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Title: Informing and Enhancing Scientific and Management Understanding of Oregon's Nearshore Groundfish Trawl Fishery by Engaging Local Ecological Knowledge

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Oregon's Coastal nearshore ecosystems are a nexus between living marine resources and coincident human recreational, industrial and socio-economic development. These nearshore regions also provide habitats vital to early life history stages of commercial non-whiting groundfish species, which supplied 21% of the Oregon fishing economy in 2018. The very shallow portions of the Oregon Coast (the area of the shelf inshore of ~30fm (180 ft or 55m) have been the subject of little to no scientific survey monitoring, and much of the details of the ecology, health and processes in these habitats remain poorly understood. Furthermore, while the activity of the offshore Pacific Whiting (*Merluccius productus*) fleet and deeper water demersal fisheries have remained more consistent from 1976-present, the nearshore sector (which for the purposes of this thesis is defined as the region of shelf extending seaward to a water depth of 110 fathoms (200 meters or 660 feet)), has become increasingly underutilized by the Oregon commercial groundfish trawl fleet. This thesis assesses the potential for a more comprehensive reconstruction and understanding of broad-timescale trawl effort in the Oregon nearshore to be extracted from the combined knowledge of the commercial fishing community, fisheries managers, and fisheries scientists. By better defining what has impacted Oregon's small nearshore fleet members, this thesis explores whether the collective experiences of fishermen in the nearshore sector through time may contribute local ecological knowledge (LEK) to lesser-studied groundfish fishery habitats in Oregon. Fisheries-dependent data were collected in the form of commercial trawl logbooks, fishticket landings, and industry interviews and assessed using mixed quantitative and qualitative methods. Results expose the nearshore sector of Oregon's groundfish trawl fishery as a niche fishery recovering from a 20-year period of management reform and fisheries rebuilding. Less tangibly, it recognizes the self-contained identity of a small, specialized subset of the broader Oregon groundfish trawl fleet, whose endemic knowledge and experiences of the nearshore shelf prove valuable to reconstructing the history and social-constructs of the unique nearshore ecosystem. The experiential knowledge and consistency in exposure of the nearshore groundfish trawl fleet offer a detailed and long-standing record of the drivers and health of the groundfish fishery both spatially and temporally. Findings from this research provide an opportunity to utilize LEK to augment scientific ecological knowledge (SEK). Adopting the LEK and contacts established within the Oregon nearshore groundfish fleet from this thesis establishes a baseline for ongoing conversations, cooperation and prospective collaboration among scientists, fisheries managers and fishermen moving forward.

Informing and Enhancing Scientific and Management Understanding of Oregon's Nearshore Groundfish Trawl Fishery by Engaging Local Ecological Knowledge

by
Anja J. C. Sjostrom

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1.1 Introduction

Industrious commercial fishing communities and their experiential knowledge of the ecosystems along Oregon's populated coastal regions continue to captivate academic and agency research attention. Such research efforts are mandated by the demand for the integrated knowledge of many experts from science, management, policy and industry to promote the comprehensive health and understanding of complex multi-use fisheries. In 2018, commercial fisheries in Oregon generated $151 million and supported an estimated 1310 jobs (State of Oregon Employment Department, 2019). While the Dungeness Crab (*Cancer magister*) and Pink Shrimp (*Pandalus jordani*) fisheries occupy significant percentages of these earnings, the West Coast groundfish fishery is also a consistent contributor to the local economy (Gann, 2019; Shaw & Conway, 2007). For a fishery managed across the diverse marine ecosystems of California, Oregon and Washington, the task of maintaining a consistent and thorough awareness of the utilization and health of the groundfish fishery is no small feat. Subsequently there are apparent gaps in the knowledge of its historical usage by the commercial trawl fleet, particularly in the nearshore region. The Oregon Department of Fish and Wildlife (ODFW) defines the nearshore as "…the area from the coastal high-tide line offshore to the 30 fathom (180 feet or 55 meter) depth contour...," which has been broadly adopted by regional science and management communities as well (Oregon Nearshore Strategy, 2016; Haven, 2019; Pearcy, 1978; Sobocinski et al., 2017). The narrative of the nearshore which emerges from the fishing community and broader management however, is less concrete. Therefore, to best incorporate multiple stakeholder understanding and use of the nearshore given established spatial and temporal records of the trawl fleet the Oregon continental shelf region (Bellman & Hepell, 2005 & 2007; Lee & Sampson, 2000), this study adopts a definition of the nearshore which extends 200 meters (or 110 fathoms) and shoreward.

Innovations to better comprehension and sustainable development of often fragile and dynamic fisheries commodities present opportunities to collaborate and integrate new knowledge into the management conversation (Haven, 2019). Recent literature has identified combining unique scientific ecological knowledge (SEK) and local ecological knowledge

(LEK) sources as a potential method to augment understanding of terrestrial and coastal resources and fill gaps in spatial and temporal monitoring (Mackinson, 2001; Sampedro et al., 2016; García-Quijano, 2007, Kupika et al., 2019, Cook et al., 2014; Beaudreau & Levin, 2014). SEK is construed as systematic knowledge accrued via the scientific method and established principles of study whereas LEK describes knowledge of a particular group of individuals about local ecosystems, and their interactions and cultural practices with their environment (Raymond et al., 2010). For coastal regions, the LEK of fishermen has been described as an accrued knowledge surrounding fisheries and the environments they exist within which has been developed by industry participants and their families (Berkes, 1993, 1999; Freeman & Carbyn, 1988; Johannes, 1981; Neis & Felt, 2000; Murray et al., 2006). In addition to narrative LEK, commercial fishing logbook and fishticket data have been found to offer valuable insight into fishery harvest rates, fleet dynamics, and the spatial distribution of targeted fish species (Lee & Sampson, 2000). Moreover, they present an additional source of resource monitoring and dialogue between fishing communities and scientists (Macomber, 2000). The SEK considered for this work are the fishery-independent surveys and accumulated body of scientific research literature from studies on Oregon groundfish species and habitats, including documents compiled from the Groundfish Management Team (GMT). The LEK comprises the Oregon trawl logbooks, fish tickets, interviews with fleet members, and processors. Fisheries-dependent catch and effort data can elucidate potential habitat degradation, while supporting a heightened understanding of how compounded ocean climate condition variability, management regime shifts, gear and vessel adaptation and extraction influence long-term target species adaptability and fishery resilience (Bellman et al., 2005; Miller et al., 2017).

Studies incorporating a broad-scale temporal assessment of commercial trawling and fish assemblages in the Oregon nearshore groundfish fishery are scarce. Furthermore, efforts to collectively understand a complex fishery utilizing combined LEK of the surrounding fishery community only moderately applied to the Oregon Coast. The dearth of research in Oregon's nearshore regions stem from limited monitoring in the areas shoreward of 55 meters or 30 fathoms (Pearcy, 1978; ODFW, 2017), and constraints posed by insufficient funding for scientific and management parties to consistently execute new or ongoing surveys. Since the mid 1970's, Oregon commercial bottom trawl logbook data have been collected by fishermen in the industry and maintained and managed by OFDW. These logbook data present a high degree of spatial and species resolution as well as the benefit of large sample size and consistency in year-round availability. Frequently under-represented in the literature, these valuable fisheries-dependent data can offer insight into seasonal and interannual variability in both harvest-effort and trawl distribution, as well as historical species composition (Lee & Sampson, 2000). Synthesizing these often-underutilized data sources in a manner which allows the opportunity to combine them with regional SEK offers a prospective augmented information stream to the deficit of historic scientific monitoring of the nearshore.

Coastal sedimentary habitats like those found along the Oregon nearshore are complex ecosystems which provide important habitats for many valuable commercial demersal fish species (Pearcy, 1978; Sobocinski et al., 2017). Regionally, the West Coast groundfish fishery includes over 90 different species which associate commonly with bottom habitats, many of which are known to use coastal nearshore and estuarine habitats as nursery areas for newly settled or settling juvenile fishes (Krygier & Pearcy, 1986; Hughes et al., 2014; Sheaves et al., 2015; Haven, 2019; PFMC FMP, 2016). The groundfish fishery and diverse fishing grounds are exposed to multiple uses recreationally, tribally and commercially, with a commercial groundfish trawl fishery which operates broadly in two sectors: whiting and non-whiting groundfish (PFMC FMP, 2016). While the spatial and temporal trends of the offshore groundfish fleet have been broadly assessed in recent literature (Mamula & Collier, 2015; Warlick et al., 2018), particularly given highly successful management and recovery, the nearshore sector of the non-whiting fleet remains largely overlooked. Despite ODFW's introduction of a fairly comprehensive nearshore strategy plan for management in 2016, scientific and management monitoring of the nearshore area remains in its nascent stages (ODFW Nearshore Strategy, 2017).

This thesis explores whether a comprehensive reconstruction and understanding of broad scale temporal trawl effort in the Oregon nearshore can be extracted from the combined knowledge of the commercial fishing community; knowledge that incorporates rich fisheries-dependent data in the form of commercial trawl logbooks, fishticket landing documentation, and personal and community experience and perception. The combination of these sources provides a unique and exciting opportunity to inform regional understanding and management by applying LEK research to compare and bolster a wealth of SEK in the form of scientific trawl surveys and research. Ultimately it provides an ideal setting to examine the potential for a cooperative approach to stakeholder engaged management and use of nearshore ecosystems.

1.2 Research Parameters & Data Coverage

Nearshore Trawl Fishery Region & Constituents

Within the confines of this research, the Oregon nearshore groundfish trawl fishery is defined as all habitat extending from the high tide line to the 110 fathom or 200-meter depth contour, incorporating both state and federally managed waters (Figure 1.1). Because this study broadly incorporates fisheries-dependent data and LEK from the commercial groundfish trawl fleet, depths are frequently discussed in fathoms. Considering the nearshore out to the 200-meter depth parameter served as an appropriate way to encompass the inner-shelf fishery as it is frequently defined by various stakeholder groups. Given the integration of ODFW bottom trawl logbooks as a significant data component to this study, the gear of focus was also refined to solely bottom trawl configurations including the ODFW logbook classifications of large-diameter footrope gear, small footrope (sole net), unspecified bottom trawl and selective flatfish trawl gear. Integral participants of the nearshore groundfish fishery community include the Pacific Fisheries Management Council (PFMC), which operates under the

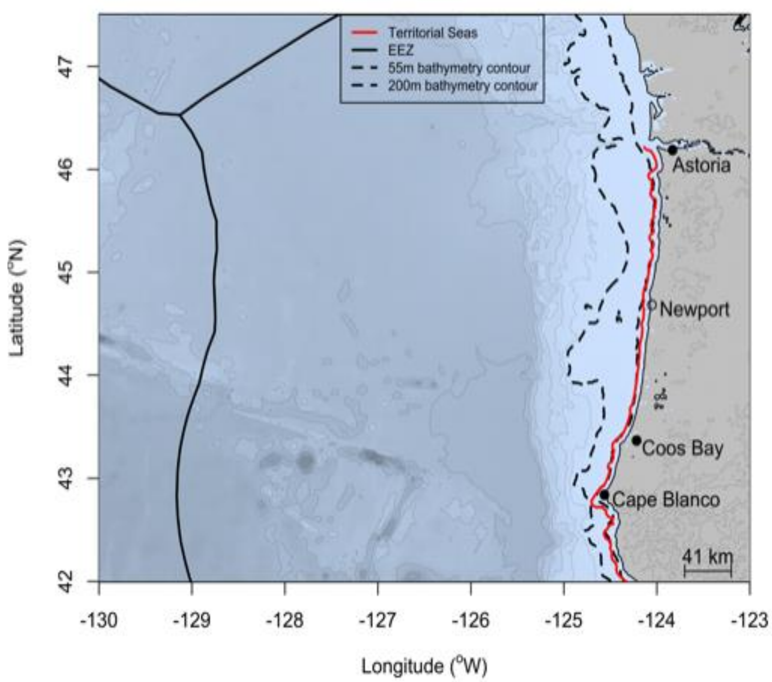

Figure 1.1 Map of Study Area
Oregon's 12 nm territorial sea (red), U.S. 200 nm Exclusive Economic Zone (EEZ) (black) and continental shelf region indicating the 200 meter (110 fathom) and 55 meter (30 fathom) depth contours of the study region from Cape Blanco to Astoria, Oregon.

Magnuson-Stevens Fishery Management and Conservation Act (MSA) National Standards to generate and adapt the regional Fishery Management Plan (FMP), and the National Marine Fishery Service (NMFS) who in turn approve and regulate the FMP. It also comprises the state of Oregon, which adheres to the management of federal FMPs with the authority to exercise species specific measures where the state finds more conservative approaches necessary (ODFW, 2015). Lastly, the commercial trawl fleet, major fishing ports and processing infrastructure from Cape Blanco to Astoria, Oregon are an inherent part of this nearshore fishery community. The interviews and analysis of the logbooks was confined to vessels and participants of the fishery who fished specifically within the defined Oregon nearshore. These individuals make up what for the duration of this project will be referred to as Oregon's nearshore groundfish trawl fleet.

1.3 Historical Context & Rationale

The rationale and historical review which follow are intended to incorporate principal aspects of the management, oceanographic and ecological characteristics of nearshore fish assemblages and fleet dynamics which have shaped the nearshore groundfish trawl fishery in Oregon through space and time. The research which stems from this summary will focus largely on the periods of 1981-present. It is, however, imperative to address critical historical events which have supplied the incumbent foundation for the West Coast groundfish fishery and which will continue to emerge as an undertow in this work. For this thesis, the results and materials assessed will progressively be cultivated within the context of science, management and groundfish industry stakeholder perspectives. Ultimately this setting aims to establish a framework which allows for an exploratory application of LEK to the Oregon nearshore groundfish trawl fishery.

1.3.1 Regional Context: Oregon's Nearshore Groundfish Trawl Fishery

Oregon Marine Fisheries Management Plan

ODFW amends and implements the management of Oregon's marine fishery resources, which include many stocks under the fisheries management plan (FMP) with the exception of a few nearshore species managed exclusively by the state (e.g., Blue Rockfish (*Sebastes mystinus)* and Blue Rockfish (*Sebastes melanops*)). The Oregon Marine Fishery Management Plan (MFMP) was recently expanded to include a more detailed strategy for the management of the nearshore ecosystem, focusing on identifying and rectifying gaps in the understanding of processes and impacts within this unique component of Oregon's larger natural resources. The urgency for this plan arose from a lack of monitoring of coastal areas less than 30 fathoms from shore, exposing a concerning gap in awareness of bathymetry, habitat and biological assemblages as well as risk of perturbations from natural environmental variability and anthropogenic impacts (ODFW, 2017). Foundationally, the nearshore agenda outlines a series of goals directed at improving communication and partnerships, generating stronger science and information, and constructing a better decision-making process to promote the participatory sustainability efforts of this resource for its diverse coastal stakeholders. This thesis aims to establish valuable connections with the historically present groundfish trawl fleet, whose knowledge and use of the coastal shelf region may assist in understanding and socioeconomic the value of the nearshore.

Nearshore habitat & commercial fish species

The Oregon nearshore and estuarine shelf areas are dynamic nutrient rich upwelling ecosystems critical to the early life history stages of many important commercial groundfish species (Beck et al., 2001, 2003; Sheaves et al., 2015; Haven, 2019). The nearshore coastal habitat is largely comprised of unconsolidated mud and sand sediment deposited to the shelf and slope by coastal rivers, as well as seasonally exposed hard bedrock features and other biogenic structures (Goldfinger et al., 2003; PFMC Appendix C Part 2, 2019; Romsos et al., 2007). In addition to sediment mobility caused by waves, ripples and seasonal upwelling activity which drives biological productivity and redistribution (Goldfinger et al., 2003; Kulm et al., 1975; van de Velde et al., 2018) these regions are prone to extensive sediment resuspension and transportation when impacted by bottom trawl gear (Kaiser et al., 2002, 2010; Auster & Langton, 1999). Loss of habitat complexity, disturbance of foraging grounds and prey species have all motivated MFMP monitoring and constraint of fishing activities which pose concerning impacts to fishery resources, including the employment of seasonal or spatial closures, and gear restrictions to fishing behavior (ODFW MFMP, 2015). While efforts in the area of long-term spatial and temporal monitoring of these habitat impacts and recoveries are improving (PFMC, 2019; Hixon & Tissot, 2007; Kaiser et al., 2006; Hannah et al., 2010), there is still a need to better understand the enduring impacts of trawling on these habitats, particularly post EFH and RCA area implementation. Given the use of the nearshore region as nursery habitat for many species of rockfishes and flatfishes prior to transition to offshore rocky reef during their adult stages (Krygier & Pearcy, 1986; Gallagher & Heppell, 2010), conservation and monitoring of these sensitive regions is vital to the preservation of commercial stock health (Fiksen et al., 2007; Haven, 2019). Vulnerability to fishing disturbance has been shown to be habitat specific, with declining stability in areas of greater complexity (biogenic and harder substrate) (Kaiser et al., 2006; Auster & Langton 1999; Bellman, 2004). There is, however, some debate over recovery times for soft sediment habitats, as some research has indicated greater vulnerability than others (Collie et al., 2000; Kaiser et al., 2006), necessitating better assessment of these areas temporally.

The assemblages of fishes found within Oregon's nearshore shelf include a mixture of bony and cartilaginous species. The logbook subset utilized to assess the nearshore groundfish trawl fishery contained a total of 39 species codes, grouped within FMP management categories including 18 species of rockfishes (*Sebastes species)*, 12 species of flatfishes (*Pleuronectiformes*), 5 species of Roundfishes, 3 species groups of Elasmobranchs (Sharks and Skates), and an Other category for Pacific Grenadier (*Coryphaenoides acrolepis*) (Love, 2011; PFMC FMP, 2016). Many of these commercial species associate with nearshore habitat features at varying depths and degrees. Extensive research along the Oregon shelf describes the spatial delineation of assemblages (Hixon & Tissot, 2007; Keller, Wallace & Methot, 2017; Beck et al., 2001; Keller et al., 2012; Keller et al., 2008) into a higher diversity deeper water group (148-195 meters) and shallow water group (74-102 meters), which was dominated by 86% Pacific Sanddab at the time (*Citharichthys sordidus*) (Pearcy, 1978; Krygier & Pearcy, 1986). Scientific sampling conducted along Oregon's shelf have identified the use of nearshore waters and estuaries as nurseries for English Sole, Butter Sole, Pacific Sanddab, Speckled Sanddab, Dover Sole and Sand Sole in particular (Haven, 2019; Pearcy, 1978; Krygier & Pearcy 1986). These scientific surveys have not extended further inshore than 30 fathoms/55 meters to assess very nearshore species composition. Additionally, the sampling gear used was described as inefficient in retaining species outside of the flatfish group, thus presenting limitations in biomass estimates (Pearcy, 1978). Higher resolution in commercial catch composition and LEK of nursery areas is important for the continued management and health of nearshore groundfish fish assemblages (ODFW, 2017; Haven, 2019).

In the time since the 1970's the Oregon Coast has seen substantial variability in climate and oceanographic conditions for which the impact on coastal fish assemblages is still not widely understood. In the period considered for this study (1976-present) the Oregon Coast has experienced several El Niño events in 1982-1983, 1997-1998, and 2015-2016 (McClatchie et al., 2016), a major swing in the Pacific Decadal Oscillation (Mantua et al., 1997), hypoxia events (Chan et al., 2008) and the presence of an anomalous coastal warm blob (Bond et al., 2015). Seasonal and interannual variability in Northern California Current (NCC) shelf ecosystems like those found along the Oregon Coast are coupled with an interactive overlap with marine resource use in nearshore areas (e.g. marine renewable energy, shipping, recreation), thus experiencing increasing levels of perturbation (Halpern et al., 2008; Boehlert et al., 2007; Haven, 2019; Chan et al., 2008; Peterson et al., 2013). Combining LEK and SEK for this period may provide enhanced understanding of past assemblage shifts in response to oceanographic conditions and anthropogenic influence, and a more detailed insight into present impacts within the nearshore.

Trawl Gear

Trawl gear deployed in the Oregon nearshore consists of conical nets towed behind vessels either on or off bottom in the form of roller, bottom or mid water trawls. Trawl gear is typically tailored to individual vessels, targeted catch complex, fishing depth and bottom type, but may display varying levels of complexity amended to catch or avoid specific target species of fish (PFMC FMP, 2016). Since the 1990's the PFMC has worked with fleet members to test adjustments to maximize exclusion of juvenile or protected species bycatch through the EFP program. Management restriction of

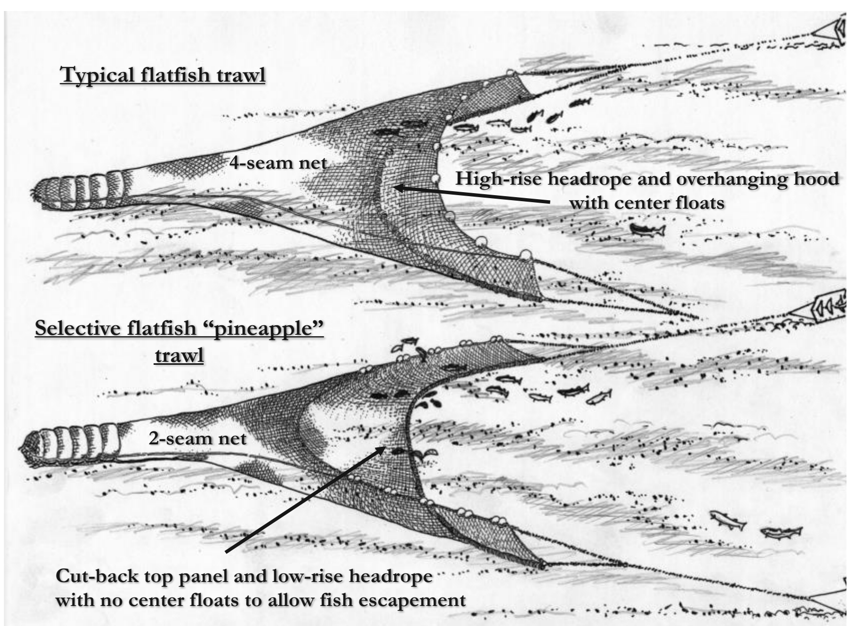

Figure 1.2 Typical vs. Selective Flatfish Trawl Diagram
Rendering of typical vs. selective flatfish (or "pineapple") trawl configurations detailing major components of the gear types. Adapted from ODFW.

trawl gear type has been focused largely on the shelf and nearshore, as 6 of the 8 overfished groundfish stocks are known to associate commonly with the habitat in these areas.

Large-diameter footrope gear was prohibited beginning in 2002, and the mandatory use of selective flatfish trawl gear (Figure 1.2), which is designed specifically to avoid catch of rockfishes began in 2005 (Figure 1.2). Hannah's (2003) evaluation of West Coast bottom trawl effort from the years 1992 to 2001 in areas deemed prime trawlable rockfish habitat revealed adjustments in spatial distribution of effort based upon gear restrictions implemented by changes in management. These changes in trawl effort occurred predominately when the maximum trawl footrope-diameter and rockfish catch limits were tightened, and effort increased when bycatch limits on yellowtail rockfish were higher (Hannah, 2003). These findings indicated an intricate relationship between both gear and catch limits which should be further examined. Managers attempt to moderate mobile gear types via consistent assessment of the gear impact on target fish species, and research continues to advance regarding the negative impacts trawl fishing gear elicits on the economic value of fisheries long-term (Watling et al., 1998). Exploration of logbooks in this study aims to further expose temporal trends in trawl gear preference relating to both efficiency and management and potential for habitat contact for the groundfish fishery.

1.3.2 **Qualitative Research in Fisheries**

Fleet & Local Ecological Knowledge

Warlick et al. (2018) found that constructing and adapting fisheries management plans for highly dynamic multispecies fisheries like the U.S. West Coast groundfish fishery is greatly enhanced by the use of historical reconstruction of management measures parallel to observed internal industry variability. Using a multi-dimensional approach promotes the generation of subsequent careful assessment of both socioeconomic and biological implications that changes in policy, environmental conditions and market inflict upon ecosystem, stakeholders and participants (Warlick et al., 2018). Though West Coast groundfish has been the focus of much natural and social science research to meet the needs of conservation and fishery community alike, the nearshore history of this fishery has remained largely overlooked (ODFW, 2017; Keller et al., 2017; Bellman & Heppell, 2007). Better understanding of how management measures and changes in the industry have impacted this fishery would encourage the inclusion of this smaller sector of the nearshore groundfish trawl fleet into the research and management agenda.

Specifically, the LEK of an individual fisherman emerges from a particular circumstantial context and may be an amalgam of perceived interaction with intergenerational knowledge, media, gear, management and scientists and peer or source insight and shared information. This LEK has been found to demonstrate a non-uniform spread of knowledge (Murray et al., 2006), highlighting the importance of the collective experiences in exploring events in fisheries LEK.

For regional FMCs and state management agencies, maintaining the MSA mandated "best available science" standards can be a factor which limits the punctuality and thoroughness of data analysis and adoption into management measures (Kirkley et al., 2001). In a fiscally challenging landscape, innovations to incorporate existing or underutilized data sources such as LEK to inform resource status, and the mandated integration of human dimensions considerations of National Standard 8 in the MSA have led to increasing social science efforts in fishing communities (Moon & Conway, 2016; Miller et al., 2017; Barclay et al., 2017). Research design which facilitates connection between the scientific community and fishermen in a cooperative setting has gained momentum as a solution to accelerating and enhancing the flow of information to management and policy, and feeding benefits back to the community (Conway & Pomeroy, 2006; Hall-Arber, Pomeroy & Conway, 2009). The adoption of cooperative fisheries research is widespread, and there are marked benefits to encouraging this to expand into a more collaborative research technique, wherein an enhanced degree of involvement in the shared benefits, capacity to conduct research, delegation of power, engrossment and investment can be obtained (Read & Hartley, 2006; Hartley & Robertson, 2008; Conway & Pomeroy, 2006). In the fisheries management and research landscape, there is a trend towards stock and ecological data collection, necessitating further integration of social science approaches to engage the human dimensions of fisheries systems (Hall-Arber et al., 2009; Russel et al., 2014).

1.3.3 **Broader Context: National Fisheries Policy & Management Dissemination**

Foreign Fleets

From a domestic economic standpoint, the West Coast groundfish fishery was not recognized as one of significant value prior to the codification of the MSA of 1976

(Mansfield, 2001). Rather, the West Coast of North America provided a historical backdrop for a large-scale fisheries prosecution effort by foreign venture fleets, the most significant of which were comprised of vessels from the former U.S.S.R and Japan. Operating heavily in the Bering Sea and extending as far as Southern Oregon, these large factory trawlers targeted groundfish stocks at rates which far exceeded United States (U.S.) and Canadian fleet harvest levels and processing infrastructure (Alverson et al., 1964; Finley, 2017). Though the Submerged Lands Act of 1953 entitled coastal states to natural resource commodities such as fish, minerals, oil and gas within 3 miles of their respective coastlines, concern over mounting foreign extraction rates served as the impetus for better regulation of domestic resources (43 U.S.C. §§ 1301 et seq.). From official Central Intelligence Agency documentation in 1976:

> *"In the future, the likely imposition of a 200-mile limit will restrict Soviet access to prime fishing grounds off the Atlantic and Pacific continental shelves, where 90% of the world's ocean catch is taken. The combination of the increased conservation measures and the possibility of access to traditional fishing grounds will force Soviet operations into less productive seas, which contain fish not normally desired by consumers." (CIA, 1976).*

Research has shown that concerns over overcapitalization of foreign fleets and the decimation of U.S. coastal resources ultimately served as the catalyst to fisheries reform in the U.S.. (Teclaff, 1967).

