Gathering Local Ecological Knowledge to Augment Scientific & Management Understanding of a Living Coastal Resource:
The case of Oregon's nearshore groundfish trawl fishery

Abstract

Globally, coastal nearshore regions are an intersecting point for human and biological productivity, often serving as hotspots for subsistence, commercial, and recreational fishing activities. Despite this, many nearshore areas remain poorly understood, monitored or managed. This case study examined the nearshore sector of Oregon's groundfish trawl fishery, which exists in shallow estuarine and continental shelf habitats common along the West Coast of North America; areas that are important for early life history stages of many commercial and recreational fisheries. The West Coast groundfish fishery includes over 90 different species, 40 of which occur within Oregon's nearshore (here defined as the region of shelf extending seaward to a water depth of 200 meters). The very shallow portions of the Oregon Coast (the area of the shelf inshore of 55m) have been subject to limited 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 research explored the capacity of capturing LEK sources to inform and enhance understanding of the drivers of effort and the vitality of nearshore fishery resources. Our approach used statistical analysis and mapping of nearshore trawl effort from 1981-2019, and gathered semi-structured interviews of intergenerational fishermen to bolster data-poor areas. Insights provided by sampling strategies and historical to current knowledge of access to groundfish assemblages provide informed 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 illuminated market and ecological drivers of fishing behavior as well as a unique sector of the groundfish fleet in Oregon: the beach fleet, with unique market and socio-economic challenges. Findings indicate a 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 insights potential for better conservation and utilization of marine resources and improved monitoring in resource limited management contexts.

Highlights

- Insights into long-term trends in commercial fisheries emerge from social and ecological analysis
- LEK may offer detail for areas of low fisheries-independent sampling
- Logbooks, fish tickets, and long-form interviews provide mixed methods local ecological knowledge (LEK) while increasing stakeholder engagement
- Stakeholder engaged research may facilitate progress in ecosystem-based management

Keywords: local ecological knowledge, US West Coast groundfishes, fisheries-dependent data, coastal fisheries

1. **Introduction**

Coastal fisheries are dynamic; nested within the variable and adaptive coupled human-natural system of the ocean and management environment. Populated coastal regions are thus a nexus for the development of intricate relationships within social-ecological systems, and often the growth of coincident fishing industry. Spatially, 90% of global employment opportunities in artisanal fisheries have been determined to fall within nearshore coastal waters and shallow continental shelf regions, broadly described as the region of interface between land and sea [1]. Innovations to better comprehension and sustainable development of these often fragile nearshore commodities present opportunities to collaborate and integrate new knowledge into the management conversation.

The United States (US) West Coast, and specifically the Oregon Coast, hosts an expansive coastline rife with commercial and recreational fishing opportunities. Commercial fisheries in Oregon support a significant portion of the coastal economy, generating $160 million in ex-vessel revenue in 2019. The estimated numbers of fishermen supported in 2019 ranged seasonally, with a high of 1,607 in August, dipping to a low of 548 in November [2]. While the Dungeness Crab (*Cancer magister*) fishery contributed the most significant portion of these earnings, ($68 million in 2019), the West Coast non-whiting groundfish fishery was also a major contributor ($20 million in 2019). The West Coast groundfish fishery includes over 90 different species which associate commonly with bottom habitats, many of which use coastal inner shelf and estuarine habitats as nursery areas for newly settled or young-of-the-year juvenile fishes [3], [4], [5], [6], [7]. This fishery and diverse fishing grounds are exposed to multiple uses recreationally and commercially, with the commercial groundfish trawl fishery operating broadly in two sectors: whiting and non-whiting groundfishes [7]. While the spatial and temporal trends of the offshore groundfish fleet have been broadly assessed in recent literature [8], [9], particularly given a highly successful management and recovery, the nearshore sector of the non-whiting fleet remains largely overlooked.

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 monitoring strategy in 2017, the management of multi-use nearshore resources (including recreational fisheries, tourism, and marine renewables) is still facilitated through Oregon's broader Oregon

Coastal Resources Management Plan and Territorial Sea plan [10], [11]. The specific dearth of groundfish data in Oregon's nearshore regions stem from minimal scientific monitoring in the areas shoreward of 55 meters [10], [12], and constraints posed by insufficient funding for scientific and management parties to consistently execute new or ongoing trawl surveys. As such, evaluations utilizing Scientific Ecological Knowledge (SEK) alone present an incomplete assessment of the target species, responses to gear and management change, and variability in the nearshore environment critical to the early life history stages of many commercial groundfish species [3], [6], [13], [14], [15]. This Oregon case study was designed to gather data that could help to enhance this assessment, with potential application to a broader range of fisheries with gaps in both monitoring and knowledge of stakeholder use.

Existing literature has identified Local Ecological Knowledge (LEK) sources and fishery dependent logbook and fish ticket records as potential data to augment understanding in terrestrial and coastal resources and fill gaps in spatial and temporal monitoring [16], [17], [18], [19], [20], [21]. Enlisting and capturing perspectives and experience of Oregon commercial nearshore groundfish trawlers could provide additional supplemental quantitative and qualitative LEK for cataloguing fish assemblages in the under-sampled nearshore habitats, as well as revealing socioeconomic changes in this fisheries system. In addition, commercial fishing logbook and fish ticket 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 scientist [22].

Since the mid 1970's, Oregon commercial bottom trawl logbook and fish ticket data have been collected by commercial fishermen and maintained and managed by the OFDW. These fisheries-dependent data present a high degree of spatial and temporal and species resolution as well as the benefit of large sample size and consistency in year-round availability. These data may offer insight into seasonal and interannual variability in both harvest-effort and trawl distribution, as well as historical species composition [23]. Intergenerational fishing families possess systemic knowledge of regional habitats and offer a unique environment to approach ecological habitat and resource assessment through LEK [24], [25], [26], [27[. Understanding spatial and temporal trends in fishing effort could 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 [28], [29].

Our Oregon case study was designed to address a gap in studies incorporating a broad-scale temporal assessment of commercial trawling and fish assemblages in the nearshore groundfish fishery. Collectively, we gathered LEK regarding the fish, fisheries management decisions, and the experience of the fishermen in the nearshore sector of the fleet in the past (1981-2017), in order to better address what should be considered for future decision making. These efforts led to new knowledge about the unique identity of the nearshore portion of the groundfish fleet; their lessons learned from the past, and their perspectives on the economic, social, ecological, and cultural connections within Oregon's nearshore groundfish trawl fishery. In turn, exploring the longitudinal data amassed in the logbooks and fish tickets demonstrated transitions in target species, as well as a punctuated decline in fishing across many of Oregon's nearshore habitats.

