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Title: Unrealized Economic Benefits in the West Coast Non-Whiting Groundfish Trawl Fishery

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Flaxen Conway

In Oregon, commercial fishing is estimated to contribute $544 million in income and 10,000 jobs per year to coastal communities. However not all fisheries are reaching their allocated quotas for catch. In 2017, 187.6 million pounds of non-whiting groundfish trawl quota worth $67 million was not attained, nearly three times the actual landings of 55.4 million pounds, which were worth $36.4 million in ex-vessel revenue. Increasing attainments of underutilized fish stocks could help diversify, stabilize, and enhance income, jobs, and overall community benefits. The “non-whiting” groundfish trawl fleet only catches 25% or less of their annual quotas of flatfish, rockfish, roundfish, cartilaginous fish, and other species. There are complex issues keeping this fleet from reaching its allocations including geopolitical market constraints, bycatch issues, inflexible regulations and lack of processing and port infrastructure. This research focused on estimating the significance of these unrealized economic benefits, in terms of jobs and income, of the “non-whiting” groundfish trawl fishery’s unutilized quota. This research estimates the potential unrealized economic benefits of full attainment of trawl quotas to West Coast coastal communities. The goal of this research is to serve as catalyst to strengthen collaboration between regulators, NGO’s, industry, and researchers so that they might work together to better address issues in this fishery.

Unrealized Economic Benefits in the West Coast Non-Whiting Groundfish Trawl Fishery

by

Aaron K. Gann

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Dean of the College of Earth, Ocean, and Atmospheric Sciences

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Dean of the Graduate School

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Aaron K. Gann, Author

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Chapter 1: Introduction

Commercial Fishing has a long history on the Oregon Coast and is a lucrative and prominent livelihood in coastal communities today. In Oregon, it is estimated to contribute roughly $544 million in income and 10,000 jobs per year to coastal communities (The Research Group, April 2017). While the Dungeness crab fishery is the most valuable on the West Coast, Salmon, Tuna, Pacific pink shrimp and the non-whiting groundfish trawl fleet all are significant contributors (Figure 1.1).

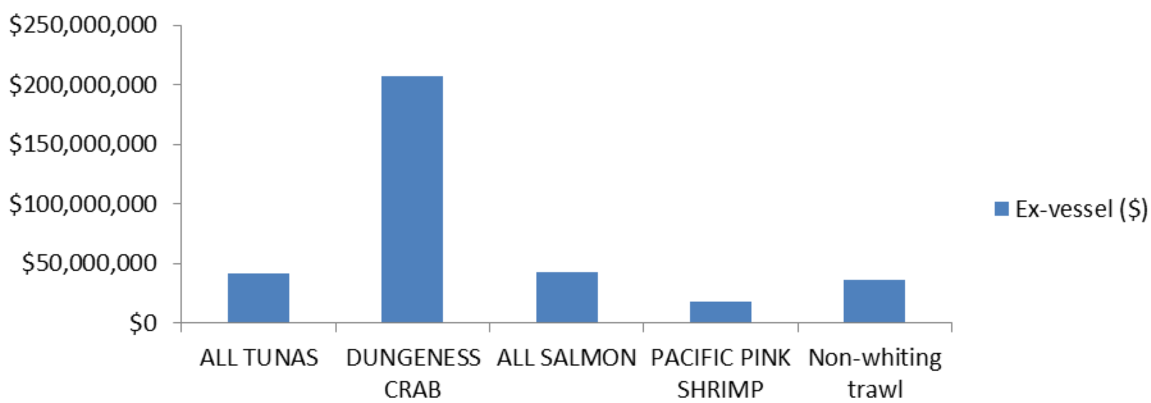

Figure 1.1 2017 non-whiting ex-vessel revenue compared to other major West Coast fisheries (PacFIN Oct 2018).