Magnuson-Stevens Fishery Conservation & Management Act

The initial iteration of the MSA in 1976 ushered in the progression of U.S. fisheries governance, establishing 8 regional fisheries management councils (FMC) and formatting a unifying framework for subsequent national fisheries policy development. Though conservation of biological resources was an essential component of this first institution, there was weighted focus on the economic advancement and growth of the domestic fleet. The "Americanization" of the fleet and increased capacity within the 200 nautical mile U.S. exclusive economic zone (EEZ) established by President Reagan in 1983 drove up harvest rates substantially, and ultimately incited the need for further amendment to ensure continued productivity and health of overfished stocks (National Research Council, 2014). The 1996 Sustainable Fisheries Act (SFA) specifically demarked overfishing and the steps to remediation. It designated the Secretary of Commerce as proprietary to determining rebuilding plans with regimented timelines for stocks considered at risk with FMCs (Hsu & Wilen, 1997). The SFA was also pivotal in tasking the FMCs with the designation of

Essential Fish Habitat (EFH) as pertaining to the species managed within their regional fisheries. The 1996 amendment has played a persistent and shaping role FMPs and recovery (Auster & Langton, 1999; PFMC FMP, 2016). The 2006 amendment to the MSA added urgency to the enhanced integration of scientific expertise to the management of U.S. stocks which was adopted into FMPs to uphold the new standard. Additionally, the 2006 reauthorization ended a moratorium on Catch Share or Individual Fishing Quota (IFQ) programs in the U.S., allowing regional councils to consider adoption of rationalization programs for specific fisheries (NOAA, (n.d)).

Regional Fisheries Management Plan (FMP)

The existing FMP, established in 1982, highlights the goals of conservation, economics, and utilization. The FMP is adaptive and incorporates frequent amendments to increase the sustainability and perseverance of the groundfish fishery (PFMC FMP, 2016). FMP conservation goals are designed to eliminate the risk of overfishing, control harvest levels and habitat impact in the interest of rebuilding and conserving overfished stocks. Economic goals are in place to assure the maximum value to the industry. Finally, utilization goals are maintained to promote the greatest possible biological yield of the fishery for both the recreational, commercial and consumer sectors while still ensuring safe harvest levels (PFMC FMP, 2016). These goals are concomitant with the guiding principles of marine ecosystem-based management (MEBM) and MSA oversight. MEBM is rooted in the goal of safeguarding the health and productivity of ocean ecosystems in a manner which maintains the long-term delivery of ecosystem services to coastal communities (McLeod & Leslie, 2009). MEBM includes focusing more on the coupled social-ecological dynamics of systems, and incorporating stakeholder interaction with ecosystem through past, present and future management and sustainable utilization (Hilborn, 2004). Accordingly, the structure of the PFMC is inclusive of perspectives and expertise from a diverse group of participatory members to maintain the health of the groundfish fishery and socioeconomic longevity of the communities who benefit from its sustainable yield.

The 14 voting members of the PFMC consist of representatives from the management agencies for Oregon, California, Idaho and Washington, a NMFS representative, 4 at large members, one tribal representative and one obligatory member for each state. The FMP also incorporates oversight from science and industry through the

Groundfish Management Team (GMT) and the Groundfish Advisory Panel (GAP). The GMT is responsible for monitoring any resource conservation issues facing species or species groups which may require the attention of management. The process mandates that the GMT present the rationale and analysis substantiating any issues raised, as well as recommended steps to amendment at the PFMC meeting. The PFMC then facilitates public testimony and submits the recommended measures to the NMFS for implementation if the measure is supported (PFMC FMP, 2016). The role of the GAP subpanel is to offer advisory expertise from stakeholders representing those impacted by management measures procured for the groundfish fishery. The transparency of process dictated by PFMC meeting structure assists in meeting FMP goals of ensuring inclusion and resource longevity to coastal resource dependent communities.

The period covered in this research limits the encapsulation of the entire course of groundfish management history, rather, this thesis will begin with the assessment of and expand upon some of the key amendments as pertinent to the nearshore sector of this fleet

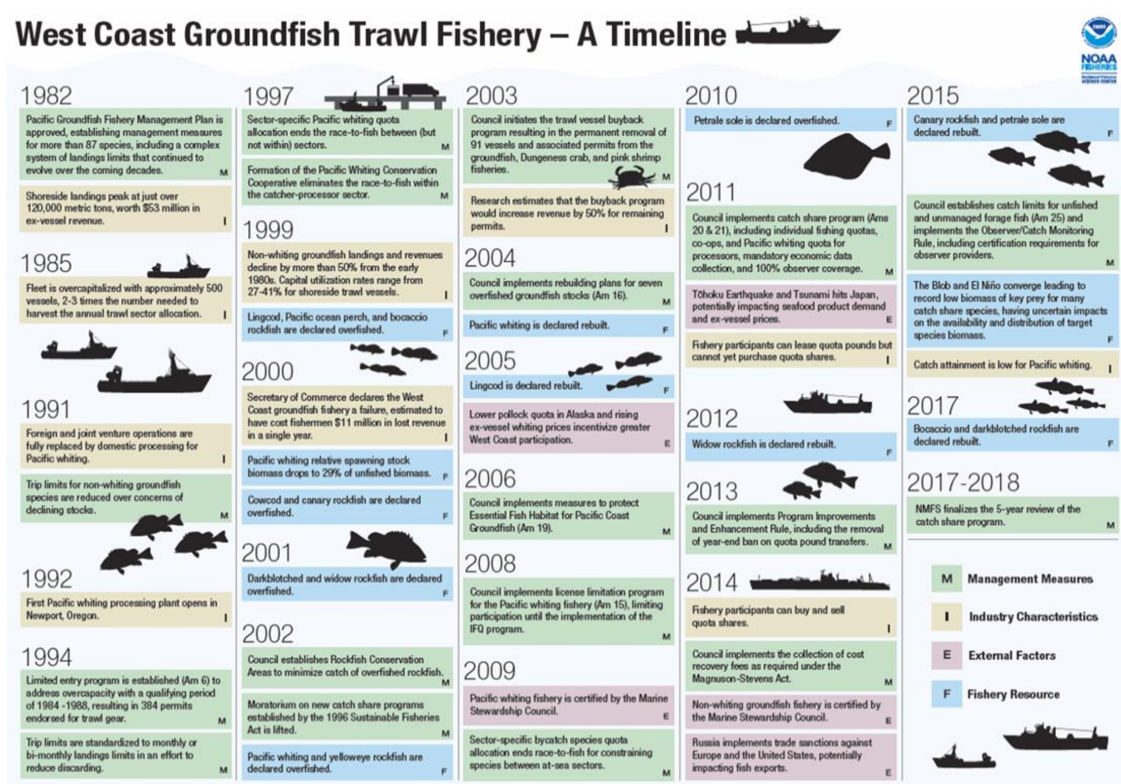

Figure 1.3 West Coast Groundfish Trawl Fishery—A Timeline
Timeline of significant events in the West Coast Groundfish Trawl Fishery 1982-2018. Source: Warlick, Steiner & Gulden 2018.

(Figure 1.3). In turn, while the Pacific Whiting (*Merluccius productus*) fishery (also commonly known as Pacific Hake) is a substantial component of the West Coast groundfish fishery, its activity rarely extends into the nearshore habitat reflected in this study. Therefore, Pacific Whiting management milestones will be considered but not heavily integrated here. The careful adaption of the FMP through many amendments has been credited with the successful rehabilitation of stocks since the declaration of the fishery collapse in 2000. The progression from foreign vessel activity in the late 1960-1970's, to joint venture agreements in 1989, to full domestic operations in 1991 began the inherent shaping of the nearshore fleet (PFMC FMP, 2016). In 1994, a license limitation plan was the crux of the Limited Entry (LE) program for fishing vessels utilizing trawl and fixed gear. It required an inspection to verify qualifying gear types and vessel capacity and designated 2-month limits to the species-poundage each vessel was permitted to harvest (Mamula & Collier, 2015; PFMC FMP, 2016). To better manage FMP stocks, following the 1996 SFA, a 1998 appendix was added to detail the life histories and Essential Fish Habitat (EFH) for each of the 83 species managed at that time (PFMC FMP, 2016). In 2000, a fishery disaster was declared for the West Coast groundfish fishery and Oregon, Washington and California, and disaster relief funds were appropriated to assist in the socioeconomic ramifications of the commercial fishery disaster and conduct rehabilitation work on the fishery (PFMC FMP, 2016; Warlick et al., 2018; Shaw & Conway, 2007). In 2002, NMFS and the FMP created seasonally alterable Rockfish Conservation Areas (RCAs) with variability by gear type to support rebuilding plans for seven fisheries management plan species. These areas were scattered across much of the continental shelf of the West Coast of the United States, and were introduced as a stock management action, bolstered in 2006 by an official EFH habitat action amendment to the FMP (PFMC Amendment 19). The RCA addition included a PFMC-mandated restriction on trawl footrope-diameter specific to nearshore and shelf trawl fisheries (Bellman et al, 2005; PFMC FMP, 2016) The removal of large-diameter footrope gear capable of tackling high-relief rocky habitats vital to many rockfish species reinforced spatial protection measures by further limiting gear which allowed access to these areas. Contingent to these spatial habitat protection measures, the PFMC adopted MSA incentivized experimental fishing permit (EFP) programs, encouraging innovation and collaboration between scientist and fishery participants in modifying and testing gear for further reduction of bycatch and habitat destruction (PFMC FMP, 2016). In 2005, the PFMC implemented required adoption of selective flatfish trawl gear by fishery participants trawling shoreward of the 100 fathom trawl RCA North of 40°10 latitude (Hannah et al., 2005; King et al., 2004, PFMC FMP, 2016). The areas closed to trawling were defined by specific latitudinal and longitudinal coordinates, not depth contours, and vessels therein adhered to RCA restrictions limiting behavior solely to transitioning between fishing locations (PFMC FMP, 2016).

The 2003 vessel buyback program was the next in a series of fleet consolidation efforts, which permanently removed 91 vessels and permits from the West Coast groundfish fishery (Holland, Steiner & Warlick, 2017; Errend et al., 2019). The fleet consolidation culminated in the 2011 trawl rationalization program for West Coast groundfish via Amendment 20, which included total accountability for the trawl sector by requiring 100% observer coverage. IFQs, also commonly referred to as Catch Shares, are designed to stimulate a reduction in conflict over total allowable catch (TAC) and shift toward resource stewardship in the interest of economic productivity (Doremus, 2013; Kaplan et al., 2013). The process of individual allocation of TAC to members of the fleet is determined by variables such as gear type, vessel historical catch levels, and years of participation within a given fishery occurs via quota distribution (Pomeroy et al., 2015; Cramer et al., 2018; Carothers & Chambers, 2012). Amendment 20 included a provision which allowed program participants to adopt "gear switching," with the intended result of reduction in bycatch by allowing for use of gear like pots and longline which have perceived lower impacts on bottom habitat than trawl gear (Chuenpagee et al., 2003). Gear switching was intended to allow diversification of portfolios among fishery participants but has been shown to have had the unintended consequence of high used of fixed gear by new entrants in to the fishery, and subsequent high demand and use of sablefish quota (Holland et al., 2017).

The Oregon and California portion of the RCA is slated to be reopened to bottom trawling in 2019 through Amendement 28 of the Groundfish FMP. This modification will result in renewed trawl access to some 3,000 square miles of formerly protected habitat (PFMC, 2018). Many of these closures have been in areas restrictive to the groundfish fleet. The reopening of these areas will allow access to waters between the 100-150 fathom lines which have not been accessed since early RCA implementation in 2002. Understanding past behavior and future interest in the nearshore via LEK and SEK is imperative to predicting a possible resurgence of effort within the Oregon nearshore groundfish fishery.

1.4 Research Objectives & Chapter Summary

This thesis examines the dynamics of fisheries harvest activities spatially and temporally in historically important fishing grounds from Astoria, Oregon to Cape Blanco, Oregon shoreward of the 110 fathom or 200-meter depth contour line. This work adopts a mixed methods approach to comprehensively consider the nearshore groundfish fishery for the Oregon coast through the following targeted research questions:

I. What roles have the management and abundance of fish species played in shaping fleet dynamic (i.e., participation and trends) in Oregon's nearshore non-whiting groundfish trawl fishery through space and time?

II. Can LEK from logbooks and interviews with fishery participants to capture their experiential knowledge fill or refine gaps in understanding for Oregon's nearshore, particularly in the minimally surveyed range of 30 fathoms and shoreward where SEK is limited?

This thesis will address these questions using the Oregon State University manuscript format. Chapter 1 imparts the important historical and management context and rationale for this study. Chapter 2 is a manuscript for Ocean and Coastal Management directed at managers and scientists studying nearshore fisheries resources who may be seeking to bolster ecological knowledge and utilization of coastal commodities in the midst of funding and monitoring constraints. By combining LEK and SEK sources, Oregon's nearshore groundfish trawl fishery provides a valuable case study in fostering enhanced cooperation and sustainable, economically favorable use of fisheries resources. Chapter 3 is a manuscript addressed to the public, fishing community members and our Oregon Sea Grant funders. It explores the value of the often overlooked nearshore fishery and incorporates contributions made by combined SEK and LEK to better define the future of the fishery. By providing more comprehensive spatial and temporal monitoring of the fishery through SEK and LEK, illuminating economic drivers and current interest within the remaining participating fleet, present and future status of the fishery can be better recognized and supported. Finally, this research is the initial component of a co-housed study. This preliminary investigation is designed to assess the LEK sources and contributions to the Oregon nearshore groundfish trawl fishery, and supply endemic fisheries community knowledge to support the integration of SEK in the form of long standing scientific trawl surveys and research which will become the second stage of this work. Chapter 4 therefore, is a discussion and conclusion which begins by outlining the learned benefits and precautions necessary to adapting mixed methods approach in SEK and LEK research. It describes the characteristics and findings of the nearshore groundfish trawl fishery developed from LEK. It concludes by inferring future needs for combined SEK and LEK approaches, and possible steps for part two of this study, which further brings in SEK with the overarching research questions, establishing a baseline for a more comprehensive and integrated narrative to this fishery and ecosystem.

Validity & Ethical Statement

The introduction of researcher bias and subjectivity in qualitative conclusions can generate scrutiny to the validity of findings drawn from work of this nature (Maxwell, 2013; Miles et al., 1994). To counteract the unintended selection of data that harkens to the theories, goals or pre-existing notions of the researcher, validity checks and biases were consistently addressed throughout the design and implementation of this study (Maxwell, 2013). Routine cross coding of transcripts was used to ensure inter-rater reliability throughout coding process and increase validity (Maxwell, 2013). Entirely eliminating the occurrence of reactivity in settings where interviews are conducted under the scaffold of an individual community culture is challenging, but these instances and biases were minimized by adhering to Institutional Review Board (IRB) approved interview guides and subduing instincts for leading questions when they arose (Maxwell, 2013, Carraciolo, 2017). A clear explanation of the project was provided before each interview was undertaken, including obtaining the verbal consent of all participants (Appendix A2). The practice of assembling participants from multiple key informants in varying geographic regions elicited a diverse array of interview participants both in age, social stature and economic disposition within the fishery, avoiding an influx of systematic bias. Triangulation was upheld by obtaining data from multiple commercial ports along the coast to avoid community bias (Maxwell, 2013). A rich data tapestry was formed by including logbook and fishticket data from ODFW, PFMC historic documents and economic data and agency perspective to supply a holistic depiction and understanding of themes (Maxwell, 2013). Throughout this process researcher background, education and societal status were reflected upon in personal memos and conversation with peers and experts in the social science community to further prevent personal bias intervention to this work.

Logbook Confidentiality

Logbook and fishticket data confidentiality are upheld by the ODFW and the Pacific Coast Fisheries Data Committee and access is granted through the approving agency including a non-disclosure agreement and specifications on how the data must be handled (Appendix B). All visualization of data was done in a manner which upheld these specifications and removed the risk of individual identification. Findings from visualizations and exploratory analysis aided in framing the initial qualitative interview questions.

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CHAPTER 2 **FIRST MANUSCRIPT [Ocean & Coastal Management]**

Combining Local Ecological Knowledge to Augment Scientific & Management Understanding of a Living Coastal Resource:

The case of Oregon's nearshore groundfish trawl fishery

Abstract

Coastal nearshore regions are a global intersecting point for human and biological productivity. Subsistence, commercial and recreational fishing activities frequently occur within these accessible areas but many are poorly monitored or managed due to funding and time constraints. Shallow estuarine and shelf habitats common in nearshore areas along the West Coast of North America are important for early life history stages of many commercial and recreational fisheries, particularly high value flatfish species (*Pleuronectiformes*). The West Coast groundfish fishery includes over 90 different species, the non-whiting component of which supplied 21% of the Oregon fishing economy in 2018. 39 of the managed groundfish species occur within a nearshore sector of Oregon's Coast (here defined as the region of shelf extending seaward to a water depth of ~110 fathoms (200 meters or 660 feet)). The very shallow portions of the Oregon Coast (the area of the shelf inshore of ~30fm (55m or 180 ft) have been the subject of little to no scientific survey monitoring, and much of the details of the ecology, health and processes in these habitats remain poorly understood. The utilization of the nearshore region by the commercial groundfish trawl fleet is also minimally documented despite the fact that experiential knowledge (local ecological knowledge [LEK]; trawl logbooks, fish tickets, interviews) exists. This case study explored the capacity of using LEK sources to inform and enhance scientific (SEK; agency/academic trawls) understanding of the vitality and drivers of effort within nearshore fishery resources. Our approach used statistical analysis and mapping of nearshore trawl effort from 1976-present, and semi-structured interviews of intergenerational fishermen to bolster data-poor areas. Offering insight to sampling strategies and historical knowledge of access to groundfish assemblages, we aim to establish a framework for combined knowledge approaches and provide baselines for future management. Spatial mapping results revealed a decline in trawl effort on the Oregon continental shelf thought time. Logbook and interview data assessment defined new market and ecological drivers of fishing behavior as well as a unique sector of the groundfish fleet in Oregon. Findings indicate this mixed-methods approach can provide

a more thorough assessment of long-term interest in Oregon's nearshore groundfish fishery. Ensuring better understanding of coastal interfacing regions such as Oregon's nearshore encourages the potential for better health and utilization of marine resources and improved monitoring in resource limited management contexts.

2.1 Introduction

Globally, populated coastal regions are a nexus for the development of intricate relationships between natural and human communities, and the growth of coincident industry. The scale of these developments and the broader sociocultural incentives vary staunchly among fisheries resources both geospatially and geopolitically. The draw to coastal resources for subsistence, aggregation and recreational enterprises are an enduring historical phenomenon. Spatially, 90% of global employment opportunities in artisanal fisheries were determined to fall within nearshore coastal waters and shallow shelf regions, broadly described as the region of interface between land and sea (Caddy & Griffiths, FAO, 1995). Innovations to better comprehension and sustainable development of these often fragile and dynamic commodities present opportunities to collaborate and integrate new knowledge into the management conversation (Haven, 2019). Existing literature has identified combining unique Scientific Ecological Knowledge (SEK) and Local Ecological Knowledge (LEK) sources as a potential method to augment understanding in terrestrial and coastal resources and fill gaps in spatial and temporal monitoring (Mackinson, 2001; Sampedro et al., 2016; García-Quijano, 2007, Kupika et al., 2019, Cook et al., 2014; Beaudreau & Levin, 2014). In addition to narrative LEK, commercial fishing logbook and fishticket data have been shown to provide valuable insight into fishing intensity, behavior and geographic spread while presenting an opportunity for dialogue and resource monitoring between the commercial fishing community and scientists (Macomber, 2000). Few studies have investigated the benefits of combining existing quantitative fisheries-dependent data and pursuing supplemental qualitative interviews. Such an approach may inform and enhance scientific and management understanding of both ecological and socio-economic changes in fisheries systems while simultaneously offering the benefit of engaging more fully with local stakeholders and sustaining two-way flow of knowledge.

The Oregon Coast hosts an expansive and diverse coastline rife with commercial and recreational fishing opportunities. Commercial fisheries in Oregon generated $151 million in revenue in 2018 and supported an estimated 1310 jobs (State of Oregon Employment Department, 2019). While the Dungeness Crab (*Cancer magister*) and Pink Shrimp (*Pandalus jordani*) fisheries occupy significant percentages of these earnings, (49.4% and 17.8% respectively for 2018), the West Coast non-whiting groundfish fishery is also a consistent contributor to the local economy (21% in 2018). In addition to notable economic income contribution to Oregon, West Coast groundfish fisheries have been shown to hold potential for expansion in volume and employment, as many of the species caught were still less than half of the total allowable catch for 2017 (Gann, 2019). This fishery and diverse fishing grounds are exposed to multiple uses recreationally, tribally and commercially, with a commercial groundfish trawl fishery operating broadly in two sectors: whiting and non-whiting groundfish (PFMC, 2016). While the spatial and temporal trends of the offshore groundfish fleet have been broadly assessed in recent literature (Mamula & Collier, 2015; Warlick et al., 2018), particularly given a highly successful management and recovery, the nearshore sector of the non-whiting fleet remains largely overlooked.

Nearshore and estuarine habitats prevalent along the continental slope and shelf of Oregon are dynamic nutrient rich upwelling ecosystems critical to the early life history stages of many important commercial groundfish species (Beck et al., 2001, 2003; Sheaves et al., 2015; Haven, 2019; Sobocinski et al., 2018). Regionally, the West Coast groundfish fishery includes over 90 different species which associate commonly with bottom habitats, many of which are known to use coastal nearshore and estuarine habitats as nursery areas for newly settled or settling juvenile fishes (Krygier & Pearcy, 1986; Hughes et al., 2014; Sheaves et al., 2015; Haven, 2019; PFMC, 2016). The limited focus on the nearshore sector hinges upon the lack of persistent monitoring and management of the Oregon nearshore region explicitly. Despite the Oregon Department of Fish and Wildlife's (ODFW) introduction of a fairly comprehensive nearshore strategy plan for management in 2017, it remains in its nascent stages (ODFW, 2017). ODFW defines the nearshore as "…the area from the coastal high-tide line offshore to the 30 fathom (180 feet or 55 meter) depth contour...," which has been broadly adopted by regional science and management communities as well (ODFW, 2017; Haven, 2019; Pearcy, 1978; Sobocinski et al., 2018). The narrative of the nearshore which emerges from the fishing community and broader management however, is less concrete. Therefore, to best incorporate multiple stakeholder understanding and use of the nearshore given established spatial and temporal records of the trawl fleet the Oregon continental shelf region (Bellman & Hepell, 2005 & 2007; Lee & Sampson, 2000), this study adopts a definition of the nearshore which extends 200 meters, or 110 fathoms and shoreward.

Studies incorporating a broad-scale temporal assessment of commercial trawling and fish assemblages in the Oregon nearshore groundfish fishery are nominal. Furthermore, efforts to collectively understand a complex fishery utilizing combined LEK to inform and enhance SEK of surrounding fishery stakeholders only moderately applied to the Oregon Coast. The dearth of research in Oregon's nearshore regions stem from limited monitoring in the areas shoreward of 55 meters or 30 fathoms (Pearcy, 1978; ODFW nearshore strategy, 2017), and constraints posed by insufficient funding for scientific and management parties to consistently execute new or ongoing surveys. Since the mid 1970's, Oregon commercial bottom trawl logbook data have been collected by fishermen in the industry and maintained and managed by the OFDW. These logbook data present a high degree of spatial and species resolution as well as the benefit of large sample size and consistency in year-round availability. Frequently under-represented in the literature, these valuable fisheries-dependent data can offer insight into seasonal and interannual variability in both harvest-effort and trawl distribution, as well as historical species composition (Lee & Sampson, 2000). The Oregon Coast is also home to a population of intergenerational fishing families possessing systemic knowledge of regional habitats, offering a unique environment in which to approach ecological habitat and resource assessment through LEK (Fox and Starr, 1996; The Nature Conservancy, 2011; Conway & Pomeroy, 2006). Synthesizing these often underutilized data sources and combining them with regional SEK offers a prospective augmented information stream to the deficit of historic scientific monitoring of the nearshore.

Given the deficit in research focusing on Oregon's nearshore fisheries resources, this research offers an assessment of how a comprehensive reconstruction and understanding of broad scale temporal trawl effort, management and fisheries in the Oregon nearshore can be extracted from the combined knowledge of stakeholders, managers, and scientists. Understanding spatial and temporal trends in fishing effort can elucidate potential habitat quality and catch assemblage shifts, as well as heightened understanding of how compounded ocean condition variability, management regime shifts, gear and vessel adaptation and extraction influence long term target species adaptability and resilience of fish and fleet (Bellman et al., 2005; Miller et al., 2017). Ultimately these data and resources could provide an ideal setting to examine the potential for a cooperative approach to stakeholder-engaged management and use of nearshore ecosystems.

In this study, examination of the dynamics of fisheries harvest activities spatially and temporally in historically important fishing grounds spans from Astoria, Oregon to Cape Blanco, Oregon shoreward of the 110 fathom or 200-meter depth contour line. This study utilizes a mixed methods approach to comprehensively consider the nearshore groundfish fishery for the Oregon Coast to explore 1) the roles the management and abundance of fish species have played in shaping fleet dynamic (i.e., participation and trends) in Oregon's nearshore non-whiting groundfish trawl fishery through space and time and 2), how this case study of LEK from logbooks and interviews with fishery participants to capture their experiential knowledge can fill or refine gaps in understanding for a nearshore region, particularly in a minimally surveyed range where SEK is limited.

2.2 **Historical Context & Rationale**

National Fisheries Policy & Management Dissemination

From a domestic economic standpoint, the West Coast groundfish fishery was not recognized as one of significant value prior to the codification of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976 (Mansfield, 2001). Rather, the West Coast of North America provided a historical backdrop for a large-scale fisheries prosecution effort by foreign venture fleets, the most significant of which were comprised of vessels from the former U.S.S.R and Japan. Operating heavily in the Bering Sea and extending as far as Southern Oregon, these large factory trawlers targeted groundfish stocks at rates which far exceeded U.S. and Canadian fleet harvest levels and processing infrastructure (Alverson et al., 1964; Finley, 2017). Though the Submerged Lands Act of 1953 entitled coastal states to natural resource commodities such as fish, minerals, and oil within 3 miles of their respective coastlines, concern over mounting foreign extraction rates served as the impetus for better regulation of domestic resources (43 U.S.C. §§ 1301 et seq.).

Pacific Coast Groundfish Management Plan

The existing Pacific Coast Groundfish Fishery Management Plan (FMP), established in 1982, highlights the goals of conservation, economics, and utilization. The FMP also incorporates oversight from science and industry through the Groundfish Management Team (GMT) and the Groundfish Advisory Panel (GAP). The Pacific Fisheries Management Council (PFMC) consists of 14 voting members: the respective management agencies for Oregon, California, Idaho and Washington, a NMFS representative, 4 at large members, a tribal representative and an obligatory member for each state. The FMP is adaptive and incorporates frequent amendments to increase the sustainability and perseverance of this fishery (PFMC FMP, 2016). Accordingly, the structure of the PFMC is inclusive of perspectives and expertise from a diverse group of participatory members to maintain the health of the groundfish fishery and socioeconomic longevity of the communities who benefit from its sustainable yield.

Of the amendments to the FMP, several have had particular impacts on fleet modernization and resounding reshaping of the nearshore sector of the fishery. In 2002 NMFS and FMP adopted modifications to EFH areas by creating seasonally alterable Rockfish Conservation Areas (RCAs) with variability by gear type to support rebuilding plans for seven fisheries management plan species. These covered much of the continental shelf regions of the West Coast of the United States and were bolstered in 2006 by an official EFH amendment to the FMP. The RCA addition included a PFMC-mandated restriction on trawl footrope length specific to nearshore and shelf trawl fisheries (Bellman et al, 2005; PFMC, 2016). The removal of large-diameter footropes capable of tackling high-relief rocky habitats vital to many rockfish species reinforced spatial protection measures by further limiting gear which allowed access to these areas. At this time, the PFMC implemented required adoption of selective flatfish trawl gear by fishery participants trawling shoreward of the 100 fathom bottom depth contour North of 40°10 latitude (Hannah et al., 2005; King et al., 2004; PFMC, FMP 2016). Trawl gear deployed in the Oregon nearshore consists of conical nets towed behind vessels either on or off bottom in the form of bottom or mid water trawls. Trawl gear is typically tailored to individual vessels, targeted catch complex, fishing depth and bottom type, but may display varying levels of complexity amended to catch or avoid specific target species of fish (PFMC FMP, 2016).