2. **Background: Theory and Experience**

2.1 Overarching Policy and Pacific Fisheries Management Council

A historic overview of the West Coast groundfish fishery provides an illustration of how policy and practices are intended to work (theory), and the reality of how they actually worked over time (experience). In theory, 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. In practice, however, concern over mounting foreign extraction rates served as the impetus for further regulation of domestic resources (43 U.S.C. §§ 1301 et seq.). Prior to the enactment of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976, West Coast groundfishes were the target of large-scale foreign fleets, most significantly from the former U.S.S.R and Japan [30]. Operating heavily in the Bering Sea and extending as far as central California, these large factory trawlers targeted groundfish stocks at rates that far exceeded domestic fleet harvest levels and processing infrastructure [31], [32]. In turn, the US introduced measures and incentives to build up domestic fleets in order to maximize US gains from coastal resources [32].

One of the key elements of the MSA is the provision for the establishment of regional fisheries management councils that are responsible for the ecological and economic sustainability of US marine fisheries. The Pacific Fisheries Management Council (PFMC) manages a diverse array of marine species under five fisheries management plans (FMPs) for fishery ecosystem, salmon, groundfishes, coastal pelagics species, and highly migratory species. The Pacific Coast Groundfish Fishery Management Plan was established in 1982 and incorporates oversight from science and industry through the Groundfish Management Team (GMT), and the Groundfish Advisory Panel (GAP), The FMP is adaptive and incorporates amendments to increase the sustainability of this fishery [7], and the structure of the PFMC is inclusive of perspectives and expertise from a diverse group of participants to maintain the health of the groundfish fishery and socioeconomic viability of the communities who benefit from its sustainable yield. Of the amendments to the FMP, several have had particular impacts on fleet modernization and reshaping of the nearshore sector of the fishery.

In 2002, NMFS in coordination with the PFMC created a spatially and seasonally alterable trawl Rockfish Conservation Areas (RCAs) with variability by gear type to support rebuilding plans for depleted rockfish species. By 2003, the trawl RCA was extended to include a narrow core ribbon of seafloor along the entire US West Coast closed to bottom trawling and approximated by the 100 to 200 meter depth contours on its shoreward and seaward boundary. In addition to the core area, there were periodic shallower and deeper bottom trawl RCA closures. The elimination of large footropes (i.e., > 8” or 29.3 cm diameter) capable of tackling high-relief rocky habitats where rebuilding rockfishes are known to aggregate reinforced spatial protection measures by limiting bottom trawl access. At the same time, the PFMC required adoption of the selective flatfish trawl by fishermen operating shoreward of the 100-fathom RCA boundary north of 40°10 latitude [7], [33], [34]. Following the PFMC’s assessment of essential fish habitat (EFH) in 2006, NOAA fisheries established 51 groundfish EFH conservation areas (EFHCA) which were restricted from bottom trawling through Amendment 19 of the FMP [35], [36]. Research continues to advance regarding the effects of fishing gear on the economic value of fisheries long-term [37].

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 midwater 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 [7]. Exploration of logbooks in this study aimed to further expose temporal trends in trawl gear preference relating to both efficiency and management and potential for habitat contact for the groundfish fishery.

2.2 Fleet Composition & Economics

Fleet consolidation strategies are another example of intention and actual experience. These strategies originated in 1993 with the limited entry program, but were furthered by the 2003 vessel buyback program – an operation meant to reduce effort by decommissioning fishing vessels. Research on the vessel buyback program report that it permanently removed 91 vessels and permits from the West Coast groundfish fishery [38], [39]. Consolidation efforts continued over time as evidenced 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 (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 [40], [41]. 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 [42], [43], [43], [44]. 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 non-trawl gear like pot and hook-and-line gear which have perceived lower impacts on bottom habitat than trawl gear [45]. 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 into the fishery, and subsequent high demand and use of sablefish quota [38].

2.3 Present & Developing Measures for Oregon

The Oregon and California portions of the RCA reopened to bottom trawling in 2020 through Amendment 28 to the Groundfish FMP. These modifications renewed trawl access to almost 3,000 square miles of fishing grounds between the 100-150 fathom RCA lines which have not been trawled since 2002. Understanding past reaction and future interest via research that captures LEK could be useful in predicting a possible resurgence of effort within the Oregon nearshore groundfish fishery.

Oregon Department of Fish and Wildlife amends and implements the management of Oregon's marine fisheries resources in coordination with the National Marine Fisheries Service (NMFS) and the PFMC. This includes 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 black rockfish (*S. melanops*). In 2017, ODFW launched an effort to engage more diverse stakeholder interests in common species and increase monitoring of nearshore habitats through the Oregon Nearshore Strategy (ONS). The motivation for the ONS arose from a lack of monitoring of coastal areas shoreward of the 55 m depth contour, exposing a gap in awareness of bathymetry, habitat and biological assemblages as well as risk of perturbations from natural environmental variability and anthropogenic impacts [10]. The ONS 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. Our research established connections with the historically present groundfish trawl fleet as their knowledge and use of the coastal shelf region may assist in understanding the socioeconomic value of the nearshore.

For federal regional fisheries management councils and state management agencies, maintaining the MSA mandated "best available science" standards can be a factor that limits the punctuality and thoroughness of data analysis and adoption into management measures [48]. 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 regarding fishing communities of place and interest [29], [49], [50]. LEK of fishermen has been described as an accrued knowledge surrounding fisheries and the environments they exist within that has been developed by industry participants/families [51], [52], [53], [54], [55], [56]. In the fisheries management and research landscape, there is a trend towards stock and ecological data collection, leading to calls for further integration of social science approaches to engage the human dimensions of fisheries systems [45], [57]. This study builds on these human dimensions efforts for management of coupled human-natural systems. By addressing gaps in the knowledge surrounding the history of the fishery and the fleet, the evolution and impacts of management, and the influence of market and public drivers in the past, we seek to gain perspective on considerations that management, markets, and the fleet might ponder for the future.

3. Study Region, Species, and Methods

3.1 Nearshore Groundfish Trawl Fishery

Within the confines of this research, the Oregon nearshore groundfish trawl fishery is delineated geographically as the trawlable seafloor extending from extending from the high tide line to the 200 meter depth contour, incorporating both state and federally managed waters (figure 1). Ultimately this area was adopted due to the absence of an assenting definition of the nearshore between management, science sectors and fleets. Considering the nearshore out to the 200 meter depth parameter served as an appropriate way to encompass the nearshore fishery as it is frequently defined by various stakeholder groups.