Each of these fisheries is managed sustainably through gear restrictions, limited entry, seasonal closures, and/or quotas. Since most of these fisheries are considered to be near full capacity West Coast fishery managers have shifted their focus on increasing attainments of underutilized groundfish stocks (PFMC, 2018b).

U.S. West Coast groundfish are caught by several different fleets. The two major fleets are the Pacific whiting trawl and the non-whiting groundfish trawl. Groundfish are also caught to a lesser degree by fixed gear targeting certain species such as sablefish, as bycatch on gear targeting other species such as in the salmon troll fleet, commercial hook and line (both open access and limited entry), and by recreational fishers. For this analysis we focus on the non-whiting groundfish trawl fleet and the associated unfulfilled quota.

The non-whiting groundfish trawl fleet uses both bottom and midwater nets. This part of the commercial fishing industry targets a diverse group of fish including flatfish, like Dover sole, Sand sole, sanddabs and Petrale sole; rockfishes, such as Widow, Canary, or Yellowtail; sablefish; and others (See Table 1.1). Some of these fish are managed as a group (complex), and some are managed as a stock (a species or complex that is managed differently based on the area). Figure 1.2 shows the West Coast and the major management lines (40°10' N for most stocks and 36° N for sablefish).

Table 1.1 List of species, stocks (if a species is considered to be two distinct populations), or complexes (when several species are lumped together and managed as a single group) targeted by the non-whiting groundfish trawl fleet on the West Coast.

IFQ species, stocks, and groupings for non-whiting groundfish trawl fishery	
Arrowtooth flounder	Other flatfish
Bocaccio rockfish South of 40°10' N.	Pacific cod
Canary rockfish	Pacific halibut (IBQ) North of 40°10' N.
Chilipepper rockfish South of 40°10' N.	Pacific Ocean perch North of 40°10' N.
Cowcod South of 40°10' N.	Petrale sole
Darkblotched rockfish	Sablefish North of 36° N.
Dover sole	Sablefish South of 36° N.
English sole	Shortspine thornyheads North of 34°27' N.
Lingcod North of 40°10' N.	Shortspine thornyheads South of 34°27' N.
Lingcod South of 40°10' N.	Splitnose rockfish South of 40°10' N.
Longspine thornyheads North of 34°27' N.	Starry flounder
Minor shelf rockfish North of 40°10' N.	Widow rockfish
Minor shelf rockfish South of 40°10' N.	Yelloweye rockfish
Minor slope rockfish North of 40°10' N.	Yellowtail rockfish North of 40°10' N.
Minor slope rockfish South of 40°10' N.	(Cell intentionally left blank)

The non-whiting groundfish trawl fleet potentially has significant unrealized income from this underutilized catch allocation, only catching 25% or less of their annual quota (PFMC, 2017). In

2017, 187.6 million pounds of non-whiting groundfish trawl quota worth $67 million remained uncaught, nearly three times the actual landings of 55.4 million pounds, which were worth $36.4 million in ex-vessel revenue, see figure 4.1.

The fact that the fishery is made up of a group of various different fishes and that there is a diverse group of target species is part of the reason non-whiting groundfish trawl catch allocations aren't being fulfilled. When a quota for one species is reached, the trawl fishing vessel will stop fishing that complex (groups of species commonly caught together) so as not to exceed the already filled quota. However, more complex issues also keep this fishery from reaching its catch allocations, including geopolitical market constraints (Sackton, 2014), complexity of compliance, bycatch issues (Somers, Pfeiffer, Miller, & Morrison, 2019), and lack of processing and port infrastructure (such as availability of lifts, hoists, ice, or bait) (Guldin, Warlick, Errend, Pfeiffer, & Steiner, 2018; PFMC, 2017).