Since the 1990's the PFMC has worked with the fleet to test adjustments to maximize exclusion of juvenile or protected species bycatch through the Experimental Fishery Permit (EFP) program. Management restriction of trawl gear type has been focused largely on the shelf and nearshore, as 6 of the 8 overfished groundfish stocks are known to associate commonly with the habitat in these areas. Large-diameter footrope gear was prohibited beginning in 2002, and the mandatory use of selective flatfish trawl gear, which is designed specifically to avoid catch of rockfishes began in 2005 (figure 2). Hannah's (2003) evaluation of West Coast bottom trawl effort from the years 1992 to 2001 in areas deemed prime trawlable rockfish habitat revealed adjustments in spatial distribution based upon gear restrictions implemented by changes in management. These changes in trawl effort occurred predominately when the maximum trawl footrope-diameter and rockfish catch limits were tightened, and effort increased when bycatch limits on yellowtail rockfish (*Sebastes flavidus*) were higher (Hannah, 2003). These findings indicated an intricate relationship between both gear and catch limits. Managers attempt to moderate mobile gear types via consistent assessment of the gear impact on target fish species, and research continues to advance regarding the negative impacts trawl fishing gear elicits on the economic value of fisheries long-term (Watling et al., 1998). Exploration of logbooks in this study aims to further expose temporal trends in trawl gear preference relating to both efficiency and management and potential for habitat contact for the groundfish fishery.

The Oregon and California portion of the RCA is slated to be reopened to bottom trawling in 2019 through Amendement 28 of the Groundfish FMP. These modifications will result in renewed trawl access to some 3,000 square miles of formerly protected habitat (PFMC, 2018). Many of these closures have been in areas restrictive to the groundfish fleet. The reopening of these areas will allow access to waters between the 100-150 fathom lines which have not been accessed since early RCA implementation in 2002. Understanding past reaction and future interest via LEK and SEK is useful in predicting a possible resurgence of effort within the Oregon nearshore groundfish fishery.

Fleet consolidation strategies initiated with the 2003 vessel buyback program permanently removed 91 vessels and permits from the West Coast groundfish fishery (Holland, Steiner & Warlick, 2017; Errend et al., 2019). Consolidation efforts culminated in the 2011 trawl rationalization program for West Coast groundfish via Amendment 20, incorporating total accountability for the trawl sector by requiring 100% observer coverage. Individual Fishing Quota (IFQ) systems, also commonly referred to as Catch Shares, are designed to stimulate a reduction in conflict over total allowable catch (TAC) and shift toward resource stewardship in the interest of economic productivity (Doremus, 2013; Kaplan et al., 2013). The process of individual allocation of TAC to members of the fleet is determined by variables such as gear type, vessel historical catch levels, and years of participation within a given fishery occurs via quota distribution (Pomeroy et al., 2015; Cramer et al., 2018; Carothers & Chambers, 2012). Amendment 20 included a provision which allowed program participants to adopt "gear switching," with the intended result of reduction in bycatch by allowing for use of gear like pots and longline which have perceived lower impacts on bottom habitat than trawl gear (Chuenpagee et al., 2003). The allowance of gear switching was intended to allow diversification of portfolios among fishery participants but has been shown to have had the unintended consequence of high use of fixed gear by new entrants in to the fishery, and subsequent high demand and use of sablefish quota (Holland et al., 2017).

Oregon Marine Fisheries Management Plan

ODFW amends and implements the management of Oregon's marine fisheries resources, which include many stocks under the FMP with the exception of a few nearshore species managed exclusively by the state (e.g., blue rockfish (*Sebastes mystinus)* and blue rockfish (*Sebastes melanops*). The Oregon Marine Fishery Management Plan (MFMP) was recently expanded to include a more detailed strategy for the management of the nearshore ecosystem, focusing on identifying and rectifying gaps in the understanding of processes and impacts within this unique component of Oregon's larger natural resources. The urgency for this plan arose from a lack of monitoring of coastal areas less than 30 fathoms from shore, exposing a concerning gap in awareness of bathymetry, habitat and biological assemblages as well as risk of perturbations from natural environmental variability and anthropogenic impacts (ODFW, 2017). Foundationally, the nearshore agenda outlines a series of goals directed at improving communication and partnerships, generating stronger science and information, and constructing a better decision-making process to promote the participatory sustainability efforts of this resource for its diverse coastal stakeholders. This research aims to establish valuable connections with the historically present groundfish trawl fleet, whose knowledge and use of the coastal shelf region may assist in understanding the socioeconomic value of the nearshore.

Nearshore habitat & commercial fish species

Coastal nearshore regions are host to a diverse and productive range of substrates which provide structural habitat for many species of fish and invertebrates in varying life stages, particularly early life history of commercial flatfishes (Yoklavich & Wakfield, 2015; Haven, 2019; Sobocinski et al., 2018; ODFW, 2017). Oregon nearshore habitat is largely comprised of unconsolidated mud and sand sediment types deposited to the shelf and slope by coastal rivers, as well as seasonally exposed hard bedrock features and other biogenic structures (Goldfinger et al., 2003; PFMC Appendix C Part 2, 2019; Romsos et al., 2007). Habitat existing shoreward of 3 kilometers (1.86 miles) consists of a mixture of rocky shores and sandy beaches, subtidal rock outcrops, boulders, high relief sand, gravel and cobble fields, seagrasses, bull kelp forests and occasional offshore islands. Seaward of 3 kilometers (1.86 miles), Continental Shelf habitats are comprised of low-relief sand, mud or cobbles with varying coverage by rock outcrops, pinnacles and boulder fields. With the exception of Heceta Bank, the majority of Oregon's Continental Shelf region consists of soft sediment sand and mud bottom habitats (Yoklavich & Wakfield, 2015).

In addition to sediment mobility caused by waves, ripples and seasonal upwelling activity which drives biological productivity and redistribution (Goldfinger et al., 2003; Kulm et al., 1975; van de Velde et al., 2018) these regions are prone to extensive sediment resuspension and transportation when impacted by bottom trawl gear (Kaiser et al., 2002, 2010; Auster & Langton, 1999). Subsequent loss of habitat complexity, disturbance of foraging grounds and prey species have all motivated MFMP monitoring and constraint of fishing activities which pose concerning impacts to fishery resources, including the employment of seasonal or spatial closures, and gear restrictions to fishing behavior (ODFW MFMP, 2015). While efforts in the area of long-term spatial and temporal monitoring of these habitat impacts and recoveries are improving (PFMC, 2019; Hixon & Tissot, 2007; Kaiser et al., 2006; Hannah et al., 2010), there is still a need to better understand the enduring impacts of trawling on these habitats, particularly post EFH and RCA area implementation.

Given the use of the nearshore region as nursery habitat for many species of rockfishes and flatfishes prior to transition to offshore rocky reef during their adult stages (Krygier & Pearcy, 1986; Gallagher & Heppell, 2010;), conservation and monitoring of these sensitive regions is vital to the preservation of commercial stock health (Fiksen et al., 2007;

Haven, 2019). Vulnerability to fishing disturbance has been shown to be habitat specific, with declining stability in areas of greater complexity (biogenic and harder substrate) (Kaiser et al., 2006; Auster & Langton 1999; Bellman, 2004). There is however, some debate over recovery times for soft sediment habitats, as some research some has indicated greater vulnerability than others (Collie et al., 2000; Kaiser et al., 2006), necessitating better assessment of these areas temporally.

The assemblages of fishes found within Oregon's nearshore shelf region include a mixture of bony and cartilaginous species. The logbook subset utilized to assess the nearshore groundfish trawl fishery contained a total of 39 species codes, grouped within FMP management categories including 18 species of rockfishes (*Sebastes species)*, 12 species of flatfishes (*Pleuronectiformes*), 5 species of Roundfishes, 3 species groups of Elasmobranchs (sharks and skates), and another category for Pacific grenadier (*Coryphaenoides acrolepis*) (Love, 2011; PFMC FMP, 2016). These commercial species associate with nearshore habitat features at varying depths and degrees. Extensive research along the Oregon shelf describes the spatial delineation of assemblages into a higher diversity deeper water group (148-195 meters) and shallow water group (74-102 meters), found to be dominated by Pacific sanddab (*Citharichthys sordidus*) during sampling efforts (Pearcy, 1978; Krygier & Pearcy, 1986; Hixon & Tissot, 2007; Keller, Wallace & Methot, 2017; Beck et al., 2001; Keller et al., 2012; Keller et al., 2008). Scientific sampling conducted along Oregon's shelf have identified the use of nearshore waters and estuaries as nurseries for commercially valuable English Sole, Butter Sole, Pacific Sanddab, Speckled Sanddab and Sand Sole in particular (Haven, 2019; Pearcy, 1978; Krygier & Pearcy 1986). These scientific surveys have rarely extended further inshore than 55 meters to assess very nearshore species composition. Additionally, the sampling gear used was described as inefficient in retaining species outside of the flatfish group, thus presenting limitations in biomass estimates (Pearcy, 1978). Higher resolution in commercial catch composition and LEK of nursery areas is important for the continued management and health of nearshore groundfish fish assemblages.

In the time since the 1970's the Oregon Coast has seen substantial variability in climate and oceanographic conditions for which the impact on coastal fish assemblages is still not widely understood. In the period considered for this study (1976-present) the Oregon Coast has experienced several El Niño events in 1982-1983, 1997-1998, and 2015-

2016 (McClatchie et al., 2016), a major swing in the Pacific Decadal Oscillation (Mantua et al., 1997), hypoxia events (Chan et al., 2008) and the presence of an anomalous coastal warm blob (Bond et al., 2015). Seasonal and interannual variability in Northern California Current (NCC) shelf ecosystems like those found along the Oregon Coast are coupled with an interactive overlap with marine resource use in nearshore areas (e.g. marine renewable energy, shipping, recreation, water quality and runoff issues), thus experiencing increasing levels of perturbation (Halpern et al., 2008; Boehlert et al., 2007; Haven, 2019; Chan et al., 2008; Peterson et al., 2013; Yoklavich & Wakfield, 2015). Detailing LEK for this period may provide enhanced understanding of past assemblage shifts in response to oceanographic conditions and anthropogenic influence, and a more detailed insight into present impacts within the nearshore region.

Mixed Methods and Cooperation in Fisheries Research

For regional FMCs and state management agencies, maintaining the MSA mandated "best available science" standards can be a factor which limits the punctuality and thoroughness of data analysis and adoption into management measures (Kirkley et al., 2001). In a fiscally challenging landscape, innovations to incorporating existing or underutilized data sources such as LEK to inform resource status, and the mandated integration of human dimensions considerations of National Standard 8 in the MSA have led to increasing social science efforts in fishing communities (Moon & Conway, 2016; Miller et al., 2017; Barclay et al., 2017). For coastal regions, the LEK of fishermen has been described as an accrued knowledge surrounding fisheries and the environments they exist within which has been developed by industry participants and their families (Berkes, 1993, 1999; Freeman & Carbyn, 1988; Johannes, 1981; Neis & Felt, 2000; Murray et al., 2006).

Research design which facilitates connection between the scientific community and fishermen in a cooperative setting has gained momentum as a solution to accelerating and enhancing the flow of information to management and policy, and dispersal of benefits back to the community (Conway & Pomeroy, 2006; Hall-Arber, Pomeroy & Conway, 2009). The adoption of cooperative fisheries research is widespread, and there are marked benefits to encouraging cooperative efforts to expand into more collaborative research techniques, wherein an enhanced degree of involvement in the shared benefits, capacity to conduct research, delegation of power, engrossment and investment can be obtained (Read &

Hartley, 2006; Hartley & Robertson, 2008; Conway & Pomeroy, 2006). In the fisheries management and research landscape, there is a trend towards stock and ecological data collection, necessitating further integration of social science approaches to engage the human dimensions of fisheries systems (Hall-Arber et al., 2009; Russell et al., 2014).

2.3 Methods

2.3.1 Study Region

Nearshore Groundfish Trawl Fishery

Within the confines of this research, the Oregon nearshore groundfish trawl fishery is defined as all habitat types extending from the high tide line to the 200-meter (110 fathom) depth contour, incorporating both state and federally managed waters (Figure 2.1). Ultimately this area was adopted due to the absence of an assenting definition of the nearshore between management, science sectors and fleet. Considering the nearshore out to the 200-meter depth parameter served as an appropriate way to encompass the inner-shelf fishery as it is frequently defined by various stakeholder groups.

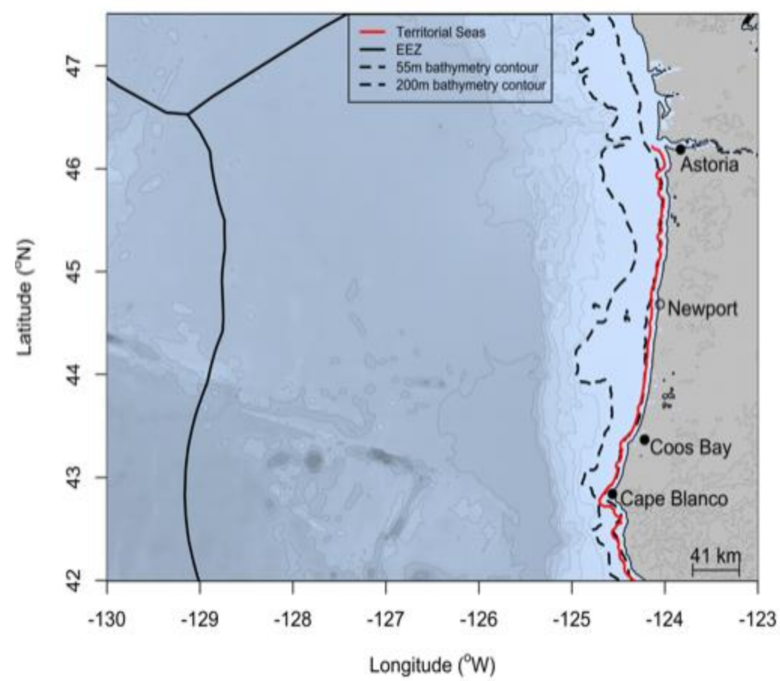


Figure 2.1 Map of Study Area
Oregon's 12 nm territorial sea (red), U.S. 200 nm Exclusive Economic Zone (EEZ) (black) and continental shelf region indicating the 200 meter (110 fathom) and 55 meter (30 fathom) depth contours of the study region from Cape Blanco to Astoria, Oregon.

Given the integration of ODFW bottom trawl logbooks as a significant data component to this study, the gear of focus was also refined to solely bottom trawl configurations including the ODFW logbook classifications of large footrope gear, small footrope (sole net), unspecified bottom trawl and selective flatfish trawl gear. Integral participants of the nearshore groundfish fishery community include the PFMC, which operates under the MSA national standards to generate and adapt the regional fishery management plan (FMP), and NMFS who in turn approve and regulate the FMP. It also comprises the state of Oregon, which adheres to the management of federal FMPs with the authority to exercise species specific measures where the state finds more conservative approaches necessary (ODFW, 2015). Lastly, the commercial trawl fleet and the major geographical ports and processing infrastructure from Cape Blanco to Astoria, Oregon are an inherent part of this nearshore fishery community. The interviews and analysis of the logbooks was confined to vessels and participants of the fishery who fished specifically within the defined Oregon nearshore. These individuals make up what for the duration of this project will be referred to as Oregon's nearshore groundfish trawl fleet.

2.3.2 **Logbook Analysis**

Data Aggregation

All logbook and fishticket data were exported from a Microsoft Access file in and uploaded into R where ensuing analysis was conducted. The data obtained contained records as far back as 1976 however, the documented challenges in accurate spatial representation of Loran A and Loran C (Bellman, 2004; Bellman et al., 2005; Sampson, 2011) recordings led to the elimination of Loran data entries. Locations were recorded consistently in latitudinal and longitudinal coordinates beginning in 1981. For this analysis, data was subdivided into distinct year blocks of 1981-1989, 1990-1999, 2000-2009 and 2010-2017 to correspond to major transitions in fisheries management. Logbook entries containing maximum trawl depths greater than 110 fathoms were removed from the dataset. The trimmed dataset contained 212,779 trawl logs from 1981-2017.

The Marmaps package in R (Pante and Simon-Bouhet, 2013) with a NOAA bathymetry data channel was used to build bathymetric maps with isobath delineations of 50m up to the 200m isobath. Initial visualization was used to avoid points on land or in depths not coinciding with the coordinate record. To verify that the depth at the latitudinal and longitudinal coordinates recorded in the logbooks were consistent with the NOAA bathymetry depth (http://maps.ngdc.noaa.gov/viewers/wcs-client/), the NOAA bathymetry and coordinates were imported and a locally weighted regression (loess function) was used to predict the accuracy of position reported at depths (Equation 1). Loess models use locally weighted regression as a nonparametric smoothing technique for weighted polynomial regressions and are easily interpretable for models with two dimensions such as the bathymetry depth data as a function of latitude and longitude.

(1) $$LOESS_{DEPTH} \sim S_1(\text{longitude*latitude}) + \varepsilon$$

where S_1=smoothing function, determined by the Loess function. A degree= 2 polynomial function was used and a span=0.05 fitted bathy data. The span specifies the fraction of total sample size around a target location used in the local regression. ε = error term.

This new Loess function was then applied to predict bathymetry depth for period blocks from 1981-2017, and predictions were correlated with logbook recorded values to determine linearity. Given the discrepancy revealed by this analysis in logbook max depth recorded and recorded set points in latitude and longitude, the loess predicted depths at the recorded set locations were adopted. This modified depth data (new.depth) was used to visualize spatial distribution of trawl set positions for each designated period.

Catch Standardization

Species not managed within the FMP and Oregon's MFMP were removed from the data for analysis. Fishticket data recorded by fish dealers present a means of verification of landed species and weighbacks and are a source of substantiation for logbook pounds recorded. No locational data aside from the port of landing is recorded on the fishtickets, thus in order to refine the ticket data to a maximum depth of 110 fathoms, fishtickets were linked to corresponding trawl logbook ticket numbers. An index was used to group species into the 5 major PFMC taxonomic categories (Table 3.1) rockfish species (18 nearshore), roundfish species (5 nearshore), flatfish species (12 nearshore), Elasmobranch species (3 nearshore groups) and other species (2 nearshore), (PFMC, 2016). To determine an average catch per unit effort (CPUE) in pounds per hour for further analysis, vessel data were linked to corresponding trawl logbook document numbers to limit the vessels to those participating within the specified study region and depths. In both logbooks and vessel data many ticket document numbers were not listed, therefore this group of vessels was used solely as a representative subset of the fleet and effort for visualizations. A Linear Model (LM) was fit to vessel length and horsepower for each year-block to verify their interchangeable use for the determination of average CPUE when dividing average CPUE by vessel type (Equation 2).

(2) Vessel Length ~ Alpha + beta * Vessel Horsepower

where alpha is the LM intercept (lowest vessel length entry) and beta is the LM slope coefficient (the rate of vessel length increase relative to vessel horsepower increase). This relationship was applied to each year-block subset.

Average CPUE was determined by equation 3:

$$cpue_{year} = \frac{\sum_{i=1}^{N_{year}} catch_{i,year}}{\sum_{i=1}^{N_{year}} duration_{i,year}} \quad (3)$$

where *i* indicates the *i_th* record set, and *Nyear* is the total number of records for the year. Average CPUE for each species category was plotted against vessel size and horse power to determine 3 size groupings: 40-60 feet, 60-80 feet and 80-110 (Appendix Figures C1 & C2). These established size groupings were assessed by gear type and tow duration to standardize average CPUE for the remaining analysis (Mander & Punt, 2004; Salthaug & Godø, 2001). Pounds landed for each category of species per year were divided by the total tow duration per year to calculate average CPUE for each category.

Mapping

To ensure confidentiality in displaying logbook data (Appendix B), a rasterization technique was used to group logbook categorical activity occurring within distinct polygons for all trawl data restricted to maximum trawl depths of 200 meters (110 fathoms) or less. Each grid cell is 27.8 km in the latitudinal direction and about 5.8 km in the longitudinal direction. The latitudinal range of 42° to 47°was divided into 20 regularly spaced intervals, and longitudinal range of -125°to -123.9° into 15 regularly spaced intervals. These were used to construct grid cells with 0.26° latitudinal and 0.08° longitudinal resolution in R using the *sgeostat* package and NOAA bathymetry data (NOAA, 2019; Majure & Gebhardt, 2016). Using the established grid, each station was established as a pixel within a grid cell and stored in a matrix. Matrices for each of the categorical analyses made were mapped using the image.plot function in R. The average CPUE in pounds per hour for all species within each of the year block subsets was plotted on bathymetric maps for each of the four gear categories (large-diameter footrope, small footrope (sole net), selective flatfish trawl and unspecified bottom trawl). Maps of average CPUE were also explored for each of the established vessel size groups (40-60 feet, 60-80 feet and 80-110 feet). Locations of catch distributions by pounds for each of the four major species categories (with the exception of the other category which contained nominal entries) were binned within grid cells and mapped for each year-block subset and gear type. Trawl latitudinal and longitudinal setpoint coordinates across the region of study were gridded and mapped by year-block subset, and were examined in greater detail by mapping activity for the most productive port regions (Astoria, Newport and Coos Bay) for each of the time blocks (Appendix Figures C3, C4 & C5). The overall adoption of the rasterization methods allowed for exploratory visualizations of average CPUE, species catch distributions, trawl setpoints and gear variability from 1981-2017 to provide spatial and temporal assessment of fishery engagement.

2.3.3 **Applied Social Science**

Data Collection

An ethnographic approach was used with the Oregon nearshore groundfish trawl fleet in order to gather data that allowed the opportunity to holistically detail patterns, interactions and values of the fishery as a system (Fetterman, 2010; Creswell & Poth, 2018). Beginning in the spring of 2017, PFMC meetings were attended, in Portland Oregon, Vancouver Washington and Seattle Washington to collect observations, conduct informal key informant interviews and gather emergent information from policy documents, meeting minutes and reports on West Coast Groundfish management. Interactions between the 14 voting members of the council, the GAP and GMT were observed and summarized in categorical memos and notes to decipher patterns in behavior over time among members of the groundfish fleet and build upon cultural interpretation (Bernard 2011; Robson, 2011).

Regular interaction with members of the PFMC and community at these meetings yielded contact with key fleet participants and the generation of potential interview contacts using a snowball sampling technique. Snowball sampling has been successfully used in settings wherein referral through an individual with an existing rapport among the community is vital in recruiting participants (Atkinson & Flint, 2001; Auerbach & Silverstein, 2003). Meetings and preliminary/informal interviews with an agency scientist led to the obtainment and discussion of important economic drivers of the fishery including market prices and poundage data for highly targeted species within West Coast groundfish during the time period assessed. These were used to compare with logbook and fish ticket data as well as themes that arose from the analysis of the semi-structured interviews (regarding market and effort drivers of the fishery).

A total of 23 semi-structured interviews were conducted with research participants selected from multiple sectors and years of exposure to the groundfish trawl fishery along the North, South and Central Coast of Oregon (Table 2.1). An interview guide containing six open-ended questions focused on introduction and duration of experience within the groundfish fishery, perceptions of management, gear, fleet, fish and market and future of the fishery were used as a standard framework for each participant interview, and probes used to further clarify responses (Appendix A3).

Table 2.1 Interview Sample Population
Summary of research interview sample population for the Oregon nearshore groundfish trawl fishery. N=North Coast (Astoria/Warrenton), C=Central Coast (Tillamook/Garibaldi/Newport), S= (Coos Bay/Charleston). No quantitative survey data was collected from interview subjects.

INTERVIEW SAMPLE POPULATION
Interviews *Managers & Scientists=4* *Industry=19*
Regional distribution (N, C, S) *N=9* *C=9* *S=5*
Age range of participants *30-85 years*
Gender distribution *F=1* *M=23*
Years of exposure to nearshore groundfish fishery *1-50+ years*

Interviews were conducted with managers (n=2), scientists (n=2) and members of the groundfish trawl fishing community (fishermen and processors; n=19). Participants were predominately male, and roughly ranged in age from 30-85 years old with varying degrees of exposure to the nearshore groundfish trawl fishery. No quantitative data were requested within the semi-structured interview format, therefore table 2.1 represents self-identified or population estimates from the interviews composed. The interviews were conducted in person at a location convenient to the participant or by phone where necessary and ranged from 30-120 minutes in length. Interviews were continued until the point of thematic saturation was reached (Berg, 2001; Miles, Huberman & Saldana, 2013). All but two were audio recorded and all were transcribed.

Data Analysis

All interview data were uploaded into the MAXQDA18 software for qualitative coding and coded for themes using the iterative grounded theory approach (Auerbach &

Silverstein, 2003). Grounded theory utilizes an inductive coding framework which allows the researcher to generate themes which emerge consistently over multiple rounds of coding and produce emergent narratives which can be connected and interpreted to guiding research questions (Creswell & Poth, 2018; Miles, Huberman & Saldana, 2013). Themes established from inductive coding were grouped into 5 overarching code groups of gear and fleet, management, fish, market and future.

Validity & Ethical Statement

The introduction of researcher bias and subjectivity in qualitative conclusions can generate scrutiny to the validity of findings drawn from work of this nature (Maxwell, 2013; Miles et al., 1994). To counteract the unintended selection of data that harkens to the theories, goals or pre-existing notions of the researcher, validity checks and biases were consistently addressed throughout the design and process of this study (Maxwell, 2013). Routine cross coding of transcripts was used to ensure inter-rater reliability throughout coding process and increase validity (Maxwell, 2013). Entirely eliminating the occurrence of reactivity in settings where interviews are conducted under the scaffold of an individual community culture is challenging, but these instances and biases were minimized by adhering to IRB approved interview guides and subduing instincts for leading questions when they arose (Maxwell, 2013, Carraciolo, 2017). The verbal consent of all participants was given and a clear explanation of the project provided before each interview undertaken (Appendix A). The practice of assembling participants from multiple key informants in varying geographic regions elicited a diverse array of interview participants both in age, social stature and economic disposition within the fishery, avoiding an influx of systematic bias. Triangulation was upheld by obtaining data from multiple commercial ports along the coast to avoid community bias (Maxwell, 2013). A rich data tapestry was formed by including logbook and fishticket data from ODFW, PFMC historic documents and economic data and agency perspective to supply a holistic depiction and understanding of themes (Maxwell, 2013). Throughout this process researcher background, education and societal status were reflected upon in personal memos and conversation with peers and experts in the social science community to further prevent personal bias intervention to this work.

2.4 Results & Discussion

2.4.1 Logbook Analysis

Logbook entry compliance through time has been highly variable in consistency with total trips, particularly in the early periods of implementation (Figure 2.2). Compliance is monitored by ODFW database managers and refers to the comprehensive groundfish fleet in Oregon. While compliance has improved with time (Figure 2.2), all visual portrayals and explorations are a representative subset of fleet behavior through time.

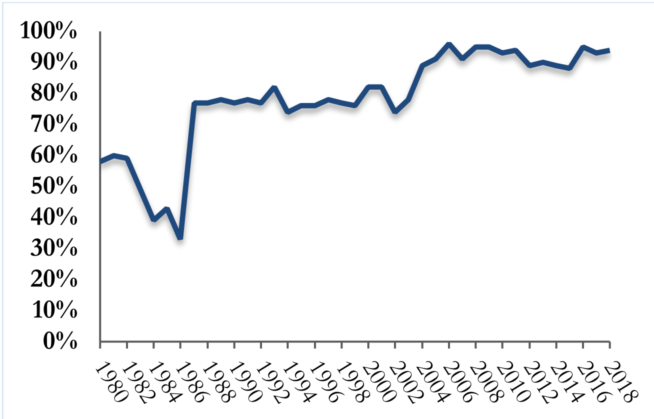


Figure 2.2 Percent Logbook Compliance 1980-2018
Compliance percentages for logbook entries 1980-2018 for the entire trawl logbook database courtesy of ODFW data managers. Logbook entries used for this work are a subset of this overall dataset of entries confined to 110 fathoms/200 meters or shallower.

