larger scale the compounding effects of harmful algal blooms are responsible for millions of dollars of loss per year in the United States, with more expected loss with an expected increase of algal blooms in global oceans (Ritzman *et al* 2018)

Conclusion

Study limitations

Limitations in this study were related to the methods in which data were gathered. Unlike the 2018 study by Ritzman *et al*, interview questions in this study were not developed specifically around community connections to the crab fishery. Instead relevant information was parsed out from a much wider qualitative dataset. Although crab specific questions would have delivered more robust results, this can be viewed as an exploratory study that identified need for future investigation and results were able to answer research questions. Another factor that limits this study to an exploratory status was the scale of results. Unlike research by Ritzman *et al* (2018), this study did not separate findings by port, opting instead to look at coastal Oregon as a whole. Themes that arose in the data analysis process showed a number of perceived connections between the crab fishery and coastal communities across the state (these related to research question 1). Any port-specific resilience plan informed by a qualitative social science research would require case studies that reflect individual needs of a given location.

Identifying threats to resilience

Findings from this study suggest that participants in Oregon's Dungeness crab fishery have been able to adapt to regulatory shifts that restricted permits and pot use over recent decades. Despite natural cycles in abundance and value of catch, interview participants reported high levels of interest in participation, particularly among younger fishermen. Major points of concern around the fishery stemmed out of less dependable management actions made in reaction to increased harmful algal blooms off of the US West Coast. Therefore, this research concludes that reduced access to a fishery, not reduced interest in participation, is a central threat to fishery resilience.

Research question 2 aimed to identify traits of resilience in communities in the face of access shifts. Commercial fisheries are coupled human-natural systems and are thus susceptible to change in both realms. Calculating resilience of a fishery requires understanding a community's (community of place and community of interest) ability to reorganize in the face of change without losing key functions (Cline *et al* 2016; Adger 2006).

In a 2017 study Fuller *et al* found that crab is disproportionately important in fishery networks across the US West Coast. While connectivity between fisheries varies by port, Fuller *et al* (2018) noted that in Newport (OR) the crab fishery plays *the* central role in the port fishery connectivity networks, meaning that any access shift to the fishery would impact the entire port in which the fishery is embedded. While not directly studied, this likely holds true in Oregon's other major crab ports, specifically Coos Bay/Charleston and Astoria. Results from Fuller's study were mirrored by lived experiences shared by Oregon fishermen in who expressed significant stress and frustration around DA related delays and closures in this study. These findings suggest high reliance on the fishery with few opportunities to minimize risk through diversification in winter months, these factors may lower crab fishery resilience in the face of increased DA producing HAB's.

If factors of resilience are low in Oregon's Dungeness crab fishery, what does that mean for Oregon port community vulnerability? Adger (2006) characterizes social vulnerability as a combination of exposure to change, sensitivity to that change and the ability to adapt and maintain in reaction to that change. Findings from this Oregon-based study suggest that port communities may rely on the fishery economically, particularly in winter

months when tourism is low and most other fisheries are not operating. The 2018 study on community impacts of HAB's by Ritzman *et al* suggests that crab fishery closures alter more than the fishery itself, creating a ripple effect across socio cultural and economic realms in the two communities they studied.

Identifying Need for Future Work

Both this study and the Ritzman *et al* study (2018) are exploratory in nature and investigate perceptions of change in fishing communities and port communities. Together these studies they have identified a need for resilience and adaptive capacity building across both communities. Both studies utilized quantitative economic and social vulnerability indices developed Jepson and Colburn (2013) and NOAA (2016) to identify community relationships to the commercial fishing industry. Needs were identified through qualitative findings that showed evidence of disproportionately high community of place and community of interest dependence on the crab fishery. The Ritzman (*et al)* study was structured as a case study in two communities, one in Washington and one in California. The article serves as a methods paper that may be referenced by future researchers who are looking to gather this type of information from individual communities, results show how this type of data could helpful for decision makers. Data was collected through semi structured interviews (15 per location) focused specifically around HAB related changes, impacts and future concerns (Ritzman *et al* 2018).