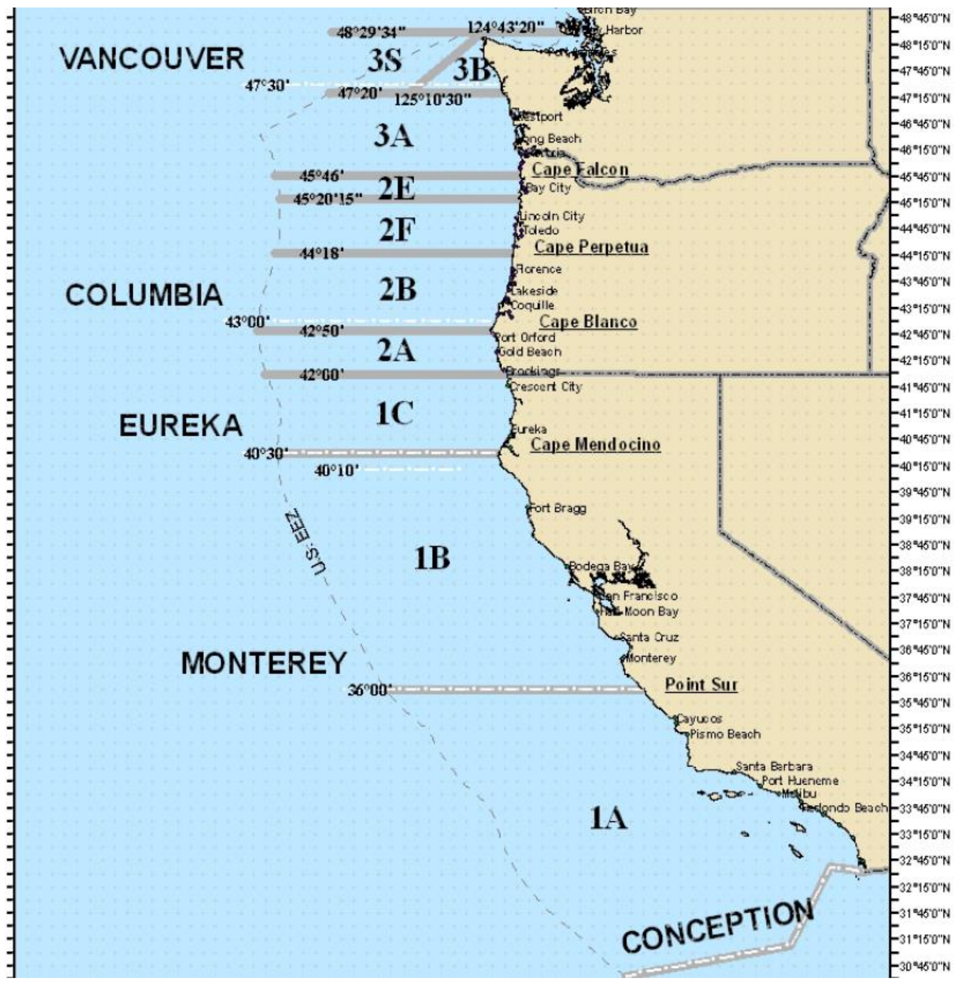

Figure 1.2 Map of the U.S. West Coast. 40°10’N is the dividing line for most species that are not managed coast wide. 36°00’N is the dividing line for sablefish. See Table 1.1.

There has been considerable interest by management in the region (e.g. Pacific Fisheries Management Council (PFMC)) to increase attainments of healthy and underutilized commercial groundfish stocks. Increasing attainments can help diversify, stabilize, and enhance income, jobs, and overall community benefits (Grafton, 1996; Kaplan, Holland, & Fulton, 2014; P. a. NMFS, 2010c). Moreover, maximization of economic benefits and ensuring long-term sustainable yields are the two main objectives of fishery laws such as the Magnuson-Stevens Act (ACT, 1996). Increasing attainments and economic benefits is important to coastal communities throughout Oregon and the West Coast, which are highly dependent on commercial fisheries (Norman et al., 2007).