Fleet

Temporally, trawl set numbers of the representative subset drastically decreased in the nearshore groundfish fishery, indicating a gradual shift in effort off of the shelf. Over the defined nearshore space, the number of recorded logged tows from the subset peaked at 541,612 in the 1990's but declined considerably to 82,314 in the truncated 2010-2017 period (Figure

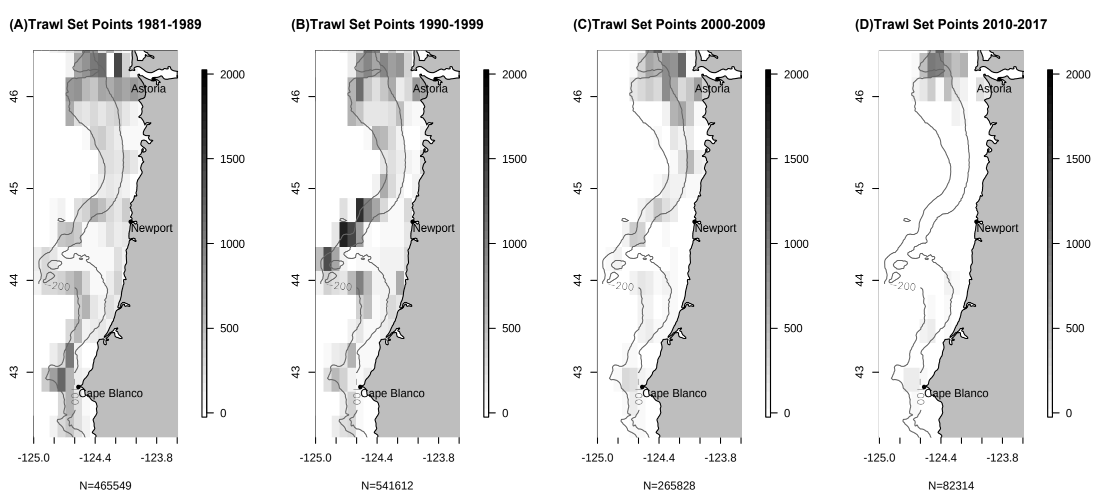


Figure 2.3 Map of Logbook Trawl Setpoints 110 fathoms/200 meters and shoreward.
Logbook trawl setpoints for all tows occurring from 1980-2017. N=total number of tows.

2.3). Even given the discrepancy in logbook compliance in the 1980's and 1990's (Figure 2.2;

Sampson, 2011), the decline in effort in this region is striking. Honing in on the very nearshore range of 30 fathoms (55 meters) and shoreward, the recorded number of trawl

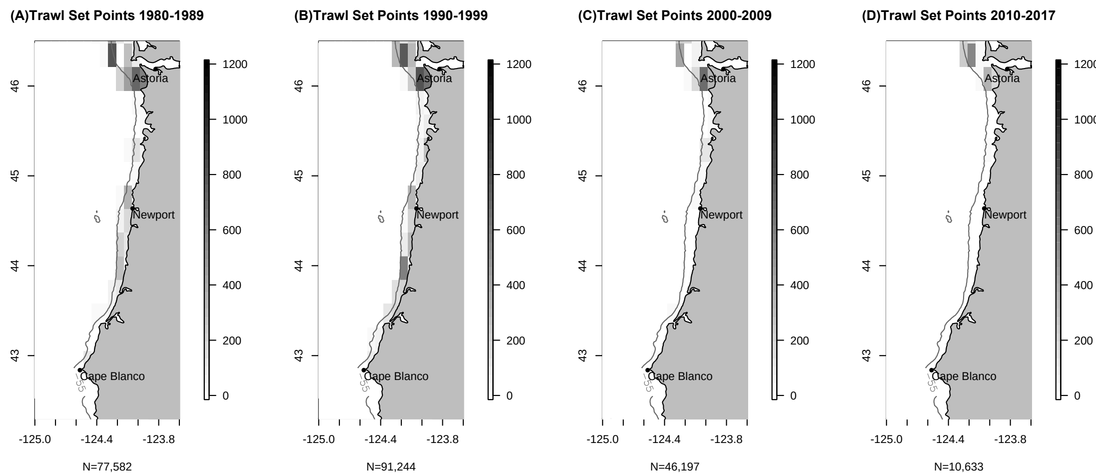


Figure 2.4 Map of Logbook Trawl Setpoints 30 fathoms/55 meters and shoreward. Logbook trawl setpoints for all tows occurring from 1980-2017. N=total number of tows.

sets decreased from a highpoint of 91,244 in the 1990's to a mere 10,633 in the abridged period of 2010-2017 (Figure 2.4). These representative declines correspond to a calculated consolidation of the fleet through time as management executed a series of fleet reduction measures beginning with limited entry in 1994, the vessel buyback program in 2003 and ultimately the IFQ program of 2011 (Warlick et al., 2018).

The gear and target fishery favored in the 1980's and 1990's indicate a more mixed fishery focused predominately on rockfishes and flatfishes using unspecified bottom trawl or small footrope trawl gear. With the 2005 transition to new regulations on gear limiting

Table 2.2 Fleet Characteristics.
Trends in vessel length, gear, fish species harvested and trawl depths from 1980-2017 for vessel subset.

YEAR BLOCK	AVERAGE VESSEL LENGTH (FT)	PREFFERED GEAR	SPECIES TARGET GROUP	AVERAGE MAXIMUM TRAWL DEPTH (Fathoms)
1980's	60 ft.	Unspecified Bottom Trawl	Flatfish & Rockfish	62 fathoms
1990's	64 ft.	Bottom Trawl Small Footrope (sole net)	Flatfish & Rockfish	68 fathoms
2000's	65 ft.	Selective Flatfish Trawl	Flatfish	57 fathoms
2010+	65 ft.	Selective Flatfish Trawl	Flatfish	58 fathoms

participation to selective flatfish trawl setups, this gear type become ubiquitous for the nearshore, and flatfish species the principally targeted species group (Table 2.2; Hannah, 2003). The depth and gear transition maintained a relatively consistent average trawl depth range in 40-80 fathom waters offshore (Figure 2.5, Table 2.2). Unspecified bottom trawl gear prior to footrope length restrictions showed the deepest tow depth effort in the 1980's. Overall variability in vessel length and depth fished reflected the characteristics of this fleet have remained largely consistent through time (Table 2.2).

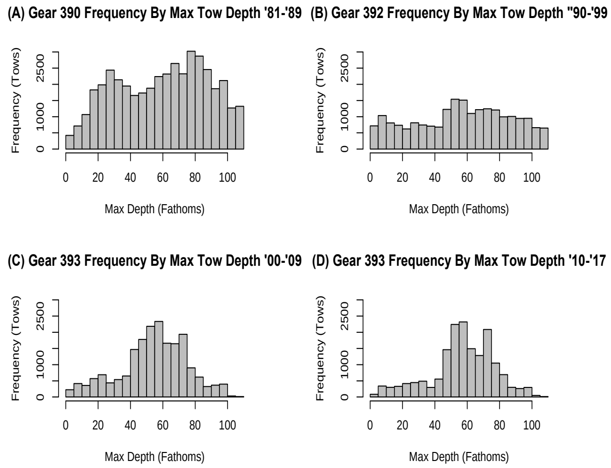


Figure 2.5 Logbook Gear Frequency & Depth Distribution.
Frequency and depth distribution of preferred gear type for each year block from 1981-2017. 390=unspecified bottom trawl gear, 392=bottom trawl, short footrope, 393=selective flatfish trawl.

Fishing activity was heavily aggregated around Newport, Astoria and Coos Bay, which served as the major port regions possessing the greatest consistency in processing infrastructure across time (Figure 2.6). The bathymetric habitat features around Newport in particular have been the subject of many

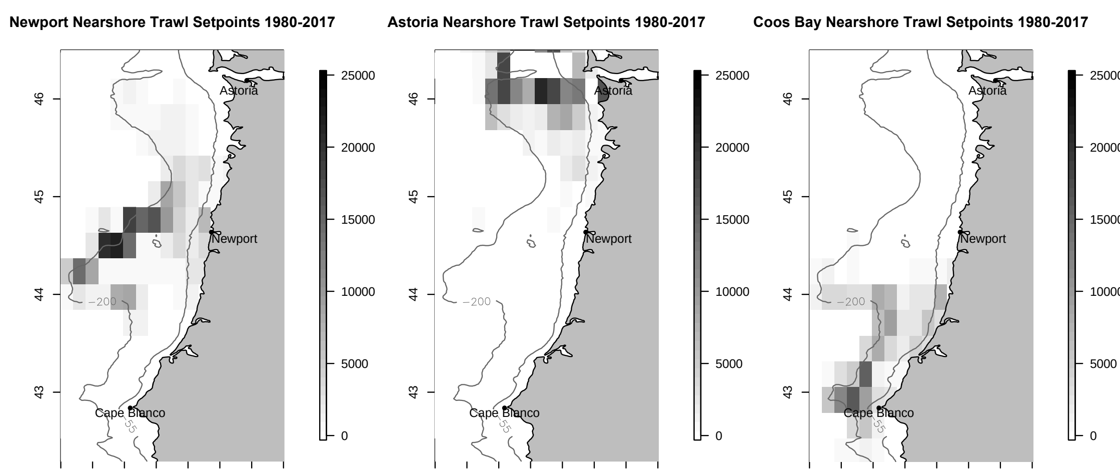
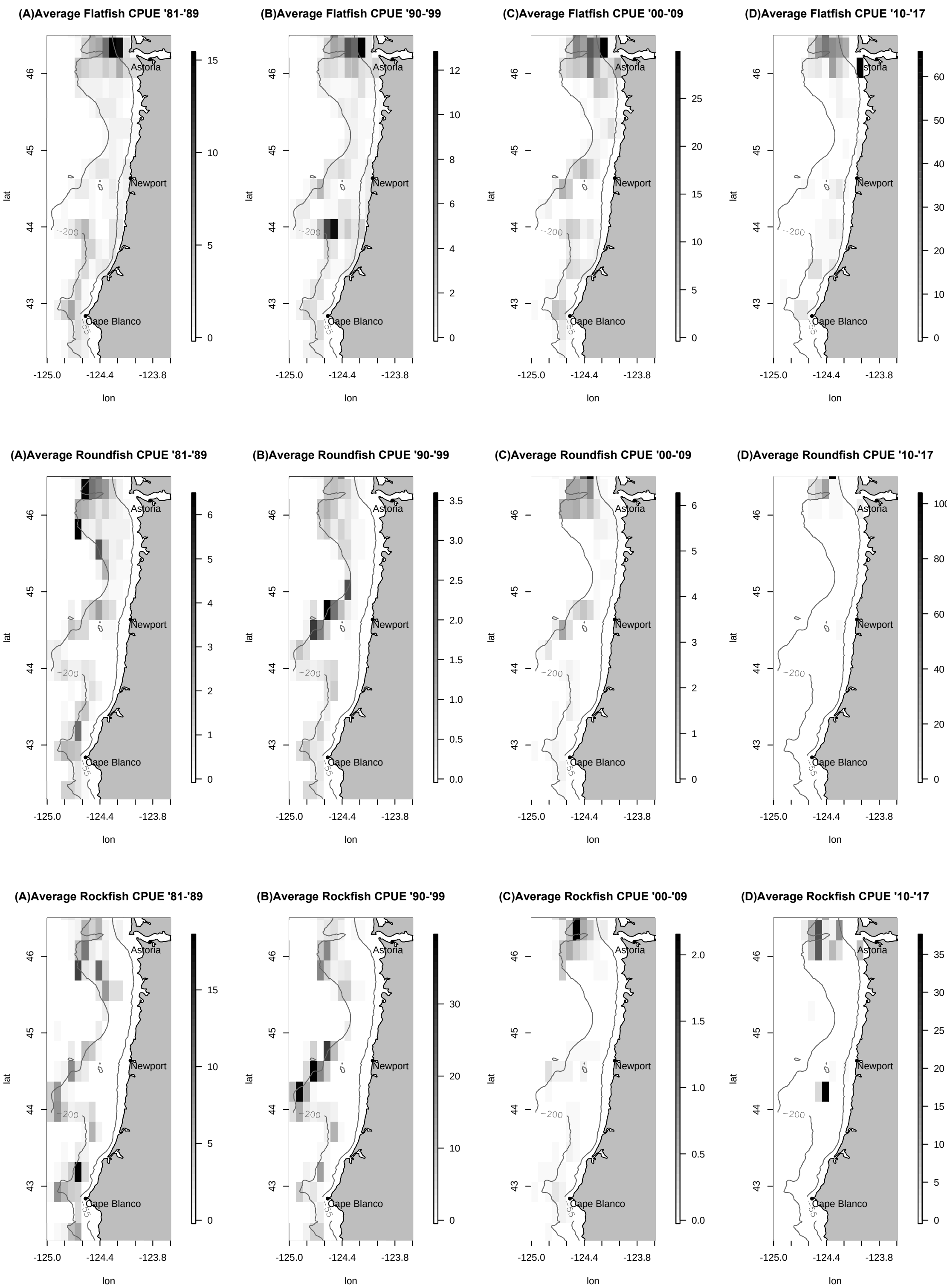


Figure 2.6 Map of Trawl Setpoint for Major Oregon Port Regions.
Trawl setpoint distributions for fleet subset for the 3 major port regions: Coos Bay, Newport and Astoria Oregon from 1980-2017).

fisheries studies through time (Day & Pearcy, 1968; Pearcy, 1978; Lee & Sampson, 2000) and the major port infrastructure of Astoria and Newport which display the most rockfish and



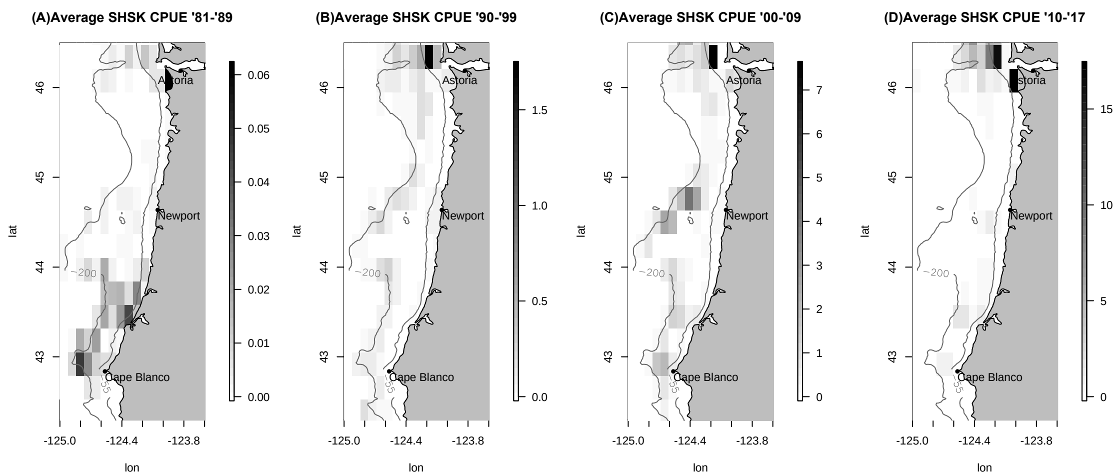


Figure 2.7 Logbooks Average CPUE Maps for Flatfish, Rockfish, Roundfish & Elasmobranch Taxonomic Groups.
Average CPUE categories in pounds per hour for the PFMC taxonomic management categories. Rockfish species (18), flatfish species (12), roundfish species (5), and elasmobranch species (3). Data included from 1981-2017 with maximum trawl depth of 110 fathoms/200 meters and shoreward with return ports from Cape Blanco to Astoria. The included vessels are a subset of the fleet. The average CPUE represented is for all vessel sizes and all gear types. Separated figures can be found in Appendix C.

flatfish average CPUE have also shown the most consistency in fishticket landings volume (Figure 2.7 & Figure 2.8).

Trawl activity in the areas adjacent bathymetric features between 43° and 45° latitude near the 100 fathom line suggested persistently favored fishing grounds across species groups, which align with the favorable shelf and slope fish prime habitat documented by Pearcy (1978). Present day efforts in the nearshore are most focused in the areas surrounding Astoria and Warrenton, where the majority of the plant and processing infrastructure remains, with marginally more refined activity in the Newport and Coos Bay port regions of the Oregon coast.

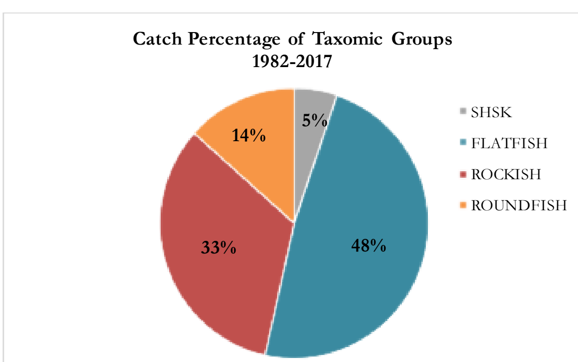


Figure 2.8 Catch Percentage of Taxomic Groups 1982-2017.
Percentage contribution of the 4 most significant PFMC taxonomic management categories: rockfish species (18), flatfish species (12) roundfish species (5), and elasmobranch species (3) for subset from 1982-2017.

Fisheries

Of the 4 species groups most consistently caught by nearshore groundfish trawlers along the Oregon coast, average CPUE for flatfishes within the designated nearshore range remained the most consistent across the mapped time periods (Figure 2.7). Further deconstruction of the taxonomic categories to species specific contributions of catch assemblages reinforced the dominance of flatfishes as a target species within the nearshore sector of the groundfish fishery for the collective years (Figure 2.8, Figure 2.9, species definitions in Table 2.3).

Flatfishes

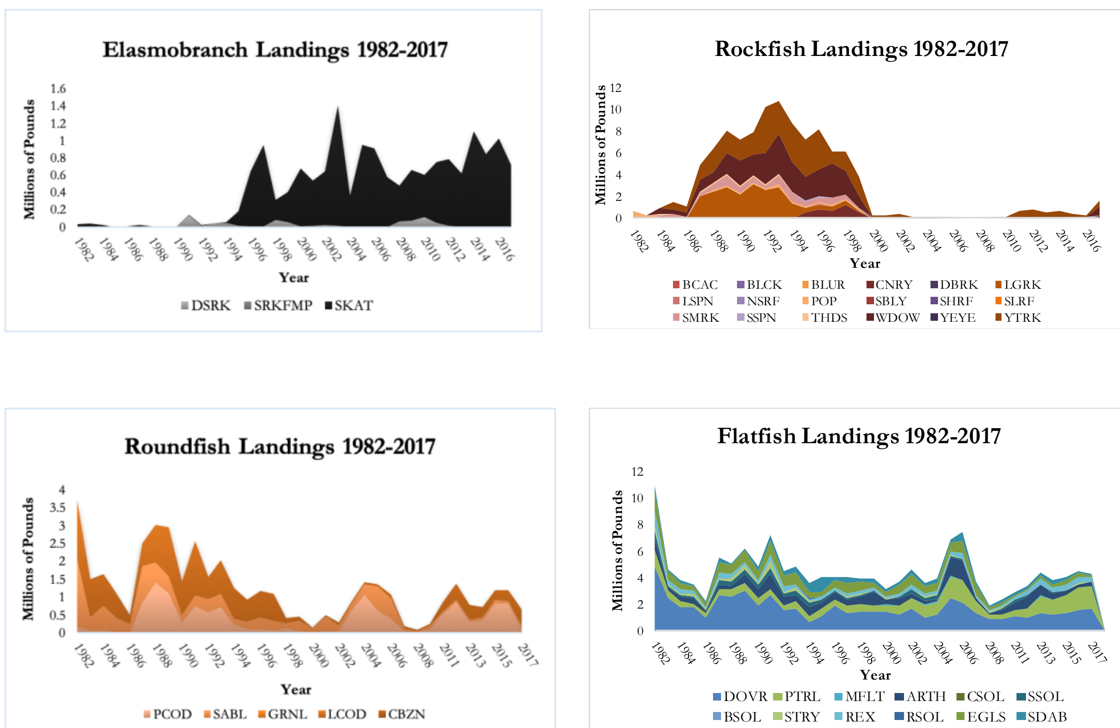


Figure 2.9 Logbook Total Pounds Landed for 4 PFMC Taxonomic Groups.
Total Pounds in millions of the 4 most significant PFMC taxonomic management categories by species: rockfish species (18), flatfish species (12) roundfish species (5), and elasmobranch species (3) for the logbook subset, 1982-2017.

Petrale Sole (*Eopsetta jordani)* and Dover Sole (*Microstomus pacificus))* supplied the greatest contributions, Dover by volume and Petrale by consistency in market value when compared to fishticket landing values (Figure 2.9). Scale bars for average CPUE maps were left non-uniform to allow full capture of average CPUE across time. This was partially a factor of the

Table 2.3 Logbook Species Codes, Common & Scientific Names & Management Categories of Nearshore Groundfishes.
Logbook species code, common and scientific name and management categories for 39 nearshore groundfish species codes.

LOGBOOK SPECIES CODE	SPECIES NAME	MANAGEMENT CATEGORY
EGLS	English Sole (*Parophrys vetulus)*	Flatfishes
RSOL	Rock Sole (*Lepidopsetta bilineata)*	Flatfishes
PTRL	Petrale Sole (*Eopsetta jordani*)	Flatfishes
DOVR	Dover Sole (*Microstomus pacificus*)	Flatfishes
REX	Rex Sole (*Glyptocephalus zachirus*)	Flatfishes
STRY	Starry Flounder (*Platichthys stellatus*)	Flatfishes
BSOL	Butter Sole (*Isopsetta isolepis*)	Flatfishes
SDAB	Pacific Sanddab (*Citharichthys sordidus)*	Flatfishes
SSOL	Sand Sole (*Psettichthys melanostictus*)	Flatfishes
CSOL	Curlfin Sole (*Pleuronichthys decurrens)*	Flatfishes
ARTH	Arrowtooth Flounder (*Atheresthes stomias)*	Flatfishes
MFLT	Miscellaneous Flatfish species (*Pleuronectiformes)*	Flatfishes
NSRF	Unspecified Nearshore Rockfish (*Sebastes* spp.)	Rockfishes
SHRF	Unspecified Shelf Rockfish(*Sebastes* spp.)	Rockfishes
SMRK	Small Rockfish (pre-2000) (*Sebastes* spp.)	Rockfishes
LGRK	Large Rockfish (pre-2000) (*Sebastes* spp.)	Rockfishes
POP	Pacific Ocean Perch (*Sebastes alutus*)	Rockfishes
DBRK	Darkblotched Rockfish (*Sebastes crameri*)	Rockfishes
WDOW	Widow Rockfish (*Sebastes entomelas*)	Rockfishes
YTRK	Yellowtail Rockfish (*Sebastes flavidus*)	Rockfishes
SBLY	Shortbelly Rockfish (*Sebastes jordani*)	Rockfishes
BLCK	Black Rockfish (*Sebastes melanops*)	Rockfishes
BLUR	Blue Rockfish (*Sebastes mystinus*)	Rockfishes
CNRY	Canary Rockfish (*Sebastes pinniger*)	Rockfishes
BCAC	Bocaccio Rockfish (*Sebastes paucispinis*)	Rockfishes
YEYE	Yelloweye Rockfish (*Sebastes ruberrimus*)	Rockfishes
THDS	Unspecified Thornyhead (*Sebastolobus* spp.)	Rockfishes
SSPN	Shortspine Thornyhead (*Sebastolobus alascanus)*	Rockfishes
LSPN	Longspine Thornyhead (*Sebastolobus altivelis)*	Rockfishes
PCOD	Pacific Cod (*Gadus macrocephalus)*	Roundfishes
SABL	Sablefish (*Anoplopoma fimbria)*	Roundfishes
GRNL	Unspecified Greenling species (*Hexagrammos* spp.)	Roundfishes
LCOD	Lingcod (*Ophiodon elongatus)*	Roundfishes
CBZN	Cabezon (*Scorpaenichthys marmoratus)*	Roundfishes
DSRK	Pacific Spiny Dogfish(*Squalus suckleyi)*	Elasmobranchs
SRKFMP	FMP Managed Shark species Tope Shark (*Galeorhinus zyopterus*) Leopard Shark (*Triakis semifasciata*)	Elasmobranchs
SKAT	Skate species (*Raja* spp.) Big Skate (*Beringraja binoculata*) Longnose Skate (*Raja rhina*)	Elasmobranchs
GRDR	Pacific Grenadier (*Albatrossia pectoralis*)	Other

retention of species catch entries of 0 as representative effort data which contributed to the increased variability of catch per hour. For flatfishes (*Pleuronectiformes*), spatial assessment displays consistent harvest in both the Northern range of the study area around a latitude of 46°with indication of more variability through time in the central coastal region proximal to Newport and the Southern extent of the range near Coos Bay and Charleston (Figure 2.7). Flatfishes, in particular Pacific Sanddabs (*Citharichthys sordidus)*, Sand Sole (*Psettichthys melanostictus*) and Dover Sole were frequently abundant in these regions (Figure 2.6 & Figure 2.7).

The Dover distributional range sits just on the cusp of the defined nearshore area (Gabriel & Tyler, 1980) but were nevertheless a species repetitively present in logbook and fishticket entries. A perceptible interaction between fishing distribution, quota and species between Black Cod and Dover Sole, Sablefish (*Anoplopoma fimbria)* (or black cod) is documented in the logbooks and PFMC management of these stocks (PFMC FMP, 2016; Lian et al., 2019).

Roundfishes

Distribution of target effort for roundfishes (figure 2.7) showed high catches across the coast along the 100 fathom depth contour with a decline in the catch of roundfishes in the most recent period of 2010-2017. Sablefish quota was expressed as a high value quota species as it associates often with Dover sole and thornyheads (*Sebastolobus* spp.), and is also a necessary quota for the nearshore fleet to cover incidental juvenile sablefish catch in trawl tows. A component to this competitive demand for sablefish quota is the "gear switching" provision included with the catch share program in 2011, which was intended to promote bycatch reduction through the use of pot and longline gear for some species within the trawl fishery. Incidentally, it introduced a group of new entrants to the fishery, using only these fixed gear types and leaving little sablefish quota to be utilized in the targeting of thornyheads and Dover quota (Ærrend et al., 2018; Chuenpagee et al., 2003).

Rockfishes

Rockfish as a species have been found less resistant to persistent heavy fishing effort given their life history characteristics and habitat dependencies (PFMC 2016; Francis, 1986; Love, 2011). Rockfish are slow growing species which live for staggeringly long times, some over 100 years (Welch, 2017). Older rockfish in the population, specifically females, tend to produce stronger broods and present greater odds of survival during periods of unfavorable environmental conditions (Hixon et al., 2013). When their numbers plummet below a certain threshold, the population becomes increasingly at risk. Canary (*Sebastes pinniger*), Widow rockfish (*Sebastes entomelas*) and the large rockfish management group were all high volume fisheries in the 1980's and 1990's but declined severely in 2000 (Figure 2.9). Some discussion surrounding a redeveloping market and tentative targeting effort was noted in interviews with currently active members of the fleet.

Rockfish were a high-volume fishery in the 1980's and 1990's but dropped sharply in 2000 maintaining a minimally significant portion of the overall catch effort (Figure 2.9). Hannah (2000) documented prime trawlable rockfish habitat as occurring along the 183 m or 100 fathom depth contour, where trawl effort was focused in Oregon during the boom of the trawl fishery in the 1990's. Figure 2.7 suggests the trends in rockfish (*Sebastes* spp.) target areas from 1981-2017 ranged spatially with consistent effort along latitudes of 44° to 46° and a sharp decline in overall average CPUE in the early 2000's. The inability to access rockfish prime habitat with adoption of the short footrope and eventually selective flatfish trawl gear in 2005, the further spatial confinement of the RCA and EFH areas, and the shift to total accountability through the trawl rationalization compositely made rockfish species fall from favorability as a target group for the nearshore fleet (Hannah, 2005; NMFS, (n.d.)).