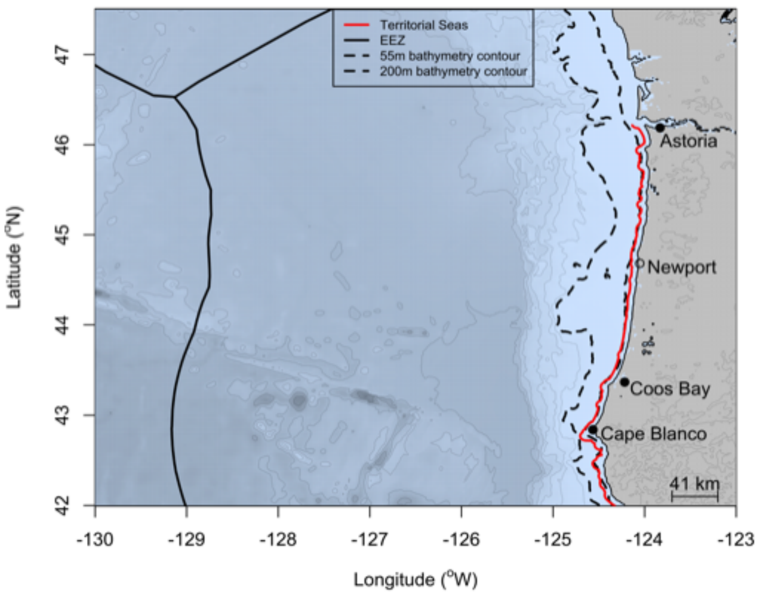


Figure 1. Map of Study Area
Oregon's 3 nm Territorial Sea (red), U.S. 200 nm Exclusive Economic Zone (EEZ) (black), and extent of the continental shelf approximated by the 200 meter depth contour.

The gear of focus was also confined to bottom trawl configurations corresponding to the ODFW logbook classifications of large footrope gear, small footrope (sole net), unspecified bottom trawl and selective flatfish trawl gear. The interviews and analysis of the logbooks was confined to the commercial trawl fleet and processing infrastructure from Cape Blanco to Astoria, Oregon; individuals that for the duration of this project will be referred to as Oregon's nearshore groundfish trawl fleet.

The assemblages of fishes found within Oregon's nearshore shelf region include a mixture of bony and cartilaginous species [58]. 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 (genus *Sebastes)*, 12 species of flatfishes (*Pleuronectiformes*), 5 species of roundfishes, and 3 species groups of elasmobranchs (sharks and skates) [7], [58], [59]. These are the commercial species associated with nearshore habitat features at varying depths and degrees. 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, and Sand Sole in particular [2], [4], [12].

3.2 Logbook and Fish ticket Data Aggregation

All logbook and fish ticket data analyses were done using the statistical package R. The data obtained contained records spanning to 1976, however, the documented challenges in accurate spatial representation of Loran A and Loran C [28], [60] recordings led to the elimination of Loran data entries. Locations were recorded consistently in latitudinal and longitudinal coordinates beginning in 1981. The data were 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 200 meter were removed from the dataset. The trimmed dataset contained 212,779 trawl logs from 1981-2017.

The Marmaps package in R [61] with NOAA bathymetry data (ETOPO1) was used to build bathymetric maps with isobath delineations of 50 meters up to the 200 meter isobath. To verify that the depth at the latitudinal and longitudinal coordinates recorded in the logbooks were consistent with the NOAA bathymetry depth [62], 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).

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

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 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 our analysis, the loess predicted depths at the recorded set locations were adopted. The modified depth data (new.depth) was used to visualize spatial distribution of trawl set positions for each designated period.

3.3 Catch Standardization al

Species not managed within the FMP and Oregon's MFMP were removed from the data for analysis. ODFW participates in federal FMPs through the Management Council, which designs and implements its five FMPs including the groundfish FMP. Currently ODFW has two FMPs, one for forage fishes and one for ocean shrimp. Fish ticket data recorded by fish dealers present a means of verification of landed species and weigh-backs and are a source of substantiation for logbook pounds recorded. No locational data aside from the port of landing is recorded on the fish tickets, thus in order to refine the ticket data to a maximum depth of 200 meters, fish tickets were linked to corresponding trawl logbook ticket numbers. An index was used to group species into the 5 major PFMC management categories (table 1) rockfish species (18 nearshore), roundfish species (5 nearshore), flatfish species (12 nearshore), Elasmobranch species (3 nearshore groups) and other species (2 nearshore), [7]. 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 of either vessel length or vessel power 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:

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

where *i* indicates the *i th* record set, and N_{year} is the total number of records for the year. Average CPUE for each management category was plotted against vessel size and horsepower, which led to the determination of 3 size groupings: 40-60 feet, 60-80 feet and 80-110 [63]. These established size groupings were assessed by gear type and tow duration to standardize average CPUE for the remaining analysis [63], [64]. 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.

3.4 Mapping

To adhere to ODFW confidentiality measures for logbook data use [63], 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 or less. 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 increments 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 [62], [66]. Each grid cell is 27.8 km in the latitudinal direction and about 5.8 km in the longitudinal direction. Using the established grid, each station was established as a pixel within a grid cell and stored in a matrix, used for plotting. 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 the distribution of catch by pounds for each of the four major taxonomic 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 [63]. 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. Maps produced were used as visual tools during semi-structured interviews with fleet members.

3.5 Qualitative Data Collection and Analysis

Ethnographic, semi-structured interviews with the Oregon nearshore groundfish trawl fleet allowed the opportunity to holistically detail patterns, interactions and values of the fishery as a system [67], [68]. Additionally, observations and informal interviews were conducted at PFMC meetings in Portland Oregon, Vancouver Washington and Seattle Washington to gather emergent information from policy documents, meeting minutes and reports on West Coast Groundfish management. Interactions between PFMC, GAP and GMT members were observed and summarized in categorical memos and notes to decipher patterns in behavior over time among members of the groundfish fleet [69]. These regular interactions with members of the “Council family” at PFMC meetings yielded contact with key fleet participants and the generation of potential interview contacts using a snowball sampling technique [70], [71]. Meetings and preliminary/informal interviews with state and federal agency scientists led to the obtainment and discussion of important economic drivers of the fishery including market prices and poundage data for highly targeted groundfish species during the time period and were used to compare with logbook and fish ticket data as well as themes that arose from the analysis of the semi-structured interviews.