In contrast, data was collected for this study though interviews conducted as a part of a multi-year OSU "graying of the fleet" research project across all major port communities in Oregon. Unlike the Ritzman *et al* (2018) study, this study had a wider focus, touching on perception of change in community, commercial fisheries and the environment. Because findings in this study were broader both in geography and subject matter, crab specific themes meant to show general perceptions across the state, and are not representative of specific port communities. Despite differences in site selection and interview question, similar themes around community connection to crab, and ripple effects from closures emerged in both studies. Parallels between the two studies point to potential roadblocks in community and crab fishery resilience across the US West Coast range.

Moving forward

As of 2018 there are no standardized strategies that regulatory agencies use to examine and describe impacts of DA (and other HAB related) closures on human systems. In a 2006 article Bauer proposed a three part strategy to 1) Identify baseline information on communities, 2) Create rapid assessment tools to be used during closures, and 3) Identify government and regulatory "game plans" in response to closures (Ritzman *et al* 2018; Bauer *et al* 2006). In line with part 1, NOAA calculated community reliance, engagement and dependence on the crab fishery by port community in response to DA closures across the US West Coast. Results are unpublished as of 2019, but show varied levels in each category across the geographical fishery range. Next steps may include site and region-specific studies to identify locally appropriate action and the development of rapid assessment strategies. Results from these studies could provide information on how different communities respond to change and identify unique needs across the geographical span of the fishery. Understanding individual community needs may aid in creating more effective management plans beyond toxicity identification and zone closures that are currently in place.

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Chapter Four: Conclusion

Fishermen and the port communities in which they are embedded are accustomed to change in the form of unpredictable weather conditions, natural cycles and elevated risk inherent to the nature of the commercial fishing industry. However, a conglomeration of external forces related to rapidly shifting ocean conditions, shifting social structures and evolving management directives present additional factors of change that are challenging resilience and adaptive capacity of these port and fishing communities (Lyons *et al* 2016).

The two studies reported in this thesis contribute to a growing body of research examining how policy, management and environmental changes in commercial fisheries impact communities of place and interest. Findings from these studies are applicable to policy integration efforts as required by the MSA National Standard 8, NOAA directives and a movement towards ecosystem based management structure that looks at fisheries as coupled human-natural systems. Research conducted for US fishery policy considerations strives for stronger social science integration, contrasting sharply with historical fisheries-related decision making processes that only marginally considered fisheries as a coupled human-natural system (Lyons *et al* 2016). Social science contributions to fisheries management are particularly valuable for informing ways to improve communication between stakeholders, ground-truthing the validity of NOAA's quantitative indices and developing social indicators in communities of place and communities of interest (Lyons *et al* 2016; Carothers 2012; Blount *et al* 2015).

Manuscript 1

Chapter 2 investigated differential graying trends among four of Oregon's major commercial fisheries. Although other major fisheries such as pink shrimp (*Pandalus jordani)* are heavily prosecuted in the state, the focus of this study was on albacore tuna, salmon, groundfish and Dungeness crab because these fisheries were discussed most extensively by

research participants. Clear differences in graying trends between these four fisheries emerged through the process of analysis. In particular, research participants noted clear graying trends in the salmon and groundfish fisheries, whereas sustained age interest was reported in Albacore tuna and crab fisheries.

Participants interviewed traced graying trends in the salmon and groundfish fisheries to management shifts in response to stock decline. A quota system was implemented in federally managed West Coast groundfish fishery in 2011 to combat overfishing and high bycatch rates. While bycatch rates have decreased species abundance is on the rise and fishermen's safety has improved (NOAA 2016), the management transition has barriers to entry for incoming fishermen and has added expenses to those already prosecuting groundfish (NOAA 2017). Graying studies conducted in Alaska have linked quota transitions to decreased employment opportunities and adverse social impacts in port communities over time (Carothers 2008; Carothers 2015; Koslow 1982). This study suggests a potential for similar community and fishery impacts in Oregon as time goes on.