Elasmobranchs (sharks & skates)

Average CPUE for the elasmobranch category was overall small and varied significantly (Figure 2.7). The Big Skate (*Beringraja binoculata*) has been described as having an on and off market, but is frequently targeted for their wings, which are marketed as imitation scallops. Additionally, skates were most often described within PFMC documentation as occurring in very shallow waters, often times shoreward of 10 fathoms. The better assessment of skate species within the fishery has been a focal conversation among the PFMC and broader research (Mcfarlane & King, 2006; PFMC, 2018). The catch of elasmobranch species (Figure 2.7 & Figure 2.9) shows a range of average CPUE and a somewhat sporadic distribution of target effort for sharks and skates. In the Southern range near Cape Blanco a shallower trend is apparent and a moderate average CPUE across time (Figure 2.7 & Figure 2.9). In the mid Coast, a slight surge in the 2000-2009 block is visible along the 100 fathom line, and some patchy frequently on the inner shelf most in the

Northern regional band toward Astoria with an indication of that area exhibiting the largest average CPUE of any of the regions and times in the 2010-2017 map (Figure 2.7).

Consolidated fishery trends

The "other" species category, comprised of Pacific Grenadier *Coryphaenoides pectoralis* and formerly Ratfishes *Chimeras* spp. (recently moved to the ecosystem component species group (PFMC, 2019)) contained such limited entries that visualization and landings contributions were not well assessed through mapping. Ratfishes and Pacific Grenadier are typically an incidental catch when fishing Dover sole or sablefish and have not been a significant target group for the fishery (Gaichas, 2000). Elasmobranchs and roundfish species have remained lower volume target groups for the nearshore sector with pulses of harvest intensification, the most notable for roundfish in the late 1980's (Figure 2.10). Challenges in predicting strong year classes and stock abundance were a resonant theme within council meetings and LEK interviews alike (PFMC, 2016). During the early 1980's, species across the groups showed a decline in catch (Figure 2.9). During this period, the Coast experienced a series of El Niño events, the 1982 and 1997-1998 events being some of the strongest in recent history (McClatchie et al., 2016), which had a devastating impact on the fishery economically (Shaw & Conway, 2007).

2.4.2 **LEK Interview Themes**

Summary findings from the logbook and fishticket data offer a verifying and enhancing narrative to the themes that arose from semi-structured interviews in documenting overall species trends and value spatially and temporally for the nearshore groundfish trawl fleet. Consideration and comparative assessment within the SEK monitoring can work with these findings to augment fleet and species behavioral variability to inform regional management and enhance cooperative fisheries research (Hall-Arber, 2009; Macomber, 2000; Mackinson, 2001).

Qualitative coding and a grounded theory approach revealed a series of prominent themes within the semi-structured interviews transcribed, each of which presented a series of frequently mentioned associated drivers with inherent overlap and synergistic connections between the themes. The interviews reflect the perspectives and experiences of industry participants with varying years of exposure to and participation within the Oregon nearshore groundfish trawl fishery. Selected quotes presented are representative of events and experiences which occurred consistently across interviews, the area of the study and the timescale assessed.

Fish: Primary species & dynamics

The West Coast groundfish fishery is perhaps instinctively shaped by the presence, diversity and health of its stocks. Given this, the story of its uses and impressions hinge on the species prevalence and trends across time (Shaw & Conway, 2007; Miller et al., 2017). The descriptions of groundfish assemblages along the Oregon nearshore revealed the makeup of the primary species present along the shelf and their contingent marketability as motivational to catch effort. The discourses surrounding fish from LEK perspectives ranged broadly, dictated in part by the age and duration of exposure of the fishermen or processors interviewed at the time of their participation. Regardless of participation, the most persistently discussed species for this sector of the groundfish fishery were flatfishes (*Pleuronectiformes*), and across all years assessed, petrale sole (*Eopsetta jordani*). petrale sole was described as a gratifying fish to target, with the market benefit of upholding consistency in abundance and market value through time. Interviews with participants active both long-term and within more recent years detailed the notable upswing in petrale abundance over the last 10-15 years. The aforementioned scale of increase was reinforced by interviews surrounding growing petrale density and subsequent challenges in obtaining quota numbers required to cover increasing volume attained in trawl sets.

> *"Back in the day, when there were bimonthly quotas and it was a wide-open fishery, in the winter when they [petrale] were spawning, the petrale were there, but they were a little harder to come by on the beach [nearshore] in the summertime. Now, petrale is bycatch for me, I have to stay away from petrale! I remember, back in the day, we would look for petrale all over the place, just towing and towing looking for our petrale limit. Now it's the opposite."*

The seasonality of the petrale fishery also invoked reflection on interactions with the wider groundfish trawl fleet during spawning events when the stock is allegedly heavily fished. Pearcy (1978) also documented spawning aggregations of petrale and Dover sole during the winter months on the continental slope and shelf. Fishermen expressly mentioned the decline in quality of the flesh during reproductive periods, as well as decline in quality of fish harvested by larger vessels where it would experience bruising in the fish holds. Additionally, several interviewees expressed concerns over the implications of heavy harvest effort during these spawning events, fearing for the longevity of their stocks. Mention was made of suggestive seasonal management closures or management intervention to these activities.

Petrale was not the only species discussed in the context of exhibiting seasonality of target effort or cyclical trends in abundance. Species flux was indicated as highly unpredictable in LEK interview and PFMC proceedings alike, particularly in the case of anticipating strong year classes. Fishermen research participants in the Central Coast regions of Oregon brought up their perceptions of a near disappearance of Starry Flounder (*Platichthys stellatus*) in the shallow areas where they were formerly dense, this appears in the landings data within the logbooks as well (figure 7.4). A decline in Dover sole (*Microstomus pacificus*) presence in the mid 1980's was described in interviews, which can be somewhat reflected in (figure 7.4) in 1986 when catches dipped although logbook consistency for 1986 was very low (figure 2). Strong year classes of black cod (*Anoplopoma fimbria*) were also often noted, including the current stocks which were perceived to be exhibiting a period of high abundance, again introducing a challenge in maintaining the quota levels to cover incidental catch when targeting other species like Dover sole. The interaction between species, annual and inter-annual variability of individual stock density and the available quota are important drivers in fleet behavior for management to be aware of in future stock allocation and utilization efficiency. One fisherman discussed this in relation to fishing Dover during spawning season:

> *"Dover group up in February and March, and you can get bigger tows then. You can get 30-40,000 pounds on a tow in 30-40 minutes. But the Sable [fish] that comes with it slows you down. Back in the day you didn't worry about it…we would go drag wherever we wanted and go catch whatever we wanted. But it's not that way now."*

The experiences of the fishery by interviewees who were active during the earlier periods from the 1970's-1990's portrayed an industry which prosecuted a greater diversity of target stocks than the contemporary fleet. The broader swath of target species was concurrently reflected in the logbook entries of these times. English sole (*Parophrys vetulus*), starry Flounder, arrowtooth flounder (*Atheresthes stomias*), rex sole (*Glyptocephalus zachirus*), Pacific sanddab (*Citharichthys sordidus*) and Sand sole (*Psettichthys melanostictus*) were commonly identified as high value flatfish species abundant in the 10-30 fathom range of the Oregon coast. Several species of rockfishes such as Canary, Widow (*Sebastes entomelas*), darkblotched (*Sebastes crameri*) and Yellowtail (*Sebastes flavidus*) were also of prevailing interest. Black cod or sablefish (used interchangeably on the Pacific West Coast) as well as big skates (*Beringraja binoculata*) were species of interest to the nearshore sector of the groundfish fleet. The skate market was described as variable, with note that SEK rarely surveyed these stocks as they were frequently distributed within the range of 10 fathoms and shoreward. The ability to target on a greater diversity of species was associated with the processing and marketing landscape of the Oregon Coast at the time. The option of selling to multiple buyers who specialized in marketing different species allowed the fleet to diversify their catch.

> *"…When I fished [Starry & Arrowtooth] flounder I fished inside of 30 fathoms. And some years I fished, it was pretty good! I'd have a mixture of flounder which was going for around .40 cents a pound, and sand sole which were going for .90 cents a pound, and a few English [sole]. And then there'd be some oddball stuff in there…I had a market for about 150 fish, and that's what they'd let me catch."*

Those with exposure to the nearshore groundfish fishery in the 1990's portrayed the state of groundfish resources on the shelf as comparatively decimated, but spoke with relative enthusiasm on the resurgence of depleted stocks they were seeing at present. Speaking about the pending access to areas formerly closed off by the trawl RCAs one fisherman noted:

> *"It'll be interesting to see the more we fish in there how that is now that the volume of fish has come back in the ocean. Because we go to sea now, fill out boats up twice as quick as we used to. It's amazing how quick the ocean bounced back. I mean, did we really ever have it overfished or did the fish just move because of all the pressure we were putting on them? I don't know."*

With nascent remedial intervention in bycatch reduction or management of individual stocks in the 1980's and 1990's, trawlable habitat and catch did not pose limitations on fleet harvest activity (Hannah, 2003; PFMC, 2016; NMFS, 2018). The gear types which were preferred for this period (Table 2.2) enabled the fleet to access high relief areas to target rockfish species using roller or rock hopper apparatus and there was frequent mention of high bycatch for species such as Pacific spiny dogfish (*Squalus suckleyi)*. With the addition of the footrope restrictions and the requirement of selective flatfish trawl gear accompanying trawl RCA implementation in 2002, these regions of the nearshore and corresponding target species became less accessible to the trawl fleet (Warlick, 2017; PFMC, 2016; King et al., 2004; Bellman et al., 2011).

Avoidance of protected rockfish species, specifically canary and yelloweye was a point of wariness for the fleet. Prior to its declared rebuilt status in 2015, fishermen were fearful of encountering Canary in tows, as these "balls of orange" coming up in the nets posed a threat of closure or painful financial fallout for the perpetrator. As the protected stocks have shifted into healthy levels again, limits of available stock to cover large groups of these species remained an element of concern in interviews. The fleet has had to adapt by avoiding or practicing extreme caution in these regions. The overall increase of rockfish species in recent years was insistently spoken of:

> *"…Everywhere it seems like there's more rockfish. There's so much rockfish out there! I think it's just spilling over from not being able to fish there for so long and then the gear changes. So you see a lot more rockfish showing up. Yelloweye, Canaries…you have to have Canary marked up, areas where they like to ball up those edges and you get a pretty good amount of them."*

The rebuilt status of Canary rockfish has alleviated some pressure for the still active fleet members. The protected status of Yelloweye rockfish however, and associated risk of catching one of two large fish which could push a boat over quota possession and launch the individual liable into a search for costly quota to cover the incident remains a source of strain for those engaged in the fishery at present. These apprehensions also manifested in targeting other species with tendencies to co-occur with lower quota or high value quota stocks. Concerns of this nature were often raised in interviews regarding species such as lingcod, rockfish species or Dover sole. The Dover sole, thornyhead, Sablefish management complex (DTS) occurs at the deeper boundary of the nearshore definition of this fishery (Cope & Punt, 2011). Dover were frequently mentioned as a target stock for this fishery, however wariness and necessity of commanding often co-occurring black cod quota when fishing dover was a common point of dissuasion, which has surfaced in literature recently as well as logbook activity (Errend et al., 2019). In earlier periods, the lack of constraining stocks, management and market limitations facilitated greater harvest of Dover sole.

Management

The role of management in shaping the nearshore groundfish trawl fishery was pervasive in the interview data. It is of note that throughout the depiction of management and fleet dynamics in accounts given, management was more often described as an aid to the fishery than not. Chronologically, considering the timeline of the fishery, members of the fleet were quick to illustrate that the rise in capacity of the groundfish fleet overall was orchestrated by the foundational policy changes and subsequent management objectives of the initial MSA enactment in 1976. By incentivizing the buildup of U.S. fleet capacity, and providing financial assistance to accommodate those pursuits, the fleet cites the government as having played a notable role in the initial heavy extraction efforts of fisheries such as West Coast groundfish; this aligns with previously reported research (Alverson et al., 1964; Hsu & Wilen, 1997). When the limited entry and buyback programs were designed to begin consolidation of the recently bolstered fleet, many fishermen were suddenly put out of work. Entry into the fishery became progressively costlier with the decline in vessel numbers and associated permits. Fisheries social scientists along the West Coast have been working to document fleet consolidation efforts and impacts on the fleet, and have witnessed the increasing cost to entry for fishermen (Russell et al., 2016; Russell, 2014; Warlick et al., 2018; Strawn, 2019; Shaw & Conway, 2007). An additional aspect of these consolidation events was the removal of smaller boats better suited for fishing the shallower grounds of the "beach fishery," inflicting further limitation on individuals with an interest in remaining in the nearshore sector. The manner in which the 2003 vessel buyback was conducted also raised some scrutiny among the fleet, as no clause was implemented during execution to prevent fishermen from buying back in. As such, research participants reported that a number of apt fishermen were able to sell their property for high value and buy back while making a profit. A narrative of bankruptcy within the fleet began to emerge surrounding these measures as fishermen described taking out loans with creeping interest rates to cover the mounting financial costs of continued participation.

The necessity of spatial management measures was somewhat contested within interview with the fishing community as a relic of gear restrictions that served the same purpose by impeding the ability to access certain high relief habitat areas vital for many rockfish species. This was somewhat counter argued by scientists interviewed who reported working to assess the gear modification performances during early flatfish trawl adoption measures (Hannah, 2003). Regardless, the spatial management and limitation of gear to selective flatfish trawls shoreward of the RCAs further restricted the grounds utilized by the nearshore non-whiting groundfish trawl fleet. Experimental Fishing Permits (EFPs) were often described surrounding RCA and EFH areas, and the opportunity to collaborate on gear innovations for bycatch reduction and work alongside scientists was reflected as a highly valued and positive experience for members of the fleet. While the high costs of observers remained unpopular, the fleet research participants expressed valuing the chance to work along researchers and demonstrate knowledge of the resource as well as best practices in harvest expertise. According to an interviewee who had recently worked with an EFP:

> *"…It was a positive experience. We went out there and did what we needed to do. We caught fish cleanly, showed the government that 'Hey, they can go in there and do this without making mistakes.'"*

Ultimately the prospect of reducing bycatch, adopting transparency of LEK and SEK in a collaborative capacity and enhancing overall efficiency and communication made EFPs a described valued experience by both fishermen and scientist connected with the groundfish fishery. The attention paid to these collaborative efforts in research is growing, with motivational factors to fleet participation inspired by the opportunity to demonstrate skill and knowledge of the region (as the quote above reflects), or assisting in the outcome of new information which may benefit them through better yields (Pomeroy & Conway, 2006; NRC 2004; Harms & Sylvia 2001). Benefits to scientists included the access to resources such as crew and boats to aid in research, and unique knowledge perspectives to a study environment (NRC, 2004).

The trawl rationalization program and the many accompanying requirements were a central theme in the reshaping of the nearshore trawl fishery. The reaction was tiered, as was the execution of the program. Fishing community research participants expressed some enduring frustration with the determination process for quota distribution during initial rationalization, which was based on catch records. Given focus on volume, some expressed discontent with the lack of consideration given to non-destructive records or documented time as a participant in the groundfish fishery. By allocating quota to so called "heavy hitting" members of the fleet, many individuals raised concern over resource depletion and increasing struggle to trade quota, compounding barriers to pursuing their fishing livelihoods. This is in alignment with previous research (Russell et al., 2014; Kaplan et al., 2013; Nayani & Warlick; 2019; Errend et al., 2019).

Research participants reported that due to the requirement of 100% observer coverage and total accountability with the advent of the IFQ program, cost hikes abounded for fleet members. This extended to members of the fleet who owned quota but are not longer interested in fishing it who leased their quota to other active participants. These individuals were referred to often as "leasers" or "mailbox fishermen":

> *"…The way I look at it, the IQ's [IFQs) brought in two new user groups. One was the observer industry, now you're paying $500 or so dollars a day…and then you have the other people that don't want to trawl anymore. It used to be if you had a permit, yeah it was limited entry, but to make money off that permit you had to have a boat and you had to be fishing it! Well now, you don't have to. So it created another little industry of paper holders that you still have to pay off. And I don't want to talk all the bad things of the IQ, because there's good things too, and of course the discards is one of them."*

Observer fees and their steady increases were a tenuous subject which arose in nearly all interviews regarding the management of the fishery. For lower volume vessels, this financial hurdle was constantly a point of strain.

The IFQs were also promoted in a favorable manner in discussions. According to one groundfish community member:

> *"You know the IFQ and all that…it made us better fishermen. We had to fish cleaner, because, even though a lot of the stuff that was discarded went against our quota it made us cleaner fishermen. Before, well, there's some stories I don't want to repeat in here."*

A subtler management impression on the fleet which emerged from interviews was changes in interaction between the remaining participants in the nearshore sector post fleet consolidation. Studies on the impacts of IFQs show that communities change under these systems in physical features such as vessels and processing infrastructure, and socioeconomically (Russell et al., 2016; Karlsdottir, 2008; PFMC 2017). In contrast to the traditional incentive to maintain secrecy over fishing hotspots and limit disclosure of information perceived as vital to long term prosperity within the industry, the IFQ was credited by many as offering a transformative property to fleet communication patterns. Given the decline in nearshore fishery participants over time, the individuals who remained began sharing information and finding networks to trade and capitalize on quota. This quote encompassed some of that impact:

> *"The IFQ thing made us cleaner fishermen, avoiding areas with small fish, and I think, as fishermen, we talked amongst ourselves and we'd say oh, I had a tow of small Sable [fish] by such and such so guys can avoid that, where back in the old days you didn't give out anything, we didn't even talk!"*

Other participants noted the value of communication in maintaining quota value and utilization:

"I never would have talked to the [identification removed] before, because they're their own little renegades, their own little group…and I've traded fish with them! So, that's how it's evolved. They called me today and said hey, what are you doing with your Yellowtail [rockfish]? And I said well, probably nothing… why do you need them? And they said yeah, we'll give you a nickel a pound for them. So I got a nickel a pound for something I am not even gonna go fish. So yeah, it's a different game and we're all learning how to play it more and more every year."

The Environmental Defense Fund hails catch shares as a tool shifting the industry towards a harmonizing role in the stewardship of fisheries, an investment in the sustainability and the future of the resources which provide their livelihood. During the 5-year review of the Catch Share Program in 2017, the PFMC reported successes including bycatch reduction, significant decreases in discard mortality which shortened rebuilding plans, and greatly increased net economic benefits (PFMC, 2017). The introduction of catch shares in 2011 shifted the need for RCAs as the catch share program was designed to create self-motivated incentives for fishermen to avoid overfished species. This led to a narrative within the fleet and PFMC on how to collectively detail knowledge of the sea floor habitat to plan and open areas of access which would maintain protected EFH and RCAs but allow the resource users to most fairly and effectively utilize them (EDF, 2018; personal memos, PFMC meetings). Many interviewees that are still active in the fleet expressed great enthusiasm for renewed access to some of these areas.

PFMC meetings are accessible to the public and encourage public testimony of vested parties on agenda items to be addressed. During attendance and observation of 3 meetings in different regions of the Pacific North West, attendance and testimony by the fleet or scientific researchers presenting findings relevant to agenda items was inconsistent. Conservation agency scientists and representatives from large processing plants along the coast more frequently attended and gave testimony and exhibited familiarity with council members as well as GAP and GMT advisory bodies. The fishing community described limited attendance largely as time and cost prohibitive issues in interviews, but there was also a sense of inaccessibility of scientific or council rhetoric and a sense of futility regarding the credence ascribed to testimony from small stakeholders which were frequently cited as deterrents:

"…When you have meetings that are spread up and down the coast like that, it costs a lot of money to go to those meetings! So, these little boats, they hardly ever go to the meetings. I went to a few but

> *nobody wanted to hear anything I had to say...they just wanted to hear what the big boats were doing."*

Another framing of this experience:

> *"…It is interesting, but again, I don't want to chime in on things that I don't understand, I am so far behind! Who cares what I am doing out of [location] you know? Some pilgrim that doesn't own any quota, I don't own a permit, I lease everything. What right do I have to get up and speak?"*

Themes which emerged from LEK interviews surrounding the gear and fleet, management, market, fish and future provided a narrative from the PFMC which overlapped with fleet themes from ongoing interviews as well as providing temporal construct to the PFMC proceedings. Reiterated through exposure to management council meetings, LEK interviews disclosed the lag in scientific information and its dissemination into management measures. For the fleet, these frustrated sentiments arose from statements of witnessing greater numbers of fish at sea than management was indicating from GMT summaries. The sources of these delays were discussed as a product of council staff capacity, consistency of scientific information and funding. The GMT and council staff chronically mentioned needing more time to assess and write up reports during council proceedings:

> *"…It was the 2017 assessment…and coming out of that you're looking at management for 2019 and 2020! So that's another thing that makes our system interesting, the lags between data collection and going through assessments, preparing specs, and when you finally get them into regulations."*

From the fleet perspective, a similar sentiment:

> *"So if someone goes out in the water, and the assessor looks at it, there's a two-year lag time before you can actually catch those fish! And that is frustrating. They cut very quickly, which it not a bad thing but they can't go up very fast."*

Interestingly, Harms and Sylvia (2001) and many others found that while the opinions of resource abundance were not consistently aligned between scientists and fleet, when it came to sustainable harvest levels and conservativism toward stocks and economic vulnerability, they were largely overlapping (Moon & Conway, 2016; Hannah & Smith, 1993; Smith, 1995; Young, Smith & Muir, 1996; Garcia & Charles, 2008). This is an example of where despite differing paradigms, multiple stakeholders and ecological knowledge expertise can unify to better commonly valued and accessible resources. Areas of concern within the fleet such as better seasonal moderation of spawning stocks or endemic habitat knowledge may be opportunities to expand these collaborative efforts.

Those interviewed often discussed the tendency of management to air on the very conservative side of quota allocation and the lack of scientific surveys of the nearshore as a hindrance to fishery economic productivity and utilization. The translation of these surveys into quota allocations and the low constraining stock quotas allegedly limited fishery utilization. Yelloweye rockfish and Canary rockfish were the most common examples, but overall the desire for a reconsideration of the quota allocation process to better assist the fishery participants in obtaining sustainable catch numbers for healthy stocks was portrayed with some urgency in interviews:

> *"We were finally going to be able to go fish on the beach and exhale, because you never really knew! I mean the stocks were rebuilt for what, two or three years before they finally allocated it to us? You pull a bag up and you see bubbles, I am always targeting rockfish you know, and Cod Fish, there again on the beach…I can't go out and make money on Dover, I gotta go out and really gamble, and catch decent fish! Which would be Cod Fish, or my greenies [Yellowtail rockfish], right with those things live Canaries [rockfish]. So, I am sitting right there and you see this bag bubbling, so you know you got something, but you're sitting there worrying…"*

Contrastingly, the allocation of greater amounts of quota distributed within the fleet for species like petrale and Dover elicited impacts on flooding the market and lowering value for these species, as well as the desirability of the quota value for trading. Given that Dover and petrale in particular were described as being heavily targeted on during their spawning aggregations, several research participants raised concerns and desires for better monitoring of seasonal harvest so as to better conserve the quality and quantity of their most prominent stocks:

> *"You know the sad part of it, whenever we caught big big schools, they were always spawning. And then when they were trying to limit everything, I tried to tell them why don't you just shut off on the spawning? That'll help! But they didn't look at that, they look at the fish number as a number, and that number, well, if that fish might complete the spawn cycle it might be another million eggs out there trying to create more fish! But they just had a different throught when it came to the quotas you know? And that would hurt because petrale, that was always the best fishing when they were spawning."*

Moving forward, interviews with both retired and active members of the nearshore groundfish trawl fishery offered a mixed sense of cautious optimism and defeat regarding the future of the fishery. The removal of the trawl RCAs was largely interpreted as an opportunity for smaller boats to move in and target the valuable nearshore stocks again, namely petrale, Sanddabs, and Sand sole. The options for engagement with nearshore groundfish sector were anticipated as offering limited opportunity for private ownership, with major constraints to any member attempting new entry to the fishery. The rationalization process is still unraveling with the recent release of IFQ sales in the management timeline, but the voices of the remaining fleet presented enthusiasm and persistence for the possibilities of the fishery and future management.

Gear & Fleet

The nearshore groundfish trawl fleet, or those who fish "the beach," were quick to self-identify as smaller vessels, specialized to Flatfish species and an increasingly diminishing group within a largely consolidated fishery. Many identified their start in the fishery stemming from family who also fished the nearshore region, many second or third generation. They reflected on experience and preference for the beach fishery given familiarity or endemic knowledge of the grounds, the ease of shorter tows and less costly wire to let out in shallower depths. Other aspects which made the nearshore favorable were closer grounds and proximity to port regions, which also provided a buffer from the often-hazardous weather of the Oregon coast, as well as fewer "hangups" to encounter (referring to shipwrecks or high relief rocky habitats). Those who inherited boats and knowledge from family members learned how to get close to target species without getting caught on derelict gear, wrecks or habitat. They described remaining in the fishery as an intuitive step but one which is harder for present new entrants, corroborated by recent research on these fleets (Russell et al., 2016; Leonard & Steiner, 2017; Kaplan, Holland & Fulton, 2014; Strawn, 2019).

Those present in the early days of the fishery following the MSA described the boats and gear as more primitive, consisting of small wooden boats with no stern ramps, lower power, menial plotting and navigational technology and the compounded challenge of a developing domestic processing industry. Tow durations were longer (in both interviews and logbook records) and the target species more generalized. One member of the groundfish fleet mentioned the weight of the groundfish disaster as a severe warning and motivator of change in fishing habits for the fleet:

"…they'd do tows that were forever long, I mean they'd just set the net and kind of snooze and all of a sudden 13 hours later they would bring up whatever! And I think really because of the groundfish disaster, that fishermen started realizing they couldn't really be fishing the way they were…and it wasn't like the fishermen didn't know these things, it was just there were no rules that told them not to do it. And so, the minute rules came along they followed the rules… so regulations saved the fishery because it helped the fishermen change their mindset."

As the gear regulations emerged, the fishery transitioned into required adoption of the selective flatfish trawl gear, or "pineapple trawl." With these changes, set against a waning array of processors and an inconsistent market, the fishery shifted energy and focus to higher value Flatfish species. While manipulation of mesh sizes and engagement with ODFW and EFP programs to further reduce bycatch continued, the pineapple trawl was described as the most revolutionary alteration and adoption to the gear makeup of the fleet. Transitioning to GPS and navigational plotter systems in the 1980's and 1990's allowed the fleet to modernize their gear and streamline fishing ability and weather prediction tools enhanced safety and timing of fishing effort. Wooden boats were widened and lengthened, updated with more powerful winches and hydraulics and some transitioned to steel with larger stern ramps, but many of the boats present in the modern fleet were described as the same or modified vessels from the early fleet.

Increasingly within the evolving landscape of the fishery and its management, those who fished nearshore groundfish described using it as a filler fishery for periods between shrimp and crab fishing seasons, and sometime only when those fisheries were performing marginally. Many also describe the ability to switch within these fisheries as a product of their existing knowledge of the nearshore grounds from this diversification.

"The most successful fishermen are only in groundfish for a few months, they fish that in the summer, which is historically the shelf fishing. The nearshore is a summer driven fishery. In the fall and winter they're gonna go more deep for black cod and Dover and such."

The contemporary fleet raised a number of internal concerns, many of which stemmed from the trawl rationalization program. Temporally, consistent members of the fleet described external participants such as so called "rent-a-skippers," foreign venture participants and the Alaska migratory fleet as having less incentive to utilize the fishery in a manner promoting long term resource vitality and investment. The consequential aftermath of those impacts on the resource was felt to be dealt in an unfair hand to long standing participants. Another repeated trepidation centered around the further division of profits to what were described as an emergent sector of the groundfish fishery, the observer industry and those who lease quota they no longer activity fish. Observer costs are not amended to lower volume smaller venture fleets, which Russell (2014) also observed in the fishery, as study participants recounted that boat size and harvest amounts lead to much smaller profit margins versus larger trawlers such as some of the offshore fleet.