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, central, and south coast of Oregon (table 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, fishes and markets, and future of the fishery was used as a standard framework for each interview [63]. Participants were 99% male, and ranged in age from 30-85 years old with varying degrees of exposure to the nearshore groundfish trawl fishery. The interviews were conducted in person or by phone and ranged from 30-120 minutes in length. Interviews were continued until the point of thematic saturation was reached [72], [73]. All interview data were uploaded into the MAXQDA18 software for qualitative coding and coded for themes using the iterative grounded theory approach [71]. Themes established from inductive coding were grouped into 4

Table 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*

overarching code groups. The introduction of researcher bias and subjectivity in qualitative conclusions can impact the validity of findings drawn from work of this nature [73], [74]. To counteract the unintended selection of data that overlapped with 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, and routine cross coding of transcripts was used to ensure inter-rater reliability throughout coding process and increase validity [74]. Verbal consent of all participants was obtained before each interview was undertaken, and triangulation was upheld by obtaining data from multiple commercial ports along the coast to avoid community bias [74]. Finally, a rich and diverse data set was formed by including logbook and fish ticket data, historic documents, published economic data, and agency perspectives all to supply a holistic depiction and understanding of themes [74].

4. Results and Discussion

The Oregon nearshore groundfish system is a coupled system, with oceanographic, socioeconomic and political drivers that are not easily discernable in examining the fishery solely through SEK. Our mixed methods LEK approach yielded 4 significant themes, relating to 1) the ecological and human geography of the fishery, 2) the identity and behavior of the fleet, 3) the economic and market drivers, and 4) the uncertainty and optimism surrounding the future of the nearshore groundfish trawl fishery. Our findings revealed these themes to be intersectional, illustrating non-intuitive dynamics and trends within fishery participation and target stocks, spatially and temporally, within Oregon's nearshore.

4.1 Ecological & Human Geography of the Fishery

As with many economically important fisheries, the West Coast groundfish fishery is shaped by the presence, diversity and health of its stocks. As such, the story of its uses and impressions, in this and other research, links closely to species prevalence and trends across time [29], [75]. The descriptions of groundfish assemblages and logbook CPUE along the Oregon nearshore revealed the makeup of the 4 primary species groups present along the shelf and their contingent marketability as motivational to catch effort (figure 2). The discourse 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, the most persistently discussed species for the nearshore sector of the groundfish fishery were flatfishes (*Pleuronectiformes*), and across all years assessed, Petrale sole (*Eopsetta jordani*) stood out. Petrale sole was described not only a gratifying fish to target, but also as having upheld the most consistency in both abundance and market value across the period surveyed.

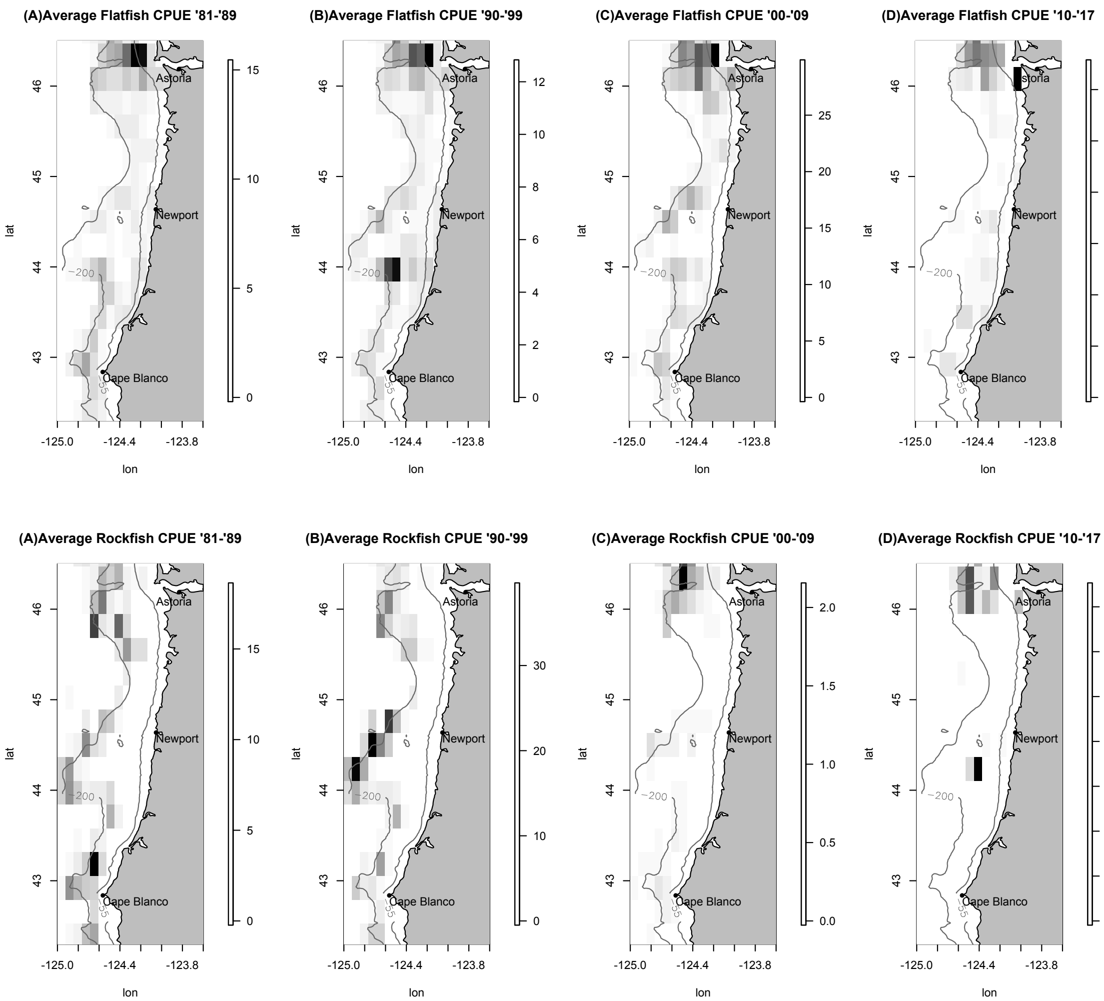
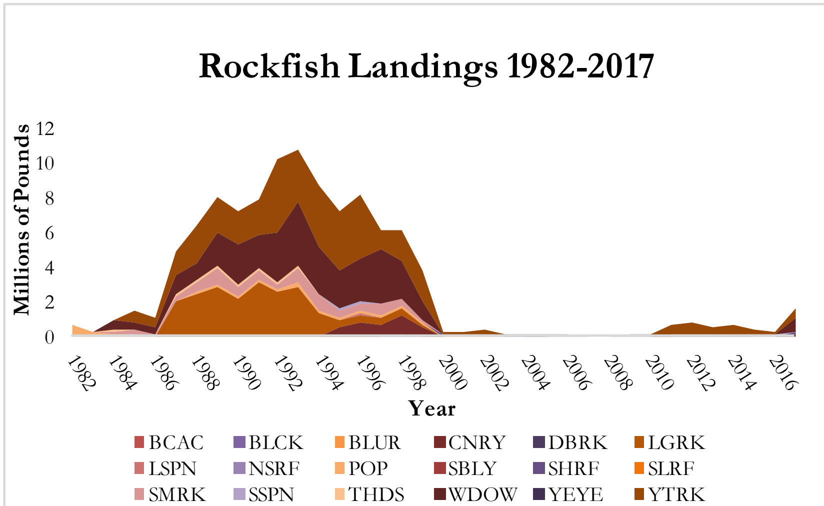


Figure 2. Logbooks Average CPUE Maps for Most Targeted Taxonomic Groups (Flatfishes and Rockfishes).
Average CPUE in pounds per hour for two PFMC taxonomic management categories: Rockfish species (18) and flatfish species (12). Data included from 1981-2017 with maximum trawl depth of 200 meters and shoreward 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 bottom trawl types.