Participants noted a stark difference between past and current salmon fishing opportunities. The salmon fishery was historically easy and inexpensive to access and was well suited for single or family businesses, but is now experiencing aging trends in response to species population decline. Participant perspectives were unsurprising given that West Coast salmon populations have decreased substantially over recent decades. 17 Pacific populations have been listed as either threatened or endangered (Otto *et al* 2016). These declines have prompted managers across the US West coast to heavily restrict or close fisheries intermittently over the past 30 years (Otto *et al* 2016).

Interview participants viewed the Albacore tuna fishery as easily accessible, lively and engaging. Because it is open access, this fishery does not experience economic and access-related entrance barriers in quota and limited entry systems. Aside from frustration cited by some fishermen around lucrative marketing opportunities, tuna fishery participation was considered to be healthier than groundfish or salmon, and reasonably desirable for both current and incoming fishermen.

Themes that emerged around the crab fishery indicate high interest in participation due to type of work, ease of entry and income potential. This fishery stood out as particularly

economically important because of fishery value and time of season. As a winter fishery, crab brings an influx of money into port communities during an otherwise slow time of year. Although ownership positions in this fishery are expensive to obtain, the major barriers to fishery access were the many closures and delays since 2015 in reaction to the toxic effects of harmful algal blooms, an occurrence that scientists expect to increase as climate change progresses.

Manuscript 2

A year-long transdisciplinary project examining climate change-related distribution shifts of Crab across their West Coast range revealed that the population is expected to shift northward by roughly two degrees in response to warming sea surface temperatures (SST). Although Crab abundance in Oregon is not expected to be impacted by this particular climate change-related factor, crab in the area are likely to experience increasing levels of domoic acid (DA) toxicity from harmful algal blooms tied to warm phases of PDO and ENSO (COST 2016). Even though it does not impact crab health, DA accumulation in meat and viscera presents significant risk to bird and mammal predators of Crab, including humans (McKibben et al. 2017). Since 2015, state fishery management has responded to increased DA "events" through fishery closures and delays, which have already created income and employment barriers to communities of fishermen targeting the species (ODA 2015).

Themes that emerged through analysis of interviews with port community members and fishing communities found that the crab fishery is unique in its role as an economic and employment connector across Oregon. The fishery is usually the most economically important single species fishery in the state and operates as a winter fishery, bringing considerable income into communities in a time of year that other major fisheries and tourism opportunities are at a low. These factors of importance indicate high engagement and reliance on the fishery across port communities studied, so increasingly limited access to the fishery could create a deficit in social, economic and employment realms.

The impacts of declining access to the Crab fishery in response to HAB's has been a focus of policy and scientific study on the West Coast since 2015 (ODA 2015). In an effort to initiate an understanding of community connection to Crab, NOAA adapted a (currently

unpublished) engagement and reliance study specific the West Coast community connections to the fishery. Ritzman *et al* (2018) utilized NOAA data and conducted a place based resilience study in two communities (CA and WA), the results of which can function as a methods article for further studies across the Crab range. Although research methods differed, the findings from this Oregon based study were similar to themes that emerged from the CA and WA case study (Ritzman *et al* 2018). Both identified a need for identifying community connections to the fishery via stakeholder perspective before creating a framework for building community resilience.

Both parts of the research for this thesis utilized interview data conducted over a four-year period across Oregon port communities. The studies aimed to distinguish possible participation differences between fisheries (1) and investigate community connections to the crab fishery (2). Southern and Central Oregon port communities were well represented in interviews, but northern communities like Astoria and Garibaldi were not. These datasets were adequate for the stated research objectives since fishery specific connections across the state were investigated instead of port-specific connections. However future projects would benefit from additional interviews in northern port communities.