Market & Processors

A major determinant in target species and overall effort for the groundfish fishery arose through the fluctuation of market demand and the shifting processing makeup of the Oregon coastal regions. Formerly, the fleet described being able to capitalize on the abundance of processors, including the potential to advocate for their livelihoods through organized strikes and marketing associations. Of the described 25 or so processors for non-whiting groundfish, there are presently only 5 major plants who buy these fish at present (Oregon Trawl Commission, 2017). With the continued consolidation of processors, the ability to push for better prices and species diversity has dwindled. The coevolution of ex-vessel prices with mounting costs to participation in the fishery were largely expressed as insufficient to promote profitability for fleet members. For some species, ex-vessel prices were said to have become increasingly more depressed. Economic data from PacFIN trended towards validation of these experiences:

> *"I had some better prices in 1986 for some of the species, they were better than they are now. English sole .41 cents, Rex [sole] .41 cents in 1986 and now they're offering us .25 cents? And if you go up to 2,000 [pounds], it might be a dime…and you know, I am just not gonna do that anymore."*

Processors noted shortages in filleters and plant labor influencing ability to buy and move groundfish catch and the struggle to compete with low cost farmed fish which cornered a new market in the midst of the fishery collapse. Even petrale, the most consistently favored by market and ex-vessel price was portrayed as struggling to compete with farmed fish in the consumer sector. Marketing groups such as Positively Groundfish are working to rebuild the groundfish name and market through Marine Stewardship Council (MSC) sustainability certifications and local engagement, but the mounting factors counteracting profitability have continued to stint the harvest capacity of the fleet.

In interviews, market demand was described as variable, and shaped the target stocks for the fleet including obscure markets which surfaced periodically through time. Examples of this were profuse in LEK interviews. English sole was a desirable target species for the nearshore fleet prior to the 70's, but fell from consumer favor according to market and fleet participants has yet to experience a resurgence in demand. Dover experienced a surge a shift into high volume extraction during military contract market demands, which lapsed as the Vietnam era military activity abated. The market price of Dover also dictated its utilization as more of a volume fishery, potentially further disincentivizing the targeting of Dover stocks and quota allocation amounts in more recent decades. Sand sole, while portrayed as a plentiful and high-quality species within the nearshore through time, have not maintained a stable market for the fleet. Much of this was mentioned to correlate to an inability to consistently supply a market during stock rebuild and restrictive management:

> *"Sand sole used to be a really big fishery for us, and now that's gone away. Ever since all the regulation when the beach fishing went away for us for a while, when you don't supply that market it's hard to get it back."*

In the modern landscape, the processors and leasers control quota as well, driving up cost of participation and quota on high value species in particular. Participants noted continued concern over the actual lucrativeness of the groundfish fishery:

> *"…It's hard when profit items, the stuff that's a little higher ex-vessel price, like black cod and petrale, are the ones that have the big lease fees, because owners are taking the profit out, because that's the way the system is!"*

As another fisherman put it:

> *"We're doing all the work, and there's not very many of us. And we're not seeing the benefits of it. So it's really frustrating, the marketing side. And is costs so much more to do now! Yeah, our catch rates are more than they used to be…but our costs are way, way higher: observer costs, lease rates, you know."*

An area where several fleet members expressed enthusiasm moving forward was through continued focus on quality of product both for opportunities to increase nearshore lower volume ex-vessel cost and market desirability. The prospect of getting fish to the dock and to the market faster given closer proximity to port regions was a component of this discourse seen to put the nearshore fleet at a marketing advantage if executed with consideration and finesse. An additional described advantage to the beach fishery and pursuit of higher quality fish and markets was small vessel fish holds limiting damage to product, and close proximity to ports allowing for rapid delivery to the markets.

2.4.3 **Potential Benefits of Combining SEK & LEK**

Given the broad temporal review this research employed and curation of interview subjects to include a swath of fishery participants from varying periods of the groundfish fishery management evolution, the narrative engages with a highly diverse array of experiences and challenges. Through time observer fees, spatial closures, fleet and processing plant consolidation, market instability and cheap farmed fish competition have all made sustained participation restrictive to many of the nearshore fleet. It is overall a fishery which has been shaped by the ecosystem, market and intensive consolidation of what already existed as a fairly minor specialized fleet. The small size of the vessels and the diversity of the fishery allowed early participants to capitalize more fully on the nearshore stocks. With the

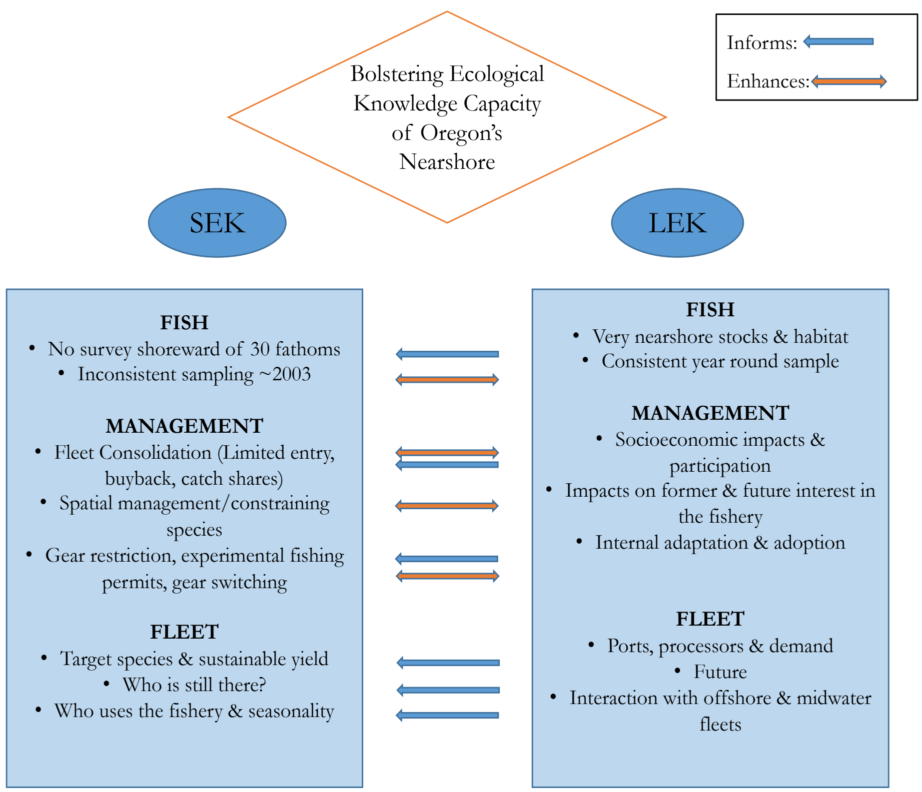


Figure 2.10 Informing & Enhancing SEK with LEK.
Relative contributions of SEK and LEK to augmenting ecological understanding of nearshore groundfish fishery & fleet participation through time from PFMC observation, interviews with SEK and LEK participants. Blue arrows inform and orange arrows enhance existing or missing SEK.

collapse of the fishery and measures adopted to restore it to ecosystem health and FMP goals, the fishery has transitioned to a flatfish fishery, and most consistently, the targeting of high value petrale Sole.

The emergent LEK and SEK relationship and their respective capacity to inform management moving forward to further integration of SEK are displayed in (Figure 2.10). The SEK considered for this work are the fishery-independent surveys and accumulated body of scientific research literature from studies on Oregon groundfish species and habitats, including documents compiled from the GMT. The LEK comprises the Oregon trawl logbooks, fish tickets, interviews with fleet members, and processors. Referring to Figure 2.10, the temporal and spatial engagement of the fleet with the very nearshore resource can inform the science of minimally surveyed nearshore fish stocks and habitat. The logbooks, as well as LEK can offer a consistent year-round sample to compare to the broader nearshore definition, which became the subject of more consistent survey efforts in 2003, but increasingly face funding risks. Understanding of the impact of FMP management measures on fleet socioeconomic influences and participation can in turn assist SEK in stock assessment and harvest potential. The successes or strains of EFH and RCA areas as well as interacting species can assist SEK in aiding FMC utilization and economic goals of the fishery, as well as future collaboration with industry to define habitat protection and flexible spatial management. Finally, understanding the inner workings of the fleet and the drivers of fluctuations in target species and harvest volume can aid in SEK adaptation of stock protection and better information for quotas. The processors and market demand play in integral role in the species the fleet targets, the fleet is consistently consolidating and many external "rent a skippers" or less vested participants may be using the fishery in different manners than the resident fleet. The seasonality of fishery use by the offshore fleet, such as described for spawning seasons of petrale and Dover are all vital to the successful monitoring and subsequent management of the fishery. The combined capacity of SEK and LEK to bolster the knowledge capacity of Oregon's nearshore has the faculty to address these gaps in regional management understanding and provide opportunities for the engagement of scientists and fishermen in coastal communities. These undertakings require a commitment to the effort of maintaining partnerships and combating participant discord so as to foster successful outcomes of these efforts for both human and biological dimensions (Pomeroy & Conway, 2006).

2.5 Conclusion

The findings disseminated in this research are a representative subset of the activity of the fleet and the ecological dimensions of the nearshore groundfish fishery from 1976-present. Results from this research have exposed the nearshore sector of Oregon's groundfish trawl fishery as a niche fishery which is in the nascent stages of recovering from a challenging 20-year period of management reform and fisheries rebuilding. Less tangibly, this research recognized the self-contained identity of a small, specialized subset of the broader Oregon groundfish trawl fleet, whose endemic knowledge and experiences of the nearshore shelf region prove invaluable to reconstructing the history and social constructs of this unique ecosystem. The experiential knowledge and consistency in exposure of the nearshore groundfish trawl fleet offers a detailed and long-standing record of drivers and health of the fishery both spatially and temporally. Adopting these findings and contacts within the fleet community establishes a baseline for ongoing conversations, cooperation and prospective collaboration among scientists, fisheries managers and fishermen moving forward. At a broader level, these methods may provide insight into the capacity of exploring the combination of fisheries-dependent and -independent data and knowledge to overcome deficits in monitoring, funding for monitoring and increase communication between coastal stakeholders.

Warlick et al. (2018) found that constructing and adapting fisheries management plans for highly dynamic multispecies fisheries like the U.S. Westcoast groundfish fishery is greatly enhanced by the use of historical reconstruction of management measures alongside internal industry variability. Though West Coast groundfish has been the focus of much natural and social science research to meet the needs of conservation and community alike (ODFW, 2015; Keller et al., 2017; Bellman & Heppell, 2007), the nearshore history of the fishery portrayed in this study had been largely undescribed. Integrated understanding of how management measures and changes in the industry have impacted this fishery would benefit from the inclusion of this smaller sector of the nearshore groundfish trawl fleet. In a localized manner, the LEK of an individual fisherman emerges from a particular circumstantial context and may be an amalgam of perceived interaction with intergenerational knowledge, media, gear, management and scientists and peer or source insight and shared information (Murray et al., 2006). In this study, employing the detailed ecological knowledge and experiences of the nearshore fleet resulted in a more comprehensive understanding of this fishery sector and ecosystem.

Epistemologically, by using integrated mixed methods to explore this small, specialized fishery and area of coastal habitat, this research illuminates non-intuitive perceptions and sources of ecological knowledge from refined and diverse experiences of a broadly accessed resource. By adopting these methods, this research has also explored approaches to navigating the perceivable complexities of disciplinary-disconnects between perceptions of an intersecting marine resource, and the importance of incorporating both SEK and LEK into further collective dialogue in research of this nature. With increasing coastal populations, heightened environmental and climate variability and changing oceans, marine resources, fishing communities and policy will continue to overlap and face limitations in time and financial reserves to implement rapidly adapted management of fisheries. Exploring non-conventional sources of ecosystem knowledge and concurrently enhancing communication and engagement in the science and management process benefits the longevity of coastal communities and ecosystem services.

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CHAPTER 3 **SECOND MANUSCRIPT [Oregon Sea Grant Publication]**

Lost in Plain Sight: Understanding the Evolution of Oregon's Nearshore Groundfish Trawl Fleet through Local Ecological Knowledge

Project Synopsis

The West Coast groundfish fishery has proven itself to be one of the more diverse and presently underutilized fisheries along Oregon's active fishing landscape. The fishery collapse in 2000 and successful recovery through the concerted efforts of management, science and fleet continues to garner the attention of researchers, conservation agencies and the public alike.

Those involved in the groundfish industry are working to rebuild the market and reconnect with a formerly active fishing ground along Oregon's coastal regions. Specifically, while the offshore Pacific Whiting (*Merluccius productus*) fleet and deeper water fisheries have remained somewhat more consistent, the nearshore sector, which for the purpose of this work was defined as the region of shelf extending seaward to a water depth of 110 fathoms (200 meters or 660 feet), has become increasingly untouched by the commercial groundfish trawl fleet. The reasons behind this are complex, but rooted in the myriad changes to the management, fish stocks, markets and fleet which have occurred in this region since the late 1970's.

The nearshore is of particular value to flatfish species (*Pleuronectiformes*) as a nursery and settlement habitat, being an area rife with diverse habitats such as rocky reef, sandy and soft muddy bottoms. In addition to being important nursery habitat, the continental shelf region is an important area for the recruitment of many species of groundfishes, which tend to settle within the shelf region and make this area a desirable trawl sector for the Oregon groundfish fishery (Pearcy, 1978; Sobocinski et al., 2018; ODFW, 2016). The very shallow portions of the Oregon Coast (the portion of the shelf inshore of ~30fm (180 ft or 55m) have been the subject of little to no scientific survey monitoring, and much of the details of the ecology, health and processes in these habitats remain poorly understood. In designing this research, it became increasingly apparent that there are many unexplored sources of tailored knowledge regarding the nearshore ecosystem resource, pooled in the notes and minds of the many scientists, fishermen, processors, and others whose lives and interests have intersected with this region of the Oregon Coast. The challenge lies in synthesizing these endemic ecological knowledge sources into a more comprehensive and insightful picture of this fishery and geographic province. Connecting narratives and information on the development of the management, fish stocks, and the fleet through time present an opportunity to holistically understand where the health, value and future of this nearshore fishery lie based on its storied past.

3.1 **Introduction & Background**

Oregon's Coastal Nearshore

In 2006, Oregon Department of Fish & Wildlife (ODFW) publicly introduced a new chapter to its coastal conservation and marine resource management efforts by identifying a strategy specific to its less consistently addressed nearshore resources. Foundationally, the nearshore agenda outlined a series of goals directed at improving communication and partnerships, generating stronger science and information, and constructing a better decision-making process to promote the participatory sustainability efforts of this resource for its diverse coastal stakeholders. According to this strategy, the nearshore ocean was designated to include all area from the coastal high tide line offshore to the 30-fathom (180 ft or 55 m) depth contour (ODFW, 2017).

What necessitated a stand-alone mitigation strategy for this highly specific region of Oregon's coast? In addition to being nested within the intersection of human recreational activity, coastal communities and local economies, the nearshore is also home to a wealth of enduring ecosystem services which are of key concern to managers and stakeholders alike (Pomeroy et al., 2014). The Oregon Coast specifically hosts an expansive and diverse coastline rife with commercial and recreational fishing opportunities. Commercial fisheries in Oregon generated $151 million in revenue in 2018 and supported an estimated 1310 jobs (State of Oregon Employment Department, 2019). The Dungeness Crab (*Cancer magister*) and Pink Shrimp (*Pandalus jordani*) fisheries occupy significant percentages of these earnings in the nearshore, however, groundfish fishery is also a consistently significant contributor to the local economy (Strawn, 2019).

While the trends and use of the larger offshore whiting groundfish fleet have been increasingly well assessed (Warlick et al., 2018; Holland, Steiner & Warlick, 2017; Errend et al., 2019) particularly since the fishery's successful management and recovery, the nearshore sector of the non-Whiting fleet remains largely overlooked. Much of this hinges upon a lack of persistent monitoring and management of the Oregon nearshore region shallower than 30 fathoms (180 ft or 55 m) explicitly, contributing to a high degree of oversight surrounding a small, specialized group of commercial fishermen participating in the groundfish fishery for over 40 years. Compounding this with the broader nearshore strategy goals, this research was designed as a way to explore whether a more comprehensive reconstruction and understanding of broad timescale trawl effort in the Oregon nearshore could be extracted from the combined knowledge of the commercial fishing community, fisheries managers, and fisheries scientists. Additionally, while gleaning a better realization of what has impacted these small nearshore fleet members, we explored whether their collective experiences of this area through time might contribute ecological knowledge to this lesser studied habitat.

Our process began with the gathering of rich fisheries-dependent data in the form of commercial trawl logbooks, fish ticket landing documentation, industry participation and a wealth of scientific trawl surveys in peripheral regions of the coast. The outcomes of this work provided a unique and exciting opportunity to combine local ecological knowledge (LEK) with the potential to inform and enhance scientific ecological knowledge (SEK), regional management and users of Oregon's nearshore resources.

What are groundfish?

In Oregon, California and Washington, groundfish refers to a wide variety of what broadly or culinarily would be considered as a "white fish". More scientifically, these are demersal species of fishes known to associate commonly with bottom habitats. The Pacific Fishery Management Council (PFMC) manages 64 rockfish species (*Sebastes, Sebastolobus, Scorpaena)*, 12 flatfish species (*Pleuronectiformes*), 6 roundfish species (sculpin, Cotidae; greenlings, Hexagrammidae; cod and hake, Gadiformes, and sablefish (Anoplopomidae), and 4 elasmobranch species (sharks and skates). In addition, the PFMC designated a number of elasmobranchs, macrourids (grenadiers) and a morid (codling) as species managed by the FMP. Of these, 39 were confined to the area designated for this research and are shown in Table 3.1 below.

The sheer diversity and productivity of fishes managed within the West Coast groundfish group allows for local, fresh fish to be available nearly year-round when the fishery is maintained in a healthy and sustainable manner. In striving to maintain this

Table 3.1 Logbook Species Codes, Common & Scientific Names & Management Categories of Nearshore Groundfishes.
Logbook species code, common and scientific name and management categories for 39 nearshore groundfish species codes.

LOGBOOK SPECIES CODE	SPECIES NAME	MANAGEMENT CATEGORY
EGLS	English Sole (*Parophrys vetulus)*	Flatfishes
RSOL	Rock Sole (*Lepidopsetta bilineata)*	Flatfishes
PTRL	Petrale Sole (*Eopsetta jordani*)	Flatfishes
DOVR	Dover Sole (*Microstomus pacificus*)	Flatfishes
REX	Rex Sole (*Glyptocephalus zachirus*)	Flatfishes
STRY	Starry Flounder (*Platichthys stellatus*)	Flatfishes
BSOL	Butter Sole (*Isopsetta isolepis*)	Flatfishes
SDAB	Pacific Sanddab (*Citharichthys sordidus)*	Flatfishes
SSOL	Sand Sole (*Psettichthys melanostictus*)	Flatfishes
CSOL	Curlfin Sole (*Pleuronichthys decurrens)*	Flatfishes
ARTH	Arrowtooth Flounder (*Atheresthes stomias)*	Flatfishes
MFLT	Miscellaneous Flatfish species (*Pleuronectiformes)*	Flatfishes
NSRF	Unspecified Nearshore Rockfish (*Sebastes* spp.)	Rockfishes
SHRF	Unspecified Shelf Rockfish(*Sebastes* spp.)	Rockfishes
SMRK	Small Rockfish (pre-2000) (*Sebastes* spp.)	Rockfishes
LGRK	Large Rockfish (pre-2000) (*Sebastes* spp.)	Rockfishes
POP	Pacific Ocean Perch (*Sebastes alutus*)	Rockfishes
DBRK	Darkblotched Rockfish (*Sebastes crameri*)	Rockfishes
WDOW	Widow Rockfish (*Sebastes entomelas*)	Rockfishes
YTRK	Yellowtail Rockfish (*Sebastes flavidus*)	Rockfishes
SBLY	Shortbelly Rockfish (*Sebastes jordani*)	Rockfishes
BLCK	Black Rockfish (*Sebastes melanops*)	Rockfishes
BLUR	Blue Rockfish (*Sebastes mystinus*)	Rockfishes
CNRY	Canary Rockfish (*Sebastes pinniger*)	Rockfishes
BCAC	Bocaccio Rockfish (*Sebastes paucispinis*)	Rockfishes
YEYE	Yelloweye Rockfish (*Sebastes ruberrimus*)	Rockfishes
THDS	Unspecified Thornyhead (*Sebastolobus* spp.)	Rockfishes
SSPN	Shortspine Thornyhead (*Sebastolobus alascanus)*	Rockfishes
LSPN	Longspine Thornyhead (*Sebastolobus altivelis)*	Rockfishes
PCOD	Pacific Cod (*Gadus macrocephalus)*	Roundfishes
SABL	Sablefish (*Anoplopoma fimbria)*	Roundfishes
GRNL	Unspecified Greenling species (*Hexagrammos* spp.)	Roundfishes
LCOD	Lingcod (*Ophiodon elongatus)*	Roundfishes
CBZN	Cabezon (*Scorpaenichthys marmoratus)*	Roundfishes
DSRK	Pacific Spiny Dogfish(*Squalus suckleyi)*	Elasmobranchs
SRKFMP	FMP Managed Shark species Tope Shark (*Galeorhinus zyopterus*) Leopard Shark (*Triakis semifasciata*)	Elasmobranchs
SKAT	Skate species (*Raja* spp.) Big Skate (*Beringraja binoculata*) Longnose Skate (*Raja rhina*)	Elasmobranchs
GRDR	Pacific Grenadier (*Albatrossia pectoralis*)	Other

resource, the structure of groundfish fishery management on the West Coast has evolved to protect the habitats these fish live in. The Oregon coastal continental shelf region comprises various habitat types. NOAA ecologists Yoklavich & Wakefield (2015) described the nearshore area seaward of 3 km [1.86 mi] from shore as Continental Shelf habitats which include patchy distributions of rock outcrops, pinnacles, and boulder fields surrounded by low-relief sand, mud, and cobbles. Other than a few notable offshore rocky banks (e.g. Heceta Bank, Cordell Bank), the vast majority of bottom on the Continental Shelf is composed of sand and sandy mud sediments. All of these features serve as essential fish habitat (EFH) for critical periods of the life history of these commercial fishes (PFMC, 2016).

Figure 3.1 Yelloweye Rockfish.
Yelloweye rockfish catch has been severely restricted due to overfishing, but they're recovering much faster than expected. Courtesy of NOAA.

Rockfish species in particular are slow growing and live for staggeringly long times; some, such as Yelloweye (*Sebastes ruberrimus*), for over 100 years (Love, 2011; Welch, 2017). Older Rockfishes in the population, specifically females, tend to produce stronger broods and present greater odds of survival during periods of unfavorable environmental conditions (Hixon, Johnson & Sogard, 2013). When their numbers plummet below a certain threshold, the remaining population becomes increasingly at risk. The protection of these species as their numbers declined alarmingly in the 1990's led to the implementation of seasonally alterable Rockfish Conservation Areas (RCAs) in 2002. The RCAs supported designated protection areas from a variety of trawl gear configurations to support rebuilding plans for seven fisheries management plan fish stocks. These covered select areas of the continental shelf regions of the West Coast of the United States and were bolstered in 2006 by an official Essential Fish Habitat (EFH) amendment to the fisheries management plan.

Trawl Gear

Trawl gear deployed in the ocean off of Oregon consists of conical nets towed behind vessels either on or off bottom in the form of roller, bottom or mid water trawls.

Figure 3.2 Selective Flatfish Trawl Gear.
Selective flatfish trawls are the most commonly employed gear type in the nearshore since the fishery collapse in 2000. This image details the size and major components of this trawl net type. Adapted from ODFW 2016.

Trawl gear is typically tailored to individual vessels, targeted catch complex, fishing depth and bottom type but may display varying levels of complexity amended to catch or avoid specific species of fish. Since the 1990's the Pacific Fisheries Management Council (PFMC) has worked with fishermen in the community to test adjustments and innovations to maximize exclusion of juvenile or protected species bycatch through the Experimental Fisheries Permit (EFP) program. Much restriction of trawl gear type has been effectuated in the nearshore and continental shelf regions, due to the fact that 6 of the 8 groundfish stocks declared overfished are known to associate with the habitat present in these areas. Large footrope gear was prohibited beginning in 2002, and the mandatory use of selective flatfish trawl gear Figure 3.2), which is designed specifically to avoid catch of rockfish species, began in 2005.

Collapse & Recovery of the Groundfish Fishery

West Coast groundfish has long been a fishery of great social and economic value but has been exposed to considerable strain over the last 40 years. Foreign fleet presence subsided following the enactment of new policies to regain domestic control of U.S. fisheries in 1976. The fishery boomed in the 1980's and 1990's, but as harvest efforts surged and the coast experienced some of the strongest El Niño events in recent history, several groundfish stocks were depleted to critically-low population levels. In 2000, this lead the Secretary of Commerce to declare the West Coast groundfish fishery a failure (Shaw & Conway, 2007). The ensuing financial fallout has been estimated to have cost fishermen $11 million in lost revenue (Warlick et al., 2018). During this challenging and controversial period, scientists and managers worked carefully to create plans to rebuild 10 different stocks of important groundfish species considered to be at risk. Harvest levels were drastically reduced, gear was modified to minimize habitat contact and major spatial restrictions were put in place to protect EFH. Needless to say, the ecosystem, including the many humans whose income and families are dependent on the groundfish fishery as a means of livelihood, reached a point of crisis.

Smaller niche segments of the trawl fleet, like the nearshore commercial groundfish trawl fishery became even more refined as several management efforts moved to further consolidate the fleet in order to reduce harvest capacity and protect resources (Holland, Steiner & Warlick, 2017; Errend et al., 2019). The most significant of these was the implementation of a catch share program in 2011 by the groundfish fishery management plan (FMP), which included a required 100% accountability through observer coverage for commercial groundfish trawl trips and economic data collection. Individual Fishing Quota (IFQ) systems, also commonly referred to as catch shares, are designed to stimulate a reduction in total allowable catch (TAC) and shift toward resource privatization to increase economic productivity. The process of individual allocation of TAC (quotas) to members of the fleet is determined by variables such as gear type, vessel historical catch levels, and years of participation within a given fishery distribution (Pomeroy et al., 2015; Cramer et al., 2018; Carothers & Chambers, 2012). The management and scientific backing for the success of catch shares is pervasive and has been further corroborated by global adoption of catch shares. Research has shown that only half of fisheries with IFQ were collapsed, in contrast to fisheries without IFQs, and that trajectory has continued to improve with time (Costello et al., 2008). What is frequently missing from many studies conducted on the successes of catch shares on stock rebound, ecosystem impacts and sustainability outcomes is the human dimension and the tenuous nature of highly variable community responses to the regional adoption of these management measures (Carothers & Chambers, 2012). Eight years after the transition to IFQs for West Coast groundfish, greater investigation on the longer term impacts on the fleet and community are underway (Russell et al, 2014; Calhoun et al., 2016; Cramer et al., 2018). Ensuring smaller stakeholder sectors like the nearshore groundfish fleet are included in these considerations is of great importance to the holistic reflection of experiences and resounding effects within the community. Understanding who has remained through the major management transitions of this fishery is imperative to addressing the future needs of those involved.

At present, changes are underway to RCAs which will allow renewed trawl access to some 3,000 square miles of formerly protected habitat in Oregon and California (PFMC, 2018). The reopening of these spaces will allow access to waters between the 100-150 fathom lines which have not been accessed since early RCA implementation in 2002. Understanding past reaction and future interest via this research project could prove essential to predicting a possible resurgence of effort within the Oregon nearshore groundfish fishery.

3.2 **Approach**

Nearshore Grounfish Trawl Fishery

For the purposes of this research project, the Oregon nearshore groundfish trawl fishery was extended beyond the Oregon Nearshore Strategy definition to include all habitat that spreads from the high tide line to the 110 fathom (or 200m) depth contour, incorporating both state and federally managed waters. Ultimately this greater area was adopted for the study due to the absence of an assenting definition of the nearshore between managers, scientists, and fleet. Considering the nearshore out to the 110 fathom depth parameter served as an appropriate way to encompass the inner-shelf or "beach" fishery as it is frequently defined by various stakeholder groups.