Earlier recounts of the fishery present more diverse catch portfolios. The gear and target species represented in the logbooks for the 1980's and 1990's indicate a mixed fishery focused predominately on rockfishes and flatfishes using unspecified bottom trawl or small footrope trawl gear. Rockfishes were a high-volume fishery in the 1980's and 1990's, but landings dropped sharply beginning in 1999 and continued to remain low through 2017 (figure 3).



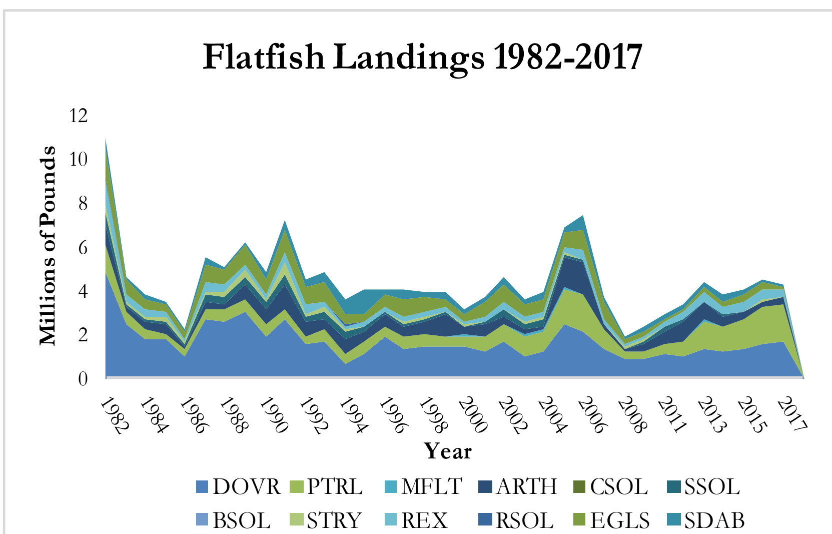


Figure 3 Logbook Total Pounds Landed for PFMC Taxonomic Groups.
Total Pounds in millions of the 2 most significant PFMC taxonomic management categories for the nearshore by species: rockfish species (18) and flatfish species (12) for the logbook subset, 1982-2017.

Given their life-history characteristics, a number of bottom-dwelling rockfishes are less resistant to persistent heavy fishing effort [7], [58], [76]. Hannah [77] documented "prime" trawlable rockfish habitat as centered along the 183 meter depth contour, where trawl effort was focused in Oregon during the boom of the trawl fishery in the 1990's. Figure 2 suggests the trends in rockfish (*Sebastes* spp.) target areas from 1981-2017 ranged spatially with consistent effort between latitudes of 44° to 46° and a sharp decline in overall average CPUE in the early 2000's. The decreased ability to reach rockfish prime habitat with adoption of selective flatfish trawl gear in 2005 (shorter footrope), the further spatial confinement of the RCA and EFH areas, and the shift to total accountability through the trawl rationalization cumulatively made rockfish species fall from favorability as a target group for the nearshore fleet [77], [78].

Interview accounts reflecting the 1980's and 1990's revealed that nascent remedial intervention in bycatch reduction or management of individual stocks meant that availability of trawlable habitat and catch did not pose limitations on fleet harvest activity [7], [77], [78]. The gear types preferred for this period (table 2) enabled the fleet to access high relief areas to target

Table 2 Nearshore Groundfish Fleet Characteristics.
Trends in vessel length, gear, management category 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

rockfishes using roller or rock hopper footropes and there was frequent mention of high bycatch of species such as Pacific spiny dogfish (*Squalus suckleyi)*. With the addition of footrope restrictions, requirement of the selective flatfish trawl and trawl RCA implementation in 2002, the nearshore and associated target species became less accessible to the trawl fleet [7], [9], [34], [79]. Logbooks and interviews demonstrate that despite an overall decrease in nearshore fishing effort, fleet characteristics such as vessel length and average trawl tow depth remained relatively constant (table 2). However, the nearshore groundfish fleet in the later decades was primarily concentrated offshore of Astoria, at the north end of the studied area.

Those present in the early days of the fishery, following the MSA described the boats and gear as more primitive, consisting of smaller wooden boats with no stern ramps, lower power, basic plotting and navigational technologies and the compounded challenge of a developing domestic processing industry. Tow durations were longer (as per both interview and logbook data) and the target species were more generalized. A member of the groundfish fleet reflects 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, 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, or "pineapple trawl." These changes, set against a waning array of processors and an inconsistent market, drove the fishery to focus on higher value flatfish species. While manipulation of mesh sizes and engagement with ODFW and experimental fishing permit (EFP) programs to further reduce bycatch continued, the selective flatfish 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 improved fishing capability; enhancements in weather prediction safety and timing of fishing effort. In the 1980's and 1990's, wooden boats were widened and lengthened and updated with more powerful winches and hydraulics. 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.

Alongside gear changes, interviews also reflected the fleet's adaptation to additional species constraints brought on by declining stocks and protective measures. The challenge of avoiding depleted rockfishes, specifically Canary and Yelloweye rockfishes, was described often by 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. As the depleted stocks have shifted into healthy levels again, limits of available quota to cover large groups of these species remained an element of concern. The fleet has "had to adapt" by avoiding or practicing extreme caution in these regions. The overall perceptions of increases in abundance of certain rockfishes in recent years was persistently spoken of in study interviews:

> *"Everywhere it seems like there's more rockfish. I think it's just spilling over from not being able to fish there for so long, and then the gear changes."*

The rebuilt status of Canary rockfish has alleviated some pressure for the still-active fleet members. The overfished status of Yelloweye rockfish, however, is another story. The associated risk of catching one or two large fish, which could push a boat over quota possession, launches the individual liable into a search for costly quota to cover the incident. Yelloweye quota remains a source of strain for those presently engaged in the fishery [80]. 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 arose 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 [81]. While Dover were frequently described in interviews as a target for this fishery, underlying wariness and the necessity of possession of quota for co-occurring Sablefish when fishing for Dover was also a concern.