Another gap, in interview data utilized, was a lack of information on other major fisheries prosecuted in Oregon including pink shrimp, urchin, halibut, black cod and whiting. Pink shrimp and halibut fisheries were mentioned by some participants, but not enough to form significant themes representative of participant perspectives. Interview participants stressed that the average fisherman's income is diverse, achieved either through prosecuting multiple fisheries or running other jobs during "off" seasons. This economic diversification complicates "graying" results because most fishermen interviewed did not identify with only one fishery.

Despite the levels of complexity it adds to analyzing data in this study, the major theme of diversification between fisheries points to reduced risk for fishermen and fishing communities as compared to areas that target only one or two major fisheries. As coupled human-natural systems, each fishery experiences unique cycles associated with oceanographic conditions, biological health and even market value (Cline *et al* 2017). A larger portfolio of fisheries targeted enables fishing businesses and their port communities to more easily absorb

the impacts of interannual changes inherent to the commercial fishing industry in the face of access change (Fuller *et al* 2017; Kasperski & Holland 2013; Cline *et al* 2017). A community that is economically diversified enough to reorganize when access to one or two fisheries declines demonstrates higher factors of resilience (Cline *et al* 2017; Folke *et al* 2010; Walker *et al* 2014).

Even though interview participants did report relatively high portfolio diversity, many expressed concerns around increasing barriers to entry in some fisheries that could diminish the opportunity to maintain economically diversified businesses. These participants expressed that the quota transition in the groundfish and whiting fisheries greatly reduced ease of entry in all positions of the fishery. This feedback is unsurprising given that rationalization is designed to consolidate the number of fishing vessels active while increasing overall productivity and flexibility for remaining quota holders. Because they represent a portion of a fishery's total allowable catch, number of quota available are finite, and those that are available are expensive to purchase. Interview participant concerns are valid, particularly since quota systems that now encompass all of Alaska's federally regulated fisheries have resulted in "graying" trends and out migration of permits from port communities, altering economic and social dynamics across port communities (Donkersloot & Carothers 2016). Although groundfish and whiting are the only quota fisheries currently operating in Oregon, decreased participation opportunities in this fishery could lead to increased pressure on more easily accessible fisheries, increased unemployment rates in fishing communities or an outmigration of working-age adults.

Future Need and Recommendations

Findings reported in this thesis support conclusions from related graying studies; the graying of the fleet phenomenon is closely tied to access shifts in ocean conditions, fisheries and social structure, which have created a need for coastal communities and the commercial fishing industry alike to increase factors of resilience and adaptive capacity. Social science roles are a key to success in management and policy decisions created in response to these shifts, and can improve communication between stakeholders, ground-truthing of NOAA's

quantitative indices and developing social indicators in communities of place and communities of interest (Lyons *et al* 2016; Carothers 2012; Blount *et al* 2015).

Both studies in this thesis contribute to the documentation of port community members and fishing community members perspectives of change related to the fishing industry in Oregon. Understanding stakeholder perceptions is an important starting point, but will not solve current policy, economic and social issues that Oregon's commercial fishing industry is facing. Similarly, NOAA's quantitative vulnerability, engagement and reliance frameworks designed to identify community need and connection to fisheries are not capable of facilitating gains in adaptive capacity and resilience.

Usable frameworks need to be developed that utilize emerging quantitative and qualitative datasets so human needs are more effectively integrated into policy and management decision making processes (Lyons *et al* 2016; Carothers 2012; Blount *et al* 2015). One qualitative-based framework was proposed by Lyons *et al* in 2016 created a qualitative tool that could be applied to beginning stages of the decision making in the commercial fishing industry called the "Means, Meanings and Contexts (MMC) framework. This framework utilizes ethnographic findings to create place-specific framework that consider unique place based economic reliance and historical connection to fisheries. Given the quantitative indices developed by NOAA, a mixed methods framework that integrates qualitative information (as in the MMC framework) and quantitative indices could capture intricate connections between fishery and community into a streamlined resilience action plan that managers can tailor to individual fisheries and port locations.