For this reason, a main focus of West Coast fishery managers has been increasing attainments of underutilized groundfish stocks since most of the other main commercial fisheries such as crab, salmon, and halibut are at full capacity (PFMC, 2018a). With attainments of 25% or less, there is considerable economic growth potential in the non-whiting groundfish trawl fisheries in terms of extra income and jobs that include benefits to fishermen, processors, and communities as a whole ("multiplier effect"). The multiplier effect is when money that is brought into the community is spent several times, supporting more than the face value of that money (Miller & Blair, 2009). Overcoming geopolitical market constraints (such as tariffs or similar products in a commodity market driving the price down), bycatch issues, quota allocation inefficiencies, and lack of processing and port infrastructure will require strong collaborative partnerships of key stakeholder groups such as federal and state politicians, fishery managers, fishing industry, and environmental groups that work towards the common goal ensuring long-term sustainable yields while strengthening the fishing community as a whole.

The objective of this research is to estimate the economic benefits of the unrealized non-whiting groundfish trawl quota. This information may help inform management and fishery participants, and to incentivize strengthening partnerships through increased understanding that will be needed to overcome the constraints that inhibit this fishery. While many involved with the PFMC process are aware that non-whiting landings are low, the economic implications have not yet been described in terms in unrealized income and jobs. Furthermore, it is uncertain if key stakeholders outside of the PFMC process are aware of the low non-whiting attainment issue. Stakeholders may have different levels of involvement and different levels of understanding (Carothers, 2015; Cramer, Flathers, Caracciolo, Russell, & Conway, 2018). Moreover, this research could underscore the issue by expressing the potential in terms that are understandable to people and entities outside the fisheries world, which may help elevate awareness of the issue and foster support for partnerships to overcome constraints.

Ex-vessel value is often used within the fisheries world to express the value of a fishery, but ex-vessel value does not express the economic benefits that the fishery provides (Miller & Blair, 2009). For example, a million in ex-vessel value in the whiting fishery does not have the same economic impact that a million in ex-vessel value of the salmon troll fishery. Processing of whiting is highly automated, landed to only the large buyers, and most of the final product is exported overseas. On the other hand, salmon is filleted by hand, sold to even the smallest buyers, with a large proportion of the final product remaining within the West Coast economy. With partnerships working to solve some of the constraints on the “non-whiting” groundfish trawl fishery the economic benefits of increasing non-whiting attainments could be considerable in terms of additional income and jobs. What are the potential economic benefits to the coastal economy on the West Coast if full attainment of the non-whiting groundfish trawl occurred?

Chapter 2: Background and Rationale

The West Coast non-whiting groundfish trawl fleet accounts for 70 percent of groundfish landed on the West Coast, the rest is landed by open access vessels, fixed gear vessels, or as non-target species in other fisheries (i.e. by the pacific whiting trawl fleet). Trawling as a fishing method is very efficient, large volumes of fish can be caught and landed by relatively few people. Although, there are tradeoffs for efficiency; two major examples are bycatch (selectivity) and habitat damage. Trawling consists of pulling a net (trawl) behind the vessel that spreads open and funnels fish into a cod-end. There are two types of trawling; midwater and bottom trawl. Midwater trawls seldom come in contact with the ocean floor and are used to target more pelagic species such as Widow, Canary, and Yellowtail rockfishes. Bottom trawls maintain contact with the seafloor and target more benthic species such as Dover Sole, sablefish, and thornyheads. Different areas and depths can be targeted with either type of trawl to harvest different species or groups of species. Due to the co-occurring nature of species targeted, bycatch of overfished and rebuilding stocks has been an ongoing concern and motivation for executing various management measures over time (Warlick, Steiner, & Guldin, 2018).