A component of the competitive demand for Sablefish quota is the "gear switching" provision included with the catch share program in 2011. Gear switching 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, who use only fixed gear. This leaves little Sablefish quota to be utilized for trawl fishers targeting Thornyheads and Dover [39], [46]. The tendency for Dover to co-occur has been reported in the literature [39], and a perceptible interaction between fishing distribution, quota and species between Dover Sole and Sablefish (*Anoplopoma fimbria)* is documented in the logbooks and PFMC management of these stocks [7], [82]. In earlier periods, the lack of constraining stocks, management, and market limitations facilitated an overall greater harvest of Dover sole.

Cyclical abundance and quality of target species were also motivators of fleet fishing effort, particularly when discussing high value Petrale sole. Beyond simple abundance, fishermen research participants expressly mentioned the decline in flesh quality during reproductive periods and lower standard of fish harvested by larger vessels where it would experience bruising in the fish holds. Additionally, several interviewees expressed concern over the implications of heavy harvest effort during spawning events, fearing for the longevity of their stocks, particularly given a notable upswing in Petrale abundance over the last 10-15 years.

> *"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."*

Our findings indicate detailed ecological knowledge and adaptive capacity within the fleet regarding target nearshore stocks. For managers and scientists monitoring shifts in harvest behavior within the nearshore groundfish fishery, enhanced knowledge of species variability and subsequent quota use is imperative to effective management goals, particularly regarding the use and sustainability of the fishery overall [80]. Shifting into the future, sustainable use goals were emergent lessons from the past groundfish fleet. Research participants 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. One participant reflected this when discussing the pending access to areas formerly closed off by the trawl RCAs:

> *"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 [when] we go to sea now, [we] fill our boats up twice as quick as we used to. It's amazing how quickly 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."*

4.2 Identity & Behavior of the Fleet

Fleet behavior as well as the unique identity which evolved around the nearshore sector of the groundfish fishery are deeply connected to the fisheries ecology of the nearshore region. Research participants clearly articulated that the nearshore groundfish trawl fleet, or those who fish "the beach," self-identify as smaller vessels, specialized to harvest flatfishes. They also described the nearshore fleet as 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; often as 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 proximity to port regions, which also provided a buffer from the often-hazardous weather of the Oregon coast, as well as fewer "hang-ups" 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 challenging for newer entrants; corroborated by recent research on these fleets [41], [45], [83], [84].

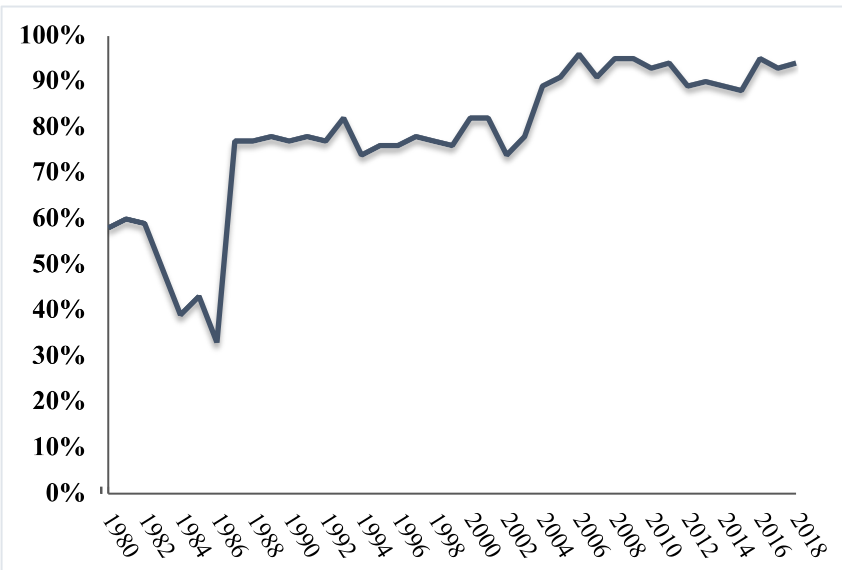


Figure 4 Percent Logbook Compliance 1980-2018
Compliance percentages for logbook entries 1980-2018 for the entire trawl logbook database courtesy of ODFW data managers. Logbook entries used for this work are a subset of this overall dataset of entries confined to 200 meters or shallower.

Management also played a pivotal role in shaping the nearshore, or "beach" fleet. It is important to note that while logbook entry compliance through time has been highly variable in consistency with total trips, particularly in the early periods of implementation, compliance has improved with time (figure 4). All visual portrayals and explorations, therefore, are a representative subset of fleet behavior through time.

Logbook and interview data indicated an overall gradual shift in effort off of the shelf as the trawl set numbers of the representative subset decreased in the nearshore. Specifically, on fishing grounds shoreward of 200 meters, while average trawl depth has not varied substantially, there has been a reduction of overall trawl sets as well as a general northward shift in fishing effort (figure 4). Over the defined nearshore space, the number of recorded logged tows peaked at 541,612 in the 1990's but declined considerably to 82,314 in the truncated 2010-2017 period (figure 5) even with the discrepancy in logbook compliance (figure 4), [60]. In the very nearshore range of 55m and shoreward, the recorded number of trawl sets decreased from a