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Walker et al 2014

Appendices

Appendix A. Conway & Cramer: Using Oral Histories to Track Changes

Purpose. We want to understand the intergenerational fishing family business, the presence or absence of the "graying of the fishing industry," and any impact on community resilience. You've been identified as a research subject based on your participation in VFWC.

Activities. We want to listen to your oral history, as shaped through answering six broad questions, and compare your experience with the literature on this topic.

Time. The length of the oral history is up to you; they generally last anywhere from 30-90 minutes.

Risks. There are no possible risks and/or discomforts associated with being in this study.

Benefits. There are no direct benefits for participation; the benefit is that you get to share your stories and life histories on the VFWC website for the public to view.

Payment. You will not be paid for participation.

Confidentiality. The VFWC oral history recordings and transcripts will be made public upon unloading to the Voices from the Fisheries website. Participants have the right to choose anonymity or remove their associated oral history from the record at any time, but this rarely happens; most tend to take great pride in their stories and their participation. If a participant refuses to save their oral history interview placed on the website, their confidentiality will be maintained by de-identifying data gathered (although there is a small chance that we could disclose information that might identify the participant).

Voluntariness. Your participation and consent are voluntary. There is no penalty for choosing not to participate or for leaving the study at any time. You are free to remain silent on any topic. You may choose to take part in the VFWC oral history project and not this research project.

Contact Information: Flaxen Conway is the leader (541-737-1339); fconway@coas.oregonstate.edu) and Astrea Strawn and Bri Haugen are the student researchers (720-365-0442; strawnas@oregonstate.edu; 612-2106533, haugenbri@oregonstate.edu) on this project. The IRB at OSU oversees all research (531-737-8008)

Sponsor. This research is supported by NOAA and Oregon Sea Grant.

Appendix B. NOAA VFWC Consent Form

TO BE COMPLETED BY THE PERSON BEING INTERVIEWED

I, _____, am a participant in the Voices from the West Coast Project (herein "VFWC") of the National Oceanic and Atmospheric Administration's National Marine Fisheries Service, Northwest Fisheries Science Center (NOAA/NMFS/NWFSC), and inclusive of collaborators at the NMFS West Coast Regional Office (WRO), Oregon State University (OSU), Warrington High Fisheries Inc. (WarHF), and the Newport Fishermen's Wives (NFW). I understand that the purpose of the VFWC is to collect audio-and video-recorded oral histories of the United States of America and its territories' commercial, recreational, and subsistence fishermen and women, and those who support them, other community members engaged and with knowledge of environmental issues in their communities such as climate change, wave energy and other issues, scientists, and environmental manager, as well as selected documentary materials such as photographs for inclusion in the Voices from the Fisheries Database (hereafter "VFF DB"). The VFF DB is housed on NOAA/NMFS servers and will be accessible to the public through a website. These oral histories and related materials serve as a record of the Nation's commercial, recreational, and subsistence fisheries and as a scholarly and educational resource for NOAA and the general public.

I understand that NOAA/NMFS/NWFSC/WRO/OSU/WarHF/NFW plans to retain the product of my participation in the VFWC in digital form, including but not limited in my interview, presentation, video, photographs, statements, name, images or likeness, voice, and written materials ("My Collection") as part of its permanent collections in the VFF Database.

I also understand the VFWC and its partners plan to retain the product of my participation for potential use in a public display(s) on website(s), community festival(s), possible museum(s), and for other outreach and educational materials.

I hereby grant to NOAA/NMFS/NWFSC/WRO/OSU/WarHF/NFW of the physical property compromising My Collection. Additionally, I hereby grant to NOAA/NMFS/NWFSC/WRO/OSU/WarHF/NFW, at no cost, the perpetual, nonexclusive, transferable, worldwide right to use, reproduce, transmit, display, perform, prepare derivative works from, distribute, and authorize the redistribution of the materials in My Collection in any medium. By giving this permission, I understand that I retain any copyright and related rights that I may hold.