2.1. Fisheries Management

The West Coast groundfish fishery is managed by a federal regional fishery council, the Pacific Fishery Management Council (PFMC), with the aid and participation of the state fisheries commissions. The Magnuson-Stevens Fishery Conservation and Management Act (MSA) and its reauthorizations create the framework for federally managed fisheries. It sets 10 National Standards that are to be considered when new policies are being created and implemented. The MSA requires by law certain integral parts and pieces of federal fisheries management; it requires the formation of the regional councils, the creation and use of Fisheries Management Plans (FMP), and status monitoring of stocks to prevent overfishing. The MSA also requires that each fishery is managed in a way that the optimum yield is achieved on a continuing basis (National Standard 1).

Currently the non-whiting groundfish trawl fleet is managed as an Individual Fishing Quota (IFQ) fishery, also known as catch shares. It is limited entry meaning a fisher must have or lease a permit to participate. Permits allow the catch of a certain amount of fish (Quota Pounds (QP)) each year depending on the Total Allowable Catch (TAC) and the permit's Quota Share (QS). There is 100% observer coverage, so all fish brought aboard the vessel are accounted for by the vessel and permit. This is different from the previous management scheme were the harvest of fish was controlled by bi-monthly landing limits (bycatch could be discarded with no repercussions).

2.1.1. The Magnuson-Stevens Fishery Conservation and Management Act

The United States Congress passed the Magnuson-Stevens Fishery and Conservation Management Act (MSA) in 1976. The MSA is the primary law governing marine fisheries management in U.S. federal waters, which extend to the United States' Exclusive Economic Zone (200 nautical miles offshore). Under the MSA, regional management councils must develop preliminary fishery management plans (FMPs) through a public process (16 U.S.C. 1852 MSA § 302). The Secretary of Commerce must approve these plans before they take effect. Significant amendments to the Act were passed in 1996 and 2006 when the MSA was reauthorized. Currently, there is legislation in both houses of Congress to reauthorize the MSA, H.R. 200 (Strengthening Fishing Communities and Increasing Flexibility in Fisheries Management Act) and S.1520 (Modernizing Recreational Fisheries Management Act).

Sustainable Fisheries Act of 1996

The Sustainable Fisheries Act of 1996 provided several steps forward in terms of fisheries management in the United States. Three new national standards were established. It required regional councils to identify “Essential Fish Habitat (EFH)”, and that other agencies consult with the Secretary of Commerce when action they take impact EFH. It set the standard to take into account communities and their reliance on fisheries when making management decisions. Research was mandated for incidental catch, conservation, and social and economic links to fisheries. Identification of overfished stocks and the rebuilding of those stocks were also required (NOAA, 2018).

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 attempted to end overfishing in several ways. It established annual catch limits and introduced new accountability measures. It directs the US to strengthen international fisheries management organizations and to address illegal, unreported, and unregulated fishing and bycatch. It solidified the role of science in fisheries management and ultimately decision making by expanding the duties of the Scientific and Statistical Committees (SSC), creating the Marine Recreational Information Program (MRIP), and introducing a peer review process for scientific information used to advise the Council about the conservation and management of a fishery. Scientific and Statistical Committees have several roles: They review FMP’s, stock assessments, rebuilding plans and other council documents to ensure that the best available science is being used. They also identify scientific sources of information for the use in developing council actions. They provide a multidisciplinary review of FMP’s and amendments, and in general give scientific advice in council actions and considerations. The MRIP replaced the Marine Recreational Fisheries Statistics Survey (MRFSS) after its use for roughly two decades (since the implementation of the MSA). The MRIP has two goals. The first is to provide timely, scientifically sound estimates of recreational catch and effort that fishery managers, stock assessors, and marine scientists need to ensure the sustainability of ocean resources. The second goal is to address regional and stakeholder needs and concerns about recreational fishing catch and effort estimates (Fisheries, 2008).

The MSA reauthorization of 2006 also opened the door for “limited access privilege programs” such as catch shares (or IFQs) which the West Coast groundfish trawl fleets started operating under in 2011 (NOAA, 2018). 2006 is the year that the PFMC started researching the Trawl Rationalization Program.

National Standards of the MSA

There are ten National Standards included in the MSA. The National