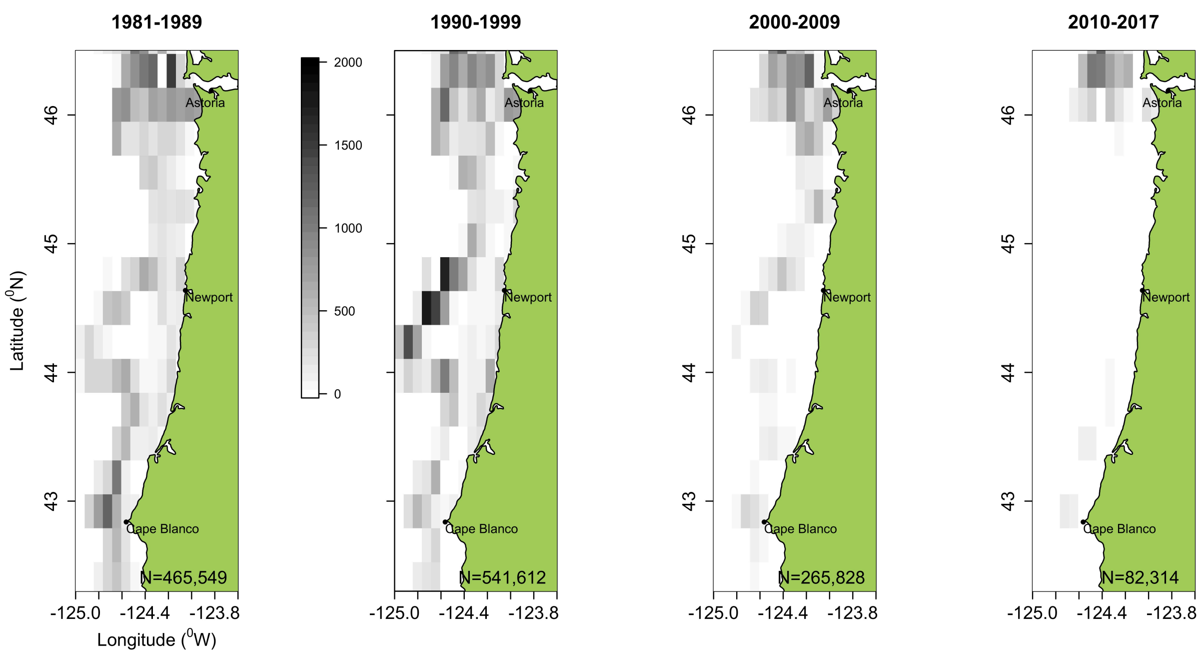


Figure 5 Map of Logbook Trawl Setpoints 200 meters and shoreward.
Logbook trawl setpoints for all tows occurring from 1981-2017. N=total number of tows.

highpoint of 91,244 in the 1990's to a mere 10,633 in the abridged period of 2010-2017. 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 1993 the vessel buyback program in 2003, and, ultimately, the IFQ program of 2011 [9].

Chronologically, considering the timeline of the fishery, research participants were quick to illustrate that the rise in overall capacity of the groundfish fleet was orchestrated by the foundational policy changes and subsequent management objectives of the initial MSA enactment in 1976. By incentivizing the buildup of US fleet capacity, and providing financial assistance to accommodate those pursuits, the government played a notable role in the initial heavy extraction efforts of fisheries such as West Coast groundfish; a perspective that aligns with previous research [31], [32], [85].

In turn, management was forced to adapt measures through an iterative process that constrained harvest as extraction pressure threatened resource health [32]. When the limited entry and buyback programs were designed, and began consolidation of the recently bolstered fleet, many fishermen were left jobless. Entry into the fishery became progressively costlier with the decline in vessel numbers and associated permits. For buybacks, no clause was instituted to ensure fishermen were unable to buy back in. In interviews, research participants reported that this allowed a number of individuals to sell their property for high value and make a profit. An ensuing narrative of bankruptcy began to emerge within the fleet from this time, with fleet members recalling turning to loans with creeping interest rates to support continued participation in the nearshore groundfish fishery.

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 [9], [45], [75], [84], [86]. An additional aspect of these consolidation events was the removal of many smaller boats that were 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.

Managers and scientist have taken measures to engage the LEK of the fleet through the stock rebuilding process. An example of this is the PFMC EFP program. This program began in the 1990's to test adjustments to maximize exclusion of juvenile or protected species bycatch. Restriction of trawl gear type focused largely on the shelf and nearshore because 6 of the 8 overfished groundfish stocks are known to associate commonly with the habitat in these areas. Allowing members of the nearshore fleet to participate in these programs offered them an opportunity to share their resource and ecological knowledge and foster cooperation in research. Ultimately the prospect of reducing bycatch, adopting transparency and the sharing of both local and scientific ecological knowledge, and enhancing overall efficiency and communication made EFPs a "valued experience" by both fishermen and scientist connected with the groundfish fishery.

> *"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.'"*

The attention paid to these types of cooperative efforts in research is growing. Fleet participation is 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 [26], [87], [88]. Benefits to scientists include access to resources such as crew and vessels to aid in research, and unique knowledge and perspectives of a study environment [87].

Literature indicates that the 2011 trawl rationalization program and ensuing modifications have been central to the reshaping and adaption of the broader groundfish fleet [9], [86], and this was reflected in our interviews and logbook data analysis. The reactions to IFQs has been mixed, particularly surrounding the volume and historical, catch-based distributional quota process [80]. For new entrants, captains, or crewmembers, as well as those who feel there should be credence lent to records with limited bycatch and non-destructive participation, the limited or lack of quota could be paralyzing to fishery use. By allocating quota to so called "heavy hitting" members of the fleet, many research participants raised concern over resource depletion and increasing struggle to trade quota as compounding barriers to pursuing their fishing livelihoods. This is in alignment with previous research [41], [86], [89], [90], including recent social science literature which suggests that while IFQ programs may meet management goals of reducing harvest pressure on overfished stocks, they widen wealth gaps between laborers (captains and crew) and vessel and permit holders [91], [92].

The socioeconomic underpinnings of IFQ programs unravel more slowly but are inherently complex and vital to comprehensive evaluations of the social and ecological system outcomes of catch share programs [46], [86], [90],[92]. Our findings corroborated the punctuated impacts that IFQ measures have had on the nearshore groundfish fleet. Research on IFQs has found that communities under these systems change in physical (such as vessels and processing infrastructure) and socioeconomic features [7], [45], [93], [94], [95].

With regards to internal fleet dynamics, research participants described changes in interaction between the remaining participants in the nearshore sector post fleet consolidation. 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. However, in contrast to the traditional incentive to maintain secrecy regarding fishing hotspots and limit disclosure of information perceived as vital to long term prosperity within the industry, the IFQ was credited 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, as reflected in this quote:

> *"The IFQ made us cleaner fishermen; avoiding areas with small fish. And I think, as fishermen, we'd talk 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!"*

This also translated to individual practices within the fishery:

> *"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. [Whereas] before, well, there's some stories I don't want to repeat in here."*

Overwhelmingly, the narratives that emerged in this research linked IFQ participation and quota use to economic and market drivers.

4.3 Economic & Market Drivers

From a management perspective, allocated quota is designed to be used by the fishery in a manner which creates the greatest economic and sustainability outcomes overall [7]. Interview and fish ticket data from this study highlighted less intuitive factors that influence quota use. Research participants discussed the tendency of management to air on the "conservative side" of quota allocation, and the lack of scientific surveys of the nearshore as a hindrance to fishery economic productivity and utilization. From their perspective, the translation of these surveys into quota allocations and the low constraining stock quotas limited fishery utilization. Yelloweye 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… I mean, the stocks were rebuilt for what -- two or three years -- before they finally allocated it to us? On the*

beach, I can't go out and make money on Dover. I gotta go out, and really gamble, and catch decent fish!"