I hereby release NOAA/NMFS/NWFSC/WRO/OSU/WarHF/NFW and their assignees and designees, from any and all claims and remands arising out of or in connection with the use of My Collection, including but not limited to any claims for copyright infringement, defamation, invasion of privacy; or right of publicity.

Should any of my part of My Collection be found to include materials that NOAA/NMFS/NWFSC/WRO/OSU/WarHF/NFW deems inappropriate for retention with the collection of for transfer to other collections, NOAA/NMFS/NWFSC/WRO/OSU/WarHF/NFW may dispose of such materials in accordance with its procedures for disposition of materials not needed for NOAA's collections.

I hereby state that I am of legal age and competent to sign this release. I agree that this release shall be binding on me, my legal representatives, heirs, and assigns. I have read this release form and I am fully aware of its contents.

ACCEPTED AND AGREED
Signature_____ DATE_____
Printed Name_____
Name of Interviewer (if applicable)_____

Appendix C. Semi- Structured Interview Questions Used in Interviews

1. What was your first job in the fishing/processing industry?
    a. How did you get involved in the industry?
    b. How long have you been working in the industry, and how has you work changed over that time?

2. Which fisheries have you worked in?
    a. Which were the best for you?
    b. Which were the worst for you?

3. Have you seen any changes in the ocean or fishing over time?

4. What role has your spouse played in your fishing-related business and how has this changed over time?

5. What does fishing mean to you?
    a. What was the high and low of your career?
    b. What brings you the most joy and the most grief in this industry?
    c. What are your greatest hopes for fishing?

6. What role has your kid(s) played in your fishing-related business and how has this changed over time?

Appendix D. Semi Structured Interview Questions for Kids of Fishermen/Young Adults that Fish

1. What was it like to grow up in a fishing-related family business?
    a. What role(s) have you played and why?
    b. Has this changed over time?
    c. In what ways was growing up in a fishing family similar or different to other family businesses in town?

2. As a young adult currently involved in the fishing industry, can you share your perspective on what attracts young people to the industry?
    a. What are the three biggest motivators?
    b. What obstacles, if any, are there for young people to get into the industry? What are the three biggest barriers? Have these changed over time?

3. Are most fishing family kids OR young adult fishermen satisfied with their work in the commercial fishing industry? Why or why not?

4. What are some key skills and abilities that help you do your tasks in a fishing-related job?
    a. Are these skills transferrable to other jobs?

5. Can you talk about the kinds of places you live and work?
    a. Do you want to stay here or move somewhere else?
    b. Where do you see yourself in 5-10 years?

6. What would it be like if you or your family fishing business (or the one you work for) were sold?
    a. Would this have any impacts on the fishing community?

b. Would this have an impact on (PLACE) or other coastal communities?
c. Is there a “tipping point”? In other words, what would happen in (PLACE) if most (or all) of the fishing family businesses were sold?

Appendix E. Oral History and Interview Questions for Non-Fishing-Related Individuals

1. Tell me about your community (including demographics, businesses, specialization, technological, environmental and economic aspects of place.)

2. How economically and culturally important is the fishing industry to (PLACE)?

3. Have you seen a lot of intergenerational fishing-related businesses in (PLACE)?

4. There are data that indicate that the average age of commercial fishermen is in the 50's. In your opinion, has that always been the case, or is the fleet "graying"? What do you see in (PLACE) that agrees or disagrees with this?
    a. Why do young adults want to/do not want to get into the fishing-related businesses?
    b. What is, or might be the impact on the fishing community over time?
    c. Please share your thoughts about how this might ripple into supporting industries over time.

5. What is, or might be the impact of this in (PLACE) or other coastal towns?
    a. What are some potential (social, cultural, economic, environmental) impacts of graying?
    b. What are other options for careers for young adults in (PLACE)?
    c. Is there a "tipping point" for the impact of an aging fleet? In other words, what would happen in (PLACE) if most (or all) of the fishing family businesses were sold?