Because ODFW bottom trawl logbooks were used as a significant data component to this study, the gear of focus was also refined to solely bottom trawl configurations including the ODFW logbook classifications of large footrope gear, small footrope (sole net), unspecified bottom trawl and selective flatfish trawl gear. Fisheries data such as the Oregon commercial trawl logbooks and correlated fishticket landing records kept by processors present a minimally explored cost effective and comprehensive source of detailed monitoring. They offer a strong indication of what happened in space and time through thorough documentation of historical gear preference and species records. Additionally, they contain a large and continuous sample size dating back to the 1970's, with little seasonal variability in sampling.

Integral research participants included members of the commercial fishing community in ports from Cape Blanco to Astoria, Oregon. Interviews and analysis of the logbooks were specified to vessels and participants of the groundfish fishery who fished specifically within the project definition of the Oregon nearshore. These individuals are referred to as Oregon's nearshore groundfish trawl fleet. Additional research participants include members of the groundfish fisheries management community including the Pacific Fisheries Management Council (PFMC), which operates under the Magnuson-Stevens Act (MSA) National Standards to generate and adapt the regional fishery management plan (FMP), and the National Marine Fisheries Service (NMFS), who in turn approve and regulate the FMP. The fisheries management community also comprises state fisheries managers who adhere to the management of federal FMPs and have the authority to exercise species specific measures when the state finds more conservative approaches necessary (ODFW, 2015).

Resource Knowledge Contained in Logbooks, Fishtickets & Interviews

Using bottom trawl logbooks kept by the commercial groundfish trawl fleet and maintained by ODFW allowed researchers to explore where fishing proved important across time in the nearshore through spatial mapping techniques, and then parse them into greater detailed inquiries to assess trends in gear, depth and species of value. Species catch in logbooks was also compared to fish tickets to comprehend the fish assemblages and valuable species to both the market and fleet from the 1980's to present. Being able to assess consistencies or inconsistencies in species through these methods provided a window into where further information should be pursued to clarify ecosystem variability and socioeconomic implications to the broader coastal stakeholders, including managers and scientists.

Using an approach known as snowball sampling, we partnered with individuals who had an established rapport to find, recruit and conduct semi-structured interviews with research participants with experience within the nearshore groundfish trawl fishery (Atkinson & Flint, 2001; Auerbach & Silverstein 2003). These participants were selected from multiple sectors and years of exposure to the groundfish fishery along the North, South and Central coast of Oregon. Interviews were conducted with members of the groundfish trawl fishing fleet including processors, as well as fisheries managers and scientists. The interviews were conducted in person at a location convenient to the participants or by phone where necessary. Each interview was recorded, transcribed, and analyzed for themes relevant to all areas of the coast through time.

3.3 Research Outcomes & Value

Who are the nearshore fleet?

A lack of available documentation and understanding of Oregon's nearshore groundfish trawl fleet left much of the initial interpretations of behavior and definition to speculation from logbook trends. However, the identity of the nearshore groundfish fleet quickly shaped through interviews and interaction with the industry as this project progressed. Participants of the nearshore groundfish trawl fleet were quick to describe themselves as "the beach" fleet. Overall, they identified as a unique subset of the broader groundfish fleet who fished with smaller vessels which became largely specialized to flatfish species as the fishery management and fleet evolved.

The modern perspective reflected an increasingly diminishing group within a largely consolidated fishery. For most, introduction to the fishery stemmed from familial involvement; many were 2nd or 3rd generation. They described experience and preference for the beach fishery given familiarity or endemic knowledge of the grounds, the ease of shorter tows and a less exorbitant set of gear costs than those associated with the deeper water fishery. Other aspects which made the nearshore favorable were closer grounds and proximity to port regions, which also provided a buffer from the often-hazardous weather of the Oregon coast, as well as fewer "hangups" to encounter (referring to shipwrecks or high relief rocky habitats). Those who inherited boats and knowledge from family members learned how to target species without getting caught on derelict gear, wrecks or habitat. They described remaining in the fishery as an intuitive step but one which is becoming increasingly costly for new entrants:

> *"It was pretty easy for me to get in; my grandpa was a fisherman, and I was the only one in the family that had expressed any interest in it. He helped me out. But it was a lot cheaper and a lot easier to get in. All you had to do then was buy a boat. Now the permits are worth more than the boats. It makes it tough."*

The Evolution of the Beach Fishery

Fishermen who experienced the early days of the nearshore fishery following the MSA described the boats and gear as more primitive, consisting of small wooden boats with no stern ramps, lower power, menial plotting and navigational technology and the compounded challenge of a developing domestic processing industry.

Tow durations were longer (documented in both interviews and logbook records) and the target species more generalized. As the fishery moved toward an impending groundfish disaster in the late 1990's, a member of the groundfish fleet described early fishing habits as both a severe warning and reflection on the change in fishing tactics for the fleet:

> *"…they'd do tows that were forever long. I mean, they'd just set the net and all of a sudden 13 hours later they would bring up whatever! And I think really because of the groundfish disaster, that fishermen started realizing they couldn't really be fishing the way they were. It wasn't like the fishermen didn't know these things, it was just there were no rules that told them not to do it. And so, the minute rules came along they followed the rules… so regulations saved the fishery because it helped the fishermen change their mindset. So, my hat's off to the fishermen in this nearshore fishery, they know the bottom, they know the fishery, and so they were able to fish cleaner, really with the same gear."*

As the gear regulations emerged and the fishery transitioned into required adoption of selective flatfish trawl gear, set against a waning availability of processors and an inconsistent market, the fishery shifted energy and focus to higher value flatfish species (Table 3.2). While

Table 3.2 Fleet Characteristics.

Trends in vessel length, gear, fish species harvested and trawl depths from 1980-2017 for vessel subset.

YEAR BLOCK	AVERAGE VESSEL LENGTH (FT)	PREFFERED GEAR	SPECIES TARGET GROUP	AVERAGE MAXIMUM TRAWL DEPTH (Fathoms)
1980's	60 ft.	Unspecified Bottom Trawl	Flatfish & Rockfish	62 fathoms
1990's	64 ft.	Bottom Trawl Small Footrope (sole net)	Flatfish & Rockfish	68 fathoms
2000's	65 ft.	Selective Flatfish Trawl	Flatfish	57 fathoms
2010+	65 ft.	Selective Flatfish Trawl	Flatfish	58 fathoms

manipulation of mesh sizes and engagement with ODFW and EFP programs to further reduce bycatch continued, the "pineapple trawl," as the selective flatfish trawl is more casually referred to, was described as the most revolutionary alteration and adoption to the gear makeup of the fleet. Transitioning to GPS and navigational plotter systems in the 1980's and 1990's also allowed the fleet to modernize their gear and streamline fishing ability and weather prediction tools enhanced safety and timing of fishing effort. Wooden boats were widened and lengthened according to interviews, updated with more powerful winches and hydraulics and some transitioned to steel construction with larger stern ramps. Still, many of the boats present in the modern fleet were described as the same or modified vessels from the early fleet. The consistency of logbook record compliance has also been variable, particularly in the earlier era of evolving management measures and stringency, which indicates the likelihood that this is only a subset of the overall effort which may have been occurring in the nearshore (Figure 3.3).

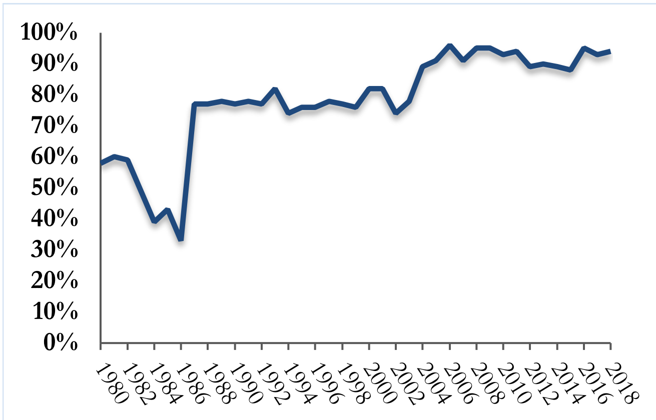

Figure 3.3 Percent Logbook Compliance 1980-2018
Compliance percentages for logbook entries 1980-2018 for the entire trawl logbook database courtesy of ODFW data managers. Logbook entries used for this work are a subset of this overall dataset of entries confined to 110 fathoms/200 meters or shallower.

Interviews, logbooks, summaries and the narrative which emerges from archival documents show a trend across time and space towards a subsiding use of the nearshore fishery grounds. Increasingly within the evolving landscape of the fishery and its management, those who fished nearshore groundfish described using it as a "filler fishery" for periods between shrimp and Dungeness crab fishing seasons, and sometime only when those fisheries were performing marginally. Many also described the ability to switch within these fisheries as a product of their existing knowledge of the nearshore grounds from this diversification:

> *"The most successful fishermen are only in groundfish for a few months. They fish that [groundfish] in the summer, which is historically the shelf fishing. The nearshore is a summer driven fishery. In the fall and winter they're gonna go more deep for black cod and Dover and such."*

Spatial maps of the number of trawl sets by the fleet subset along the Oregon shelf region from the 1980's to present declined from 541,612 in 1990 to 82,314 in the most recent shortened time period for the nearshore (Figure 3.4). Within the minimally

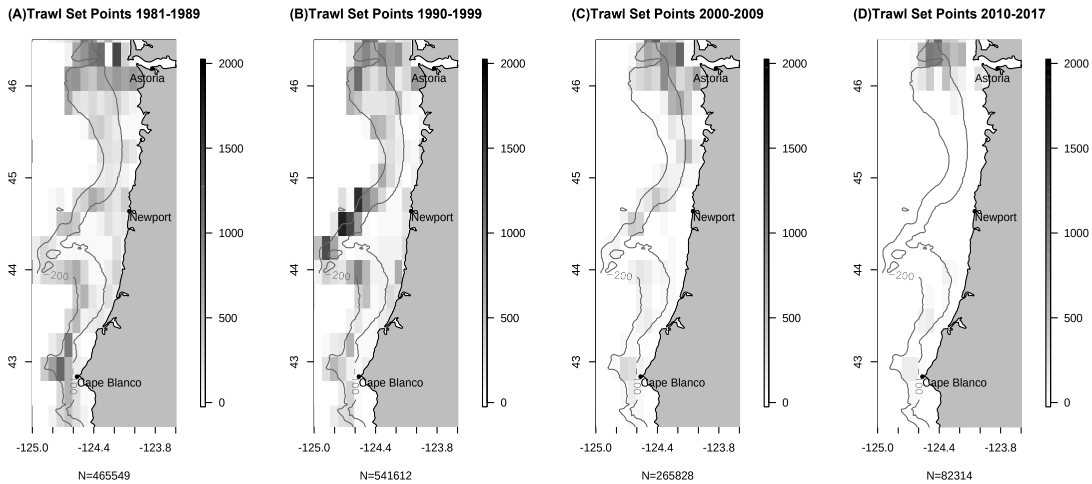

Figure 3.4 Map of Logbook Trawl Setpoints 110 fathoms/200 meters and shoreward. Logbook trawl setpoints for all tows occurring from 1980-2017. N=total number of tows.

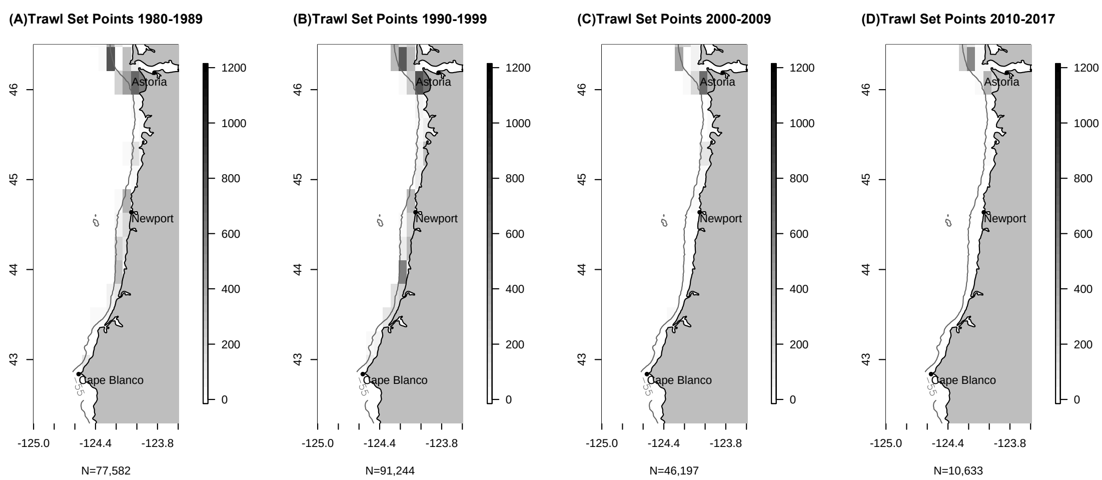

Figure 3.5 Map of Logbook Trawl Setpoints 30 fathoms/55 meters and shoreward. Logbook trawl setpoints for all tows occurring from 1980-2017. N=total number of tows.

scientifically surveyed range of 30 fathom (55 meter) depth contour and shoreward, trawl sets for the subset of the fleet dropped from a 1990's record of 91,244 to a most recent record of 10,633 (Figure 3.5) The contemporary fleet raised a number of internal concerns regarding interaction with other fleet sectors. Across time, consistent members of the fleet described external participants such as so called "rent-a-skippers." These were participants they described as foreign venture participants, groups such as the Alaska migratory fleet or seasonal fishermen, whose lack of vested interest in the region long-term tended to lead to less prerogative for engaging in the fishery in a manner promoting continuing resource vitality and investment. The prospect of consequential aftermath of those impacts on fisheries resources was met with concern by the local fleet, who felt they might accordingly be dealt an unfair hand by regulations or the market in the aftermath.

Another repeated source of strain centered around the further division of profits to what were described as emergent sectors of the groundfish fishery since the catch share program: the observer industry and those who lease quota they no longer activity fish. For a small boat fishing the nearshore, volume is not nearly as high, thus the cost of $500 a day to have the required observer on board, pay crew and lease quota to cover any catch outside of the target species presents a daunting overhead cost. Compounded with market values which have remained largely static across time for nearshore species, the cost to fishing was often discussed as greater than the available profit margin:

> *"We're doing all the work, and there's not very many of us, and we're not seeing the benefits of it. So, that's really frustrating, the marketing side. And, it costs much more to do now! Yeah, our catch rates are more than they used to be…but our costs are way, way higher: observer costs, leaser fees, you know."*

Despite certain vexations, an abounding narrative of cautious optimism threaded throughout the discourse surrounding a future nearshore groundfish trawl fishery. These opinions surfaced most perceptibly within conversations about upcoming removal of RCA areas. However, they frequently discussed the potential of marketing campaigns such as Positively Groundfish working to promote the sustainability of the recovered fishery and its diversity of species, and some favorability to being a smaller more specialized fleet in an underutilized sector of a broader fishery. The consolidation of the processors spanning the coast and a rising labor shortage for filleters within processing plants is proving problematic to quota utilization and cost competitiveness.

Some members of the fleet however, are innovating by collaborating and selling their own fish. In light of increased communication between the nearshore trawl fleet, the remaining or newly entered members to the nearshore fishery also describe the way the management, andcatch shares in particular, has reshaped the manner in which they interact with other active fleet members. In contrast to guarding secrets of fishing spots or unexpected abundances, they're warning each other of pockets of rebuilding stocks. Quota going unused by on member of the fleet may be bought by another so both make a profit. Having more frequent dialogue with other nearshore community members allows them to source rebuilding species stock when an incidental catch occurs. While there are certainly still areas of discontent with management, the current landscape resonated wary interest and enthusiasm for the fishery moving forward and recognition of the successes of management measures such as EFH protection:

> *"…We're accountable for every pound of fish we catch, that's what lets us go fishing basically. But next year, we're gonna be able to go in there [former RCA areas], everybody is, and basically fish how we want to. It's going to be neat! There's going to be areas that are still closed that we've given up, and that's good, I am all for that, that's a good thing."*

Lessons learned about nearshore species through LEK

The West Coast groundfish fishery is perhaps instinctively shaped by the presence, diversity and health of its fish stocks. Given this, the story of its uses and impressions hinge on the species prevalence and trends across time. The descriptions of groundfish assemblages along the Oregon nearshore revealed the makeup of the primary species present along the shelf and their contingent marketability as motivational to catch effort. The discourses surrounding fish from LEK perspectives ranged broadly, dictated in part by the age and duration of exposure of the fishermen or processors interviewed at the time of their participation. Some individuals had remained active in the fishery predating the transition to a domestic fishery in 1976, some had exposure of 2 years or less. Regardless of exposure, the most persistently-discussed species for this sector of the groundfish fishery were flatfishes (*Pleuronectiformes*), and across all years assessed, petrale sole (*Eopsetta jordani*) (Figure 3.6). The experiences of the fishery by interviewees who were active during the earlier periods from the 1970's-1990's portrayed an industry which prosecuted a much wider range of fishes than the contemporary fleet. The broader swath of target species was concurrently reflected in the logbook entries of these times. Due to the limited amount of scientific survey sampling information in the nearshore areas 30 fathoms and shoreward, early information on presence and harvest of

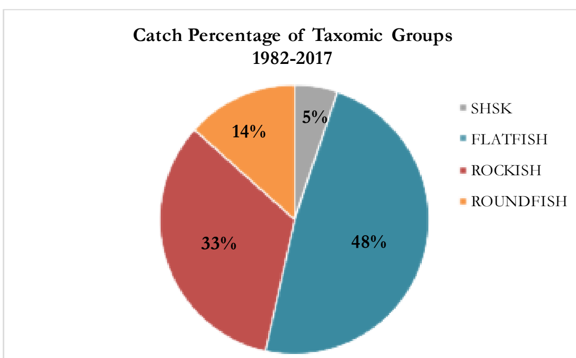

Figure 3.6 Catch Percentage of Taxomic Groups 1982-2017.
Percentage contribution of the 4 most significant PFMC taxonomic management categories: rockfish species (18), flatfish species (12) roundfish species (5), and elasmobranch species (3) for subset from 1982-2017.

species of fishes from LEK is particularly insightful. English sole (*Parophrys vetulus*), starry flounder, arrowtooth flounder (*Atheresthes stomias*), rex sole (*Glyptocephalus zachirus*), Pacific sanddab (*Citharichthys sordidus*) and and sole (*Psettichthys melanostictus*) were commonly identified as high value flatfish species abundant in the 10-30 fathom range of the Oregon coast. Several species of rockfishes such as canary (*Sebastes pinniger*), widow (*Sebastes entomelas*), darkblotched (*Sebastes crameri*) and yellowtail (*Sebastes flacidus*) were also of prevailing interest. Black cod or sablefish (used interchangeably on the Pacific West Coast) as well as big skate (*Raja binoculata*) were species of interest to the nearshore sector of the groundfish fleet. The ability to target on a greater diversity of species was associated with the processing and marketing landscape of the Oregon Coast at the time. The option of selling to multiple buyers who specialized in marketing different species allowed the fleet to diversify their catch:

> *"…when I fished [Starry & Arrowtooth] flounder I fished inside of 30 fathoms. And some years I fished, it was pretty good! I'd have a mixture of flounder which was going for around .40 cents a pound, and sand sole which were going for .90 cents a pound, and a few English [sole]. And then there'd be some oddball stuff in there. I had a market for about 150 fish, and that's what they'd let me catch!"*

An additional variable to the ability to select and target a larger mixed bag of species was the differences in regulations. With a lack of intervention in bycatch reduction or management of individual stocks, trawlable habitat and catch were not limiting to fleet harvest activity. The gear types which were preferred for this period (Table 3.2) enabled the fleet to access high relief areas to target rockfish species using roller or rock hopper apparatus. With the addition of the footrope restrictions and the requirement of selective flatfish trawl gear with the implementation of trawl RCAs in 2002, these regions of the nearshore and corresponding target species became less accessible to the trawl fleet. As a result of this many species were no longer consistently supplied to markets, generating reverberating impacts on long-term target species. There has been a great amount of combined effort between scientists and members of the fleet community to innovate gear to further minimize bycatch of juvenile and non-target species. Avenues to collaboration and bycatch reduction such as the EFP left a noted impression of solidarity and trust between scientific researchers and fleet members alike. Fleet participants in the EFP have the opportunity to test new gear as well as fish in areas often closed to fishing otherwise to test effectiveness of various additions or modifications to trawl gear. The opportunity to demonstrate knowledge of grounds and become part of the adaptive solution to more efficient use of Oregon's groundfish fishery is one that was expressed as decidedly rewarding to participants:

> *"…It was a positive experience. We went in there and we did what we needed to do. We caught fish cleanly, showed the government that 'Hey, they can go in there and do this without making mistakes.'"*

The decades since the RCA, EFH and IFQ amendments mandated significant behavioral alteration of the fleet in order to fish within regulations. Strategizing for target species revealed the immanent need to consider protected species known to occur in the same areas as target stocks, particularly considering stringent quota and the constraints of rebuilding stock avoidance. Prior to its declared rebuilt status in 2015, fishermen were anxious about encountering Canary rockfish in tows, describing them as "balls of orange" coming up in the nets, posing a threat of closure or painful financial fallout for the individual fisherman. As the protected stocks have shifted into healthy levels again, limits of available stock to cover large groups of these species remained an element of concern in interviews. The fleet has had to adapt by avoiding or practicing extreme caution in these regions. Information of this sort may be valuable for scientists and managers to examine these associations, and potentially explore better ways to allocate quota to enhance utilization and monitoring.

3.4 Final Thoughts

The story of nearshore groundfish ultimately centers around an exceptionally diverse group of fishes, tightly enmeshed with the people who have managed, researched and chased them through time and space along Oregon's continental shelf region. The prominent intersections of the resource and stakeholders have been less than aptly explored, and the prospect of inspiring better understanding and communication surrounding the use and conservation of this rich Oregon coastal asset are encouraging based on this study. The long and tumultuous road to rehabilitation for West Coast groundfish has drastically reshaped the remaining fleet, and the future of the nearshore group is in a transitionary stage. Pending successes for this industry are intricately tied to the continued redevelopment of a market which can support the sustainable harvest utilization necessary to supply enough income for the fishing fleet to survive. This includes the better dissemination of reactive behaviors from fleet to management and the further integration of LEK and SEK into long term monitoring of the nearshore region.

In closing, a quote which emerged from a very early project interview surfaced in revolving forms in the continued voices of fleet and scientific community members during this research. It serves as a thoughtful transition into the next stages of the nearshore groundfish fishery and an unusually succinct synopsis of an incredibly complex fishery, its evolution, and this project's attempt to incorporate non-uniform ecological knowledge into the dialogue surrounding Oregon's productive nearshore:

> *"…The fishermen have been working and operating under a lot of regulations, especially related to this groundfish fishing disaster and all the quotas and catch limits. And now that we're sort of coming out the other side, I think they would just like to have the flexibility and availability to just fish."*

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CHAPTER 4 **DISCUSSION & CONCLUDING REMARKS**

4.1 **Futher SEK Integration & LEK Limitation**

The results of this study expose the nearshore sector of Oregon's groundfish trawl fishery as a niche fishery which is in the nascent stages of recovering from a challenging 20-year period of management reform and fisheries rebuilding. The outcomes of this research also offer an exploration of existing Local Ecological Knowledge (LEK) for Oregon's nearshore groundfish trawl fishery and fleet (Table 4.1). By amassing established and

Table 4.1 SEK, LEK, Regulatory Timelines & Climate/Oceanographic states defined for OSG study.
Temporal extent, divided in four periods as documented in the broader proposal of this study. For each period, the main SEK (in blue) constituents (scientific surveys) and industry driven knowledge sources (LEK, etc., in orange) are outlined in the context of climate and oceanographic states. Adapted from Ciannelli et al., 2017 Oregon Sea Grant (OSG) proposal.

Period	Main attribute	SEK	LEK-Industry	Regulatory regime	Climate and oceanographic state
1970-1990	Historical	Flatfish survey Historical beam trawl survey Small mesh survey	Fish tickets Logbooks LEK	Open access	Pre- and early-1976 regime shift, causing warming and positive PDO
1990-2000	Transition	NWFSC groundfish survey	Fish tickets Logbooks LEK	Disaster declaration	Post-1989 regime shift causing temporary cooling, followed by 1997-98 strong El Nino
2000-2010	High Regulation	NWFSC groundfish survey Modern beam trawl survey	Fish tickets Logbooks LEK	Footrope regulation Buyback program RCA	Hypoxia intensification, followed by cooling and negative PDO
>2011	Rationalization	NWFSC groundfish survey Modern beam trawl survey	Fish tickets Logbooks LEK	IFQs	Temperature and hypoxia intensification, 2014 Warm blob, 2015 El Nino

obtained data, and producing a spatial and temporally summarized illustration of a minimally surveyed region and stakeholder group, this research provides a complementary assessment to the existing Scientific Ecological Knowledge (SEK) of the nearshore (Table 4.1). This is true despite the perspective that LEK can present limitations to detailed information and consistency. Much of this arises from an anticipated inclination to protect personal livelihood, trepidation and distrust established between fishery managers, scientists and fleet

(Eayrs, Cadrin & Glass, 2014; Merrill, 2011) and lagged adoption of enforcement and consistency through time (as demonstrated in Figure 2.1; Moon & Conway, 2016; Kirkley et al., 2001). Nevertheless, the findings disseminated in this work are a representative subset of the activity of the fleet and the ecological dimensions of the nearshore groundfish fishery from 1976-present.

The experiential knowledge and consistency of exposure of the fleet offers a detailed and long-standing record of drivers and health of the fishery both spatially and temporally. The contact with the fleet and the knowledge they shared establishes a baseline for ongoing conversations, cooperation and prospective collaboration among researchers, managers and fleet moving forward into Phase 2 of this OSG funded project.

Phase 1 (this thesis) has assessed the LEK-industry components of the project including logbooks, fishtickets and personal experience of the groundfish trawl fishery conveyed through interviews. Phase 2 will involve using the SEK and climate oceanographic states (Table 4.1) to determine the health and understanding of the nearshore groundfish trawl fishery resource. Table 4.1 summarizes the SEK to be analyzed in conjunction with major climate and oceanographic regimes. Upon completion of the second phase, results will be disseminated collectively and presented to the participating community with broader potentially beneficial application to regional scientific and management groups.

4.2 Study Outcomes & Contributions to SEK/LEK Approaches in Management

This research provides a highly diverse array of experiences and challenges because interview subjects included a swath of fishery participants engaged with varying periods of groundfish fishery management. As summarized in the historical review (Chapter 1), management underwent a tremendous amount of adaptation, which in turn drastically influenced the experiences and behaviors of the fleet as the interview and logbook spatial representation reflects. The nearshore groundfish fishery has been shaped by the ecosystem, market and intensive consolidation of what already existed as a relatively minor and specialized fleet. The small size of the vessels and the diversity of the fishery allowed early participants to capitalize more fully on the nearshore stocks. With the collapse of the fishery and measures adopted to restore it to ecosystem health and Groundfish Fishery

Management Plan (FMP) goals, the fishery has transitioned to a flatfish fishery, and most consistently, the targeting of high value Petrale Sole.

The LEK from this research offered many perspectives and reactions to the management amendments which would be valuable for both state and Pacific Fishery Management Council (PFMC) to include in their planning and optimal utilization of the nearshore fishery. Additionally, the combination of LEK and SEK of the fish assemblages through time, with particular attention to spawning aggregation areas, year class prediction and future changes to the ecosystem could benefit understanding of the Oregon nearshore and perseverance of the fishery. Enhanced understandings of coastal ecosystem function and variability could continue to inform management and foster beneficial cooperation among scientists, fishermen and fisheries managers to better facilitate sustainable use of Oregon's nearshore fishery resources. At a broader level, these methods may provide insight into the capacity of exploring the combination of fisheries-dependent and independent data and knowledge to overcome deficits in monitoring, funding for monitoring and increase communication between coastal stakeholders.

4.3 Overall Lessons Learned from Using a Mixed Methods Approach to Understand Oregon's Nearshore Groundfish Fishery System

From its earliest iteration, this research aimed to derive a baseline for better comprehensive understanding of what has occurred in the coupled social-ecological system of Oregon's nearshore groundfish trawl fishery through time. Initially, the absolute direction of this process was appropriately ineffable, as both the nearshore commercial trawl fishing community and the very nearshore fish stocks have been only superficially surveyed. The breadth of time, space and contingent diversity of the nearshore groundfish fishery fleet and stock introduced an ingrained limitation to the level of detail which could be undertaken for this particular work. The intention was never to delve into minutia. Rather, this was a valuable initial step into gathering LEK and combining it with remedial narrative SEK from scientists and the PFMC in a setting with a high density of often overlooked fisheries-dependent and fisheries-independent data. Less tangibly, it recognized the self-contained identity of a small, specialized subset of the broader Oregon groundfish trawl fleet, whose endemic knowledge and experiences of the nearshore shelf region prove invaluable to reconstructing the history and social constructs of this unique ecosystem.

As is often the case in both social and natural science approaches, the nature of hypotheses and definitions evolve with exploratory analysis and contextualization among a broader historical and research milieu (Castillo, 2011). The first step of summarizing logbook and fishticket data and attendance of PFMC meetings was integral to determine who the nearshore fleet was, helped to define the gaps that could be more broadly addressed in LEK interviews with the community, and what had influenced the fishery the fleet has known and worked within spatially and temporally.

Definition of the "nearshore space" was one of the first illustrations of a disciplinary disconnect between perceptions of an intersecting marine resource and the importance of incorporating both SEK and LEK. While the natural science and extended management lens established a bounded, functional definition of the nearshore marine environment within Oregon, the qualitative, intuitive definition within the fishery community reflected greater complexity in the social and ecological dimensionality of the nearshore space.

Conceptualizing spatial thinking as the unifying contributions of localized social phenomena, drivers to these regional trends and subsequent impacts and adaptations within larger areas is a common hurdle addressed within social science techniques (Logan, 2012). Fisheries management, aided by the integrated Magnuson-Stevens Fishery Conservation and Management Act (MSA) standards of consistent adherence to the best available science, has a compulsory obligation to ensure best monitoring and safe harvest practices for its living coastal resources. By identifying an existing gap in comprehensive assessment of Oregon's marine regions, the nearshore strategy was designed to:

> "promote actions that will conserve ecological functions and nearshore marine resources to provide long-term ecological, economic and social benefits for current and future generations of Oregonians." (ODFW, 2017).

The nearshore strategy further outlines substantial integration of stakeholder participation and progressive transparency. As such, the emergence of experiential and disciplinarily-distinctive definitions of a common space are indicative of the complexities of multiple knowledge and data source integration into management strategies. Arguably, discounting the LEK definition of the "beach fishery" would have both stunted the encompassment of the fisheries ecology and identity of this unique fleet. The same applies to the SEK and management definition of the nearshore space, which provides an equallyvaluable acknowledgement and structure to their understanding of these same systems.

Table 4.2 Qualitative & Quantitative Research Characteristics.
Contrasting progression and analytical processes for quantitative and qualitative research approaches. Adapted from Creamer, 2018.

Phases of the Research Process	Quantitative	Qualitative
Design	Variable oriented (offers breadth) Addresses *what* and *why* questions	Case oriented (offers depth) Process oriented Can also address *how* questions
Data collection	Numbers	Words
Sampling	Allows for generalizability	Can pursue negative case or exemplary case
Analysis	Deductive Confirmatory Used to test theory	Context bound Inductive and sometimes emergent Exploratory Used to produce or modify theory
Inferences	Interpretations that extend the data	Interpretations that extend the data

Using mixed methods–integrating multiple knowledge sources and adapting to the interdisciplinary literacy required to execute research of this nature (Creamer, 2018) – requires flexibility and engagement from all partners. Table 4.2 from Creamer (2018), illustrates the complementary but disparate research processes of qualitative and quantitative strategies, which, when used conjunctively in a study of this level of timescale and complexity, can prospectively facilitate a greater scope of inference. Moreover, in an era where research increasingly seeks to combine the expertise and engagement of scientists and fishermen in coastal communities, commitment to the effort of maintaining partnerships and combating participant discord are impetuses to the successful outcomes of these efforts for both human and biological dimensions (Conway & Pomeroy, 2006; Mackinson, 2001).

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APPENDICES

Appendix A: Semistructed interview guide & Participant contact

Appendix A1: Recruitment
Initial recruitment email/phone script for interview

Subject: Seeking input for a student research project on the nearshore groundfish trawl fishery

Dear [insert name],

My name is Anja Sjostrom and I am a graduate student in the Marine Resource Management (MRM) program at Oregon State University.

For my thesis research, I am interested in exploring the benefits of combining local ecological knowledge with scientific data to reconstruct historical usage of the nearshore groundfish trawl fishery from Astoria to Cape Blanco over six time periods (pre-1980s to the present). We're trying to understand how the fishery has evolved over time due to changes in species, management, gear, and markets.

This research project is titled "Combining Local and Scientific Ecological Knowledge to Reconstruct Historical Usage of the Oregon Nearshore Groundfish Trawl Fishery." Professor Flaxen Conway, Director of the OSU MRM Program, is the Principal Investigator leading this research. Funding support comes from a research grant from Oregon Sea Grant.

I am contacting you because your perspective is needed and your experience lends important information to this research. Participation in this study is voluntary. The information you provide will be kept confidential to the extent permitted by law.

Would you be able to meet with me to share your insight? If so, please let me know your availability for an interview. You can contact me via email at sjostroa@oregonstate.edu or phone at (510) 691-2660. If you have any additional questions, please contact me, or Flaxen Conway at fconway@coas.oregonstate.edu or (541) 737-1339.

If you have questions about your rights or welfare as a participant, contact the Oregon State University Institutional Review Board (IRB) Office, at (541) 737-8008 or by email at IRB@oregonstate.edu.

Thank for your time.
Anja Sjostrom

Appendix A2: Verbal Consent Card

Conway&Sjostrom: "Combining Local and Scientific Ecological Knowledge to Reconstruct Historical Usage of the Oregon Nearshore Groundfish Trawl Fishery."
Thank you for meeting with me today.

Purpose: We are interested in exploring the benefits of combining local ecological knowledge with scientific data to reconstruct historical usage of the nearshore groundfish trawl fishery from Astoria to Cape Blanco over six time periods (pre-1980s to the present). We're trying to understand how the fishery has evolved over time due to changes in species, management, gear, and markets. We reached out to you because of your experience; we would like to include your perspective in our research.

Activity: This interview is focused on understanding your experience with the nearshore groundfish trawl fishery. The length of the interview is up to you; they generally last anywhere from 30-90 minutes.

Voluntary and Confidential: Your participation in this interview is voluntary and you may refuse to answer any question for any reason. In order to accurately reflect what you share with me, I will be audio recording this interview. You have the option to decline recording at any point in the interview. If the results of this study are published, your identity will not be made public. Information collected from you for this research will not be used or distributed for future research.

Sponsor: This research is funded by Oregon Sea Grant.

Contact information. If you have any questions about your rights as an interview subject, you may ask now or email me at sjostroa@oregonstate.edu, or contact Flaxen Conway (as the leader; 541-737-1339; fconway@coas.oregonstate.edu), or contact the OSU IRB office at at (541) 737-8008 or by email at IRB@oregonstate.edu.

With that said, do you provide your consent to be interviewed for this research?

Conway&Sjostrom: "Combining Local and Scientific Ecological Knowledge to Reconstruct Historical Usage of the Oregon Nearshore Groundfish Trawl Fishery."
Thank you for meeting with me today.

Purpose: We are interested in exploring the benefits of combining local ecological knowledge with scientific data to reconstruct historical usage of the nearshore groundfish trawl fishery from Astoria to Cape Blanco over six time periods (pre-1980s to the present). We're trying to understand how the fishery has evolved over time due to changes in species, management, gear, and markets. We reached out to you because of your experience; we would like to include your perspective in our research.

Activity: This interview is focused on understanding your experience with the nearshore groundfish trawl fishery. The length of the interview is up to you; they generally last anywhere from 30-90 minutes.

Voluntary and Confidential: Your participation in this interview is voluntary and you may refuse to answer any question for any reason. In order to accurately reflect what you share with me, I will be audio recording this interview. You have the option to decline recording at any point in the interview. If the results of this study are published, your identity will not be made public. Information collected from you for this research will not be used or distributed for future research.

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With that said, do you provide your consent to be interviewed for this research?

Appendix A3: Semi-structured Interview Guide

Introduction

Thank you for meeting with me today. As a graduate student at OSU in the Marine Resource Management program, I'm working on a research project trying to reconstruct a history of the Oregon nearshore groundfish trawl fishery. We're trying to understand how the fishery has evolved over time due to changes in species, management, gear, and markets.

Body of Interview

1) Let's start with how long have you been fishing commercially in Oregon and what led you to become a nearshore (100 fathoms or less) groundfish trawler?

If possible, ***thinking about the changes over time***, please talk with me about:

2) Which groundfish **species** have been the most valuable for you to catch, and how have you seen these particular groundfishes go through changes in distribution or presence over time?

3) Which **management decision**s have been the most beneficial or challenging for you? In what ways are these decisions reflected in your logbooks (could they be used beneficially for the industry)?

4) Let's talk about **gear**. What have been the greatest challenges and opportunities when it comes to gear you've fished with in the nearshore? As of right now, what do you think would be the best gear for fishing groundfish in the nearshore and how could that be made even better if possible?

5) Let's talk about **markets**. Please share your thoughts about demand and supply (consistent/sporadic?), or anything else related to when a species (say one that has been protected) enters a market (what aids in developing a market for those fish?).

Wrap Up

Let's wrap up by focusing on the future with regard to species fished, management, gear, or markets.

6) What would make a future nearshore groundfish fishery valuable to you or others?

Thank you so much for taking the time to talk to me and share your experiences. It is so valuable to have your perspectives. Are there any last things you would like to share?

Appendix B: Oregon Department of Fish & Wildlife Data Request

Oregon Department of Fish & Wildlife, Marine Resources Program
Data Request Form Guidance and Instructions

Some commercial fishing information held by ODFW is confidential under Oregon law (ORS 192.501), and may not be released to the public unless the public interest requires disclosure in the particular instance. In practice, ODFW finds that purposes that are clearly in the public interest are fish stock assessments and analyses for use by regional fishery management councils and/or federal or state agencies in developing or evaluating fishery management measures.

Most other proposed uses are not usually considered to meet the public interest standard. However, some proposed projects appear to have significant potential value to resource managers even if the project is not being undertaken at their request. Requesters are encouraged to contact ODFW staff prior to submitting a formal data request, in order to discuss their specific needs and identify appropriate data that may be available.

The following items will aid in evaluating a request. Including as many as possible/appropriate, as well as other relevant information, in a written data request is recommended. Please replace the Red example text in the form with your actual request information.

Project working title: **Collaborative Fisheries Research Project of Nearshore Groundfish Assemblages**

Names: **Lorenzo Ciannelli, David Fox, Waldo Wakefield, Robert Eder, Flaxen Conway and Anja Sjostrom**

Affiliation: **Oregon State University, NOAA, and ODFW.**

Contact:
Lorenzo Ciannelli,
lciannelli@coas.oregonstate.edu
541-737-3142

Goal(s)
Reconstruct a more accurate picture of the nearshore groundfish assemblages with the potential for management applications and future collaborative research using fish ticket and logbook data, focused fisheries interviews and long-term scientific beam trawl data.

Purpose
To combine survey based estimates of groundfish community composition in the nearshore with the local ecological knowledge of fishermen to assess large scale spatial and long scale temporal changes in these assemblages.

Approach
Summarize the fish ticket data for landings, year, season, port of landing, and species and logbook data for fishing effort. Following this, conduct semi structured interviews with fishermen to fill in and missing data and address causation and shifts in nearshore use from 1969-present. These data will be compared to an analysis of historical and current beam trawl survey data collected by NWFSC and others. Ultimately this combined data will be incorporated into ODFW's nearshore ecological data atlas.

Spatial resolution
Highest currently and consistently available spatial resolution.

Temporal resolution
Highest currently and consistently available temporal resolution.

Temporal extent
1969-2017.

Models
- Spatial maps of catch by location by time period, boat size and seasons.
- Frequency distribution and cumulative density function of standardized catch by depth, time, location and other oceanographic variables.
- Spatial maps of composition by time period, boat size and seasons.
- Spatial maps of standardized catch of most frequently occurring species.

Fishery data requirements
- Port of departure
- Vessel size (exact size not required – bins/classes ok), horsepower if possible
- Catch (weight) by species per haul (Hailed catch)
- Location latitude/longitude or Loran A, Loran C if not converted for start of stop
- (Set depth & bottom depth) Average depth if available
- Date of haul
- Length of haul (hours/mins)
- Gear type per haul, size of net
- Mean depth of haul
- Composition of catch if available

Timeframe for use of data
3/2018-3/2022

Research products
A clearer understanding of the feasibility of using scientific ecological and local ecological data in assessing the nearshore fishing effort and groundfish assemblages. This will produce an initial publication, reports and presentations at conferences and industry meetings. Our hope is to produce insights into how collaborative scientific ecological and local ecological knowledge research can be incorporated at a management level as well.

Data security

Data will only be accessed and stored on devices owned and operated by those who sign the data request form and will be kept in locked offices on locked computers at all time. No confidential information will be disclosed when discussing the data in meetings and any figures produced will not display information granted in confidentiality.

Oregon Department of Fish & Wildlife

CONFIDENTIAL DATA USE AND NON-DISCLOSURE AGREEMENT

DISCLOSER: The Oregon Department of Fish and Wildlife
ADDRESS: 2040 SE Marine Science DR, Newport, OR 97365

REQUESTER: Lorenzo Ciannelli

ORGANIZATION: CEOAS
ADDRESS: Oregon State University
104 CEOAS Admin Bldg
Corvallis, OR 97331

REQUESTER: Anja Sjostrom

ORGANIZATION: CEOAS
ADDRESS: Oregon State University
104 CEOAS Admin Bldg
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REQUESTER: Flaxen Conway

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Corvallis, OR 97331

REQUESTER: Waldo Wakefield

ORGANIZATION: NOAA, National Marine Fisheries Service
ADDRESS: Fishery Resource Analysis and Monitoring Division-Northwest Fisheries Science Center
2032 SE OSU Dr.
Newport, OR, 97365

EFFECTIVE DATE: This agreement is effective immediately upon signature by all parties.

RECEIVER has requested to use the following data:

Oregon Fish Ticket (live and dead landings) by gear type, port, weight and market sample data for groundfish, all available years.

Oregon Trawl Logbook data for port of departure, vessel size, catch (weight/species haul), latitude/longitude, average depth, length of haul (hours/min), gear type per haul, net size, mean depth of haul for groundfish data, all available years.

The Oregon Department of Fish and Wildlife (DEPARTMENT) recognizes the confidentiality of these data and that this information is exempt from public disclosure under ORS 192.501-505, and may only be publicly released under such circumstances as required by the Public Records Law. The DEPARTMENT finds pursuant to this same statute that it is in the public interest in this case to allow disclosure of the specified information to the individuals named in this Agreement for the limited purpose described below. Therefore, the DEPARTMENT agrees to allow RECEIVER to use the data described above on the following conditions:

(1) These data will be used only for the following purpose:

The nearshore groundfish assemblage project.

(2) The timeframe for the use of these data and results of this project are:

March 2018-February 2020

(3) RECEIVER agrees that these data will be treated as confidential and handled with the utmost security. The data shall not be disclosed in any manner that identifies the individual or enterprise from which the data were originally collected.

(4) RECEIVER agrees not to distribute the data, and shall limit access to the individuals named on the top of this form. All individuals who are allowed access to the provided data must abide by the conditions set forth in this agreement and by signing this agreement agree to be bound by these conditions.

(5) RECEIVER agrees to gain approval by the DEPARTMENT of all products (publications, reports, presentations, maps, etc.) which include any representation of the confidential data, including products in which the data are summarized or aggregated to a non-confidential level, prior to public display, release, or distribution. **ODFW requires two weeks for this review**. The purpose of the DEPARTMENT's review is solely to ensure that the confidentiality of the source data is preserved.

(6) RECEIVER agrees not to present specific location or identity data (e.g., vessel or processor), either in graphical or tabular format, where any vessel fished without aggregating by a minimum of 3 (e.g., vessels) and additional approval by the DEPARTMENT.

(7) RECEIVER agrees to hold the DEPARTMENT harmless for any damages or liability incurred as a result of the violation of any of the terms of this agreement.

(8) Reports, manuscripts or other print or video material shall contain an acknowledgement of the DEPARTMENT for providing the requested information.

(9) A copy of this agreement shall remain with the requested data, whether it resides in an electronic or printed format.

(10) RECEIVER agrees to promptly destroy or return all of the original raw data provided upon completion of work or should funding for project not be secured for the purpose described above.

(11) RECEIVER agrees to notify the DEPARTMENT if the general timeframe for the project, as described in box (2) above is significantly altered.

OREGON DEPARTMENT OF FISH AND WILDLIFE, MARINE RESOURCES PROGRAM

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XXX
Technical and Data Services Section Leader

Date: Click here to enter a date.

RECEIVER(S) *(Please print & sign manually; date may be entered or written; return by fax or scan and email.)*

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Enter name and affiliation here (replace this text); sign above

Date: Click here to enter a date.

Appendix C: Supplemental Figures

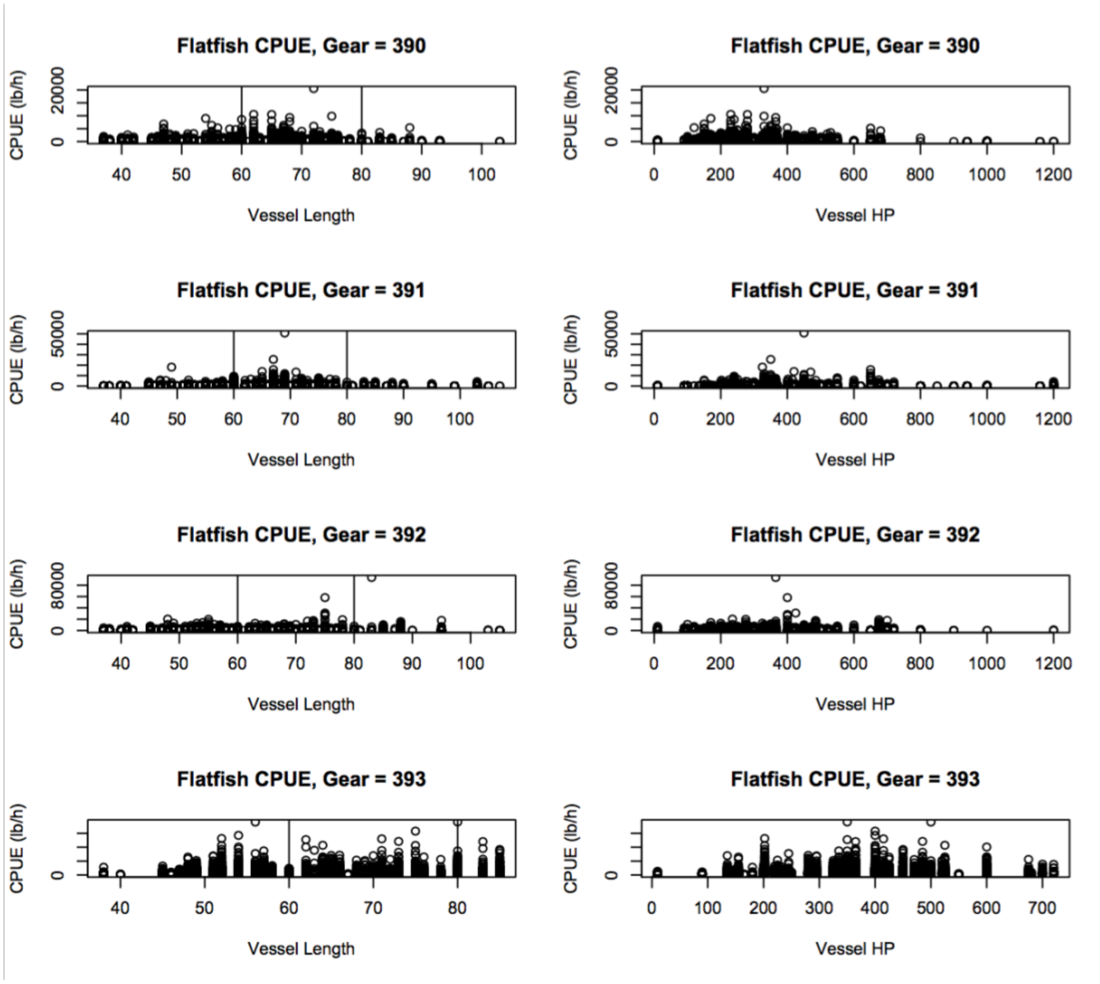

Figure C1 Flatfish CPUE by Gear Type for Vessel Length & Horsepower.
Flatfish CPUE by vessel length (with indication of size groupings adopted) and vessel horsepower for each of the 4 logbook gear codes from 1980-2017. 390=unspecified bottom trawl gear, 392=bottom trawl, short footrope, 393=selective flatfish trawl.

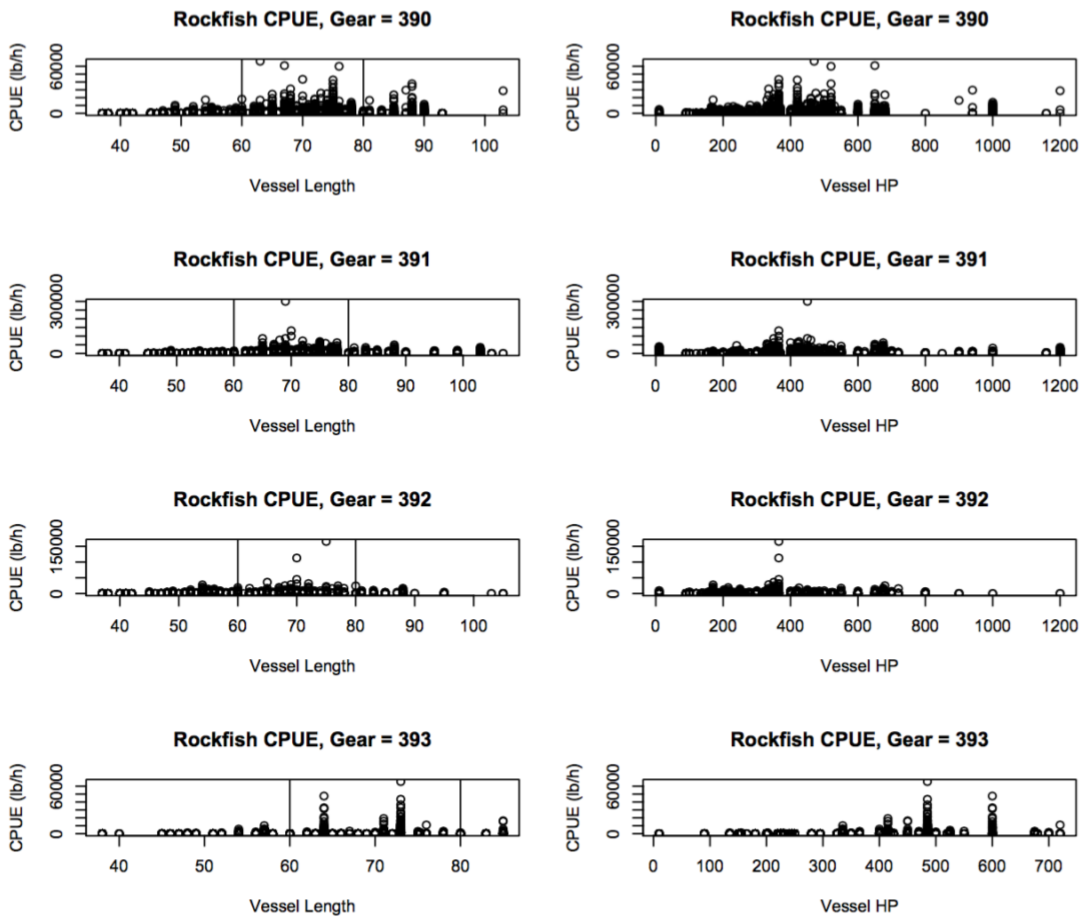

Figure C2 Rockfish CPUE by Gear Type for Vessel Length & Horsepower.
Rockfish CPUE by vessel length (with indication of size groupings adopted) and vessel horsepower for each of the 4 logbook gear codes from 1980-2017. 390=unspecified bottom trawl gear, 392=bottom trawl, short footrope, 393=selective flatfish trawl.

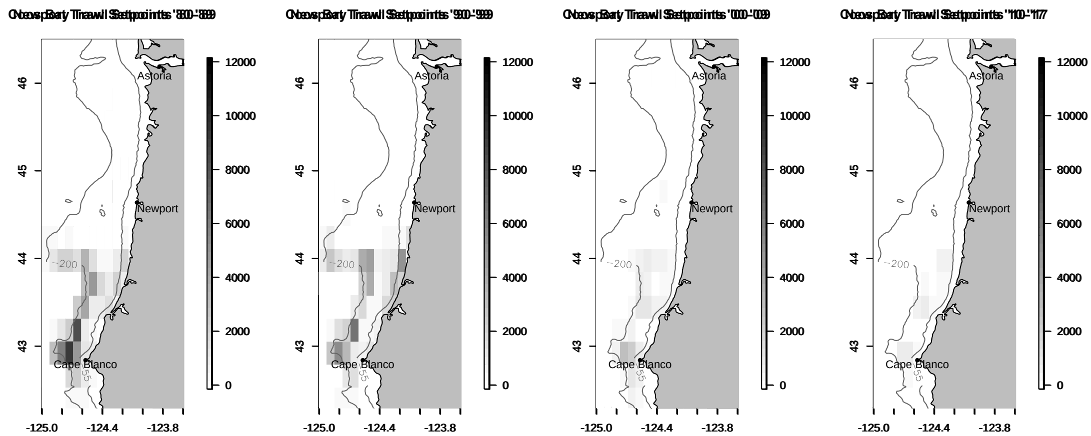

Figure C5 Logbook Trawl Setpoints 1981-2017 Southern Oregon Coast.
Logbook trawl setpoints for all tows occurring from 1980-2017 at depths of 110 fathoms/200 meters and shoreward for the Coos Bay/Charleston South Coast of Oregon.

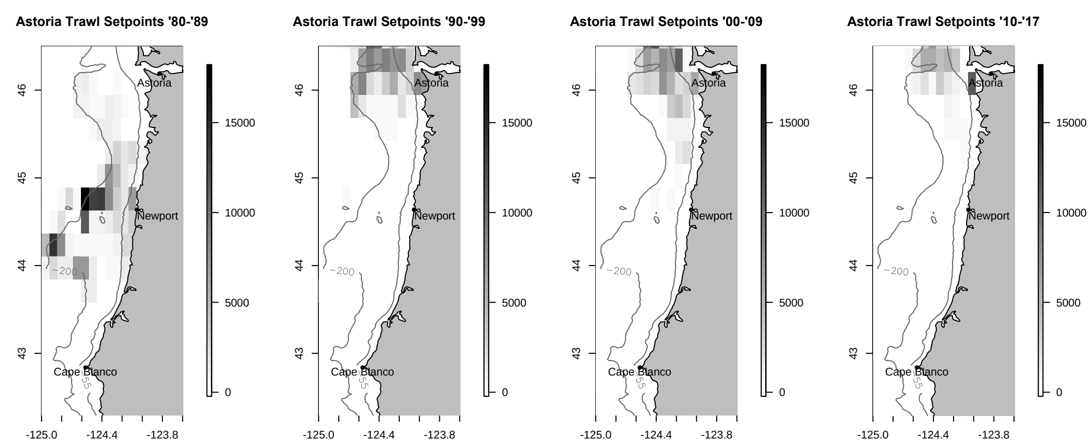

Figure C4 Logbook Trawl Setpoints 1981-2017 Northern Oregon Coast.
Logbook trawl setpoints for all tows occurring from 1980-2017 at depths of 110 fathoms/200 meters and shoreward for the Astoria/Warrenton Northern Coast of Oregon.