Contrastingly, the allocation of greater amounts of quota distribution for species like Petrale and Dover elicited impacts on flooding the market and lowering value for those species, as well as the desirability of the quota value for trading. Given that Dover and Petrale in particular were described as heavily targeted 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 [during] 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 thought when it came to the quotas, you know? And that would hurt because Petrale, that was always the best fishing, when they were spawning."*

Another element of IFQs which was heavily criticized by members of the nearshore fleet were observer fees (and steady increases). Research participants shared that observer costs are not amended to lower-volume, smaller venture fleets, which Russell et al. [86] also observed in the fishery. Study participants recounted that boat size and harvest amounts lead to much smaller profit margins when compared with larger trawlers like the offshore fleet. For lower-volume vessels, this financial hurdle was described as a constant a point of strain. As an added cost of participation, fleet members described exterior members of the fleet who owned quota, but were no 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 IFQs brought in two new user groups. One was the observer industry; now you're paying $500 or so dollars a day [for this]. 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 -- and 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 [be fishing it]. So, it created another little industry of paper-holders that you still have to pay off. And I don't want to talk about all the bad things of the IFQ, [system] because there's good things too; and, of course, the [lower] discards are one of them."*

The context of unequal distribution of wealth among the fishery [91] was described as yet another challenge in maintaining equitable wages to crew member livelihoods, as well as the decision to go fishing and utilize quota [75]. In the modern landscape, processors and leasers control quota as well. This drives up cost of participation and quota on high value species in particular. It also leads to concern over the actual lucrativeness of the groundfish fishery, as captured through this representative quote:

> *"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!"*

From an economic standpoint, as our interview participants consistently alluded to, for commercial fishermen to go fishing there must be a market [80], [96]. Therefore, a major determinant in target species and overall fishing effort arose through fluctuation in market demand and the shifting processing abilities in Oregon coastal regions. Research participants described the fleet of the past as being able to capitalize on an abundance of processors, and the potential to advocate for their livelihoods through organized strikes and marketing associations. At present, of the described 25 or so processors for non-whiting groundfish, there are only 3 major plants who buy groundfish [97]. They described a situation where, with the continued consolidation of processors, the ability to push for better prices and species diversity has dwindled. The coevolution of ex-vessel prices and mounting costs to participate in the fishery was largely expressed as insufficient to promote profitability for fleet members. For some species, ex-vessel prices were described as increasingly more depressed, and economic data from PacFIN trended towards validation of these experiences as reflected in this quote:

> *"I had better prices in 1986 for some of the species; English sole and Rex [sole] was 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."*

Research participants noted shortages in filleters and other processing plant labor that influenced the ability to buy and move groundfish catch. Added to this was the farmed fish industry which emerged and corned a new market during the fisheries collapse in the 1990's, becoming the new competition. Even Petrale, the most consistently favored by market and ex-vessel price, was portrayed as struggling to compete with cheap farmed fish.

Industry trade association and market focused groups Stakeholder such as the West Coast's Positively Groundfish are working to rebuild the groundfish reputation among consumers, engage locally, and highlight the Marine Stewardship Council (MSC) certification. The mounting factors counteracting profitability, however, have continued to stint the harvest capacity of the fleet as this research participant described:

> *"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 it 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..."*

That said, narratives of innovation, market benefits, and optimism moving forward for the nearshore arose constantly across this study. Several fleet member participants expressed enthusiasm for continued focus on quality of product, both as opportunity to increase nearshore lower volume ex-vessel cost and market desirability. The prospect of getting fish to the dock and the market faster with closer proximity to port regions were key themes in the data. They also perceive an advantage to small vessel fish holds that limit damage to product, when also marketed with consideration and finesse, as important to the pursuit of higher quality fish and market success.

Research participants reflected that some fishermen have adapted in other ways within the evolving landscape of the fishery and its management. One example is using "nearshore groundfish" as a filler fishery for periods between shrimp and crab fishing seasons; sometimes only when those fisheries perform marginally. They also described the ability to switch within fisheries as a product of their existing knowledge of the nearshore grounds from this diversification, channeled again within the theme of identity and fleet behavior:

> *"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 deeper for Black Cod and Dover and such."*

4.4 Uncertainty & Optimism for the Future

Fishing is an uncertain business, however, interviews from this study revealed that fishermen are risk takers and highly adaptive; confirmed by previous research [98], [99]. 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 RCAs was largely interpreted as an opportunity for smaller boats to move in and target the valuable nearshore stocks again; namely Petrale, Sanddab, and Sand sole. Having the option to fish for groundfishes in the nearshore was described as offering limited opportunity for private ownership, with major constraints to any member attempting new entry to the fishery. They spoke to how the rationalization process is still unraveling, with the recent release of IFQ sales in the management timeline. That said, the voices of the remaining fleet presented enthusiasm and persistence for the possibilities of the fishery and future management.

This study focused on the nearshore groundfish trawl fishery. It highlights a future where there is a need for better communication and collaboration between the PFMC and the smaller sector of the groundfish fleet. The interviews and observations at management council meetings shed light on the lag in scientific information and its dissemination into management measures. Frustration in the fleet was reflected in 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."*

A similar sentiment was reflected from the fleet's perspective:

> *"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."*

Previous research 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 [51], [88], [100], [101], [102]. Our study's evaluation of multiple LEK sources reflected this as well: despite differing paradigms, multiple stakeholders and ecological knowledge expertise can unify to better commonly valued and accessible resources. For the future of nearshore groundfish, 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.

5. Conclusion

The West Coast groundfish fishery has been the focus of much natural and social science research to meet the needs of conservation and community alike [78], [103], [104]. Although SEK has been instrumental in scientific and management understanding of the living resources, the history of the nearshore fishery had been largely undescribed. This study used integrated mixed methods to fill this gap by exploring this small, specialized fishery and area of coastal habitat, and illuminating non-intuitive perceptions and sources of ecological knowledge from refined and diverse experiences of a broadly accessed resource. Engaging with multiple sources of LEK aided in reconstructing the history and social constructs of the unique nearshore ecosystem. The experiential knowledge and consistency in exposure offered 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 fishermen, scientists, and fisheries managers moving forward. Our study 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. By adopting similar methods, future research could explore approaches to navigating the perceivable complexities of disciplinary-disconnects between perceptions of an intersecting marine resource, and the potential benefits of using LEK to augment SEK in order to further understanding and collective dialogue in research and management.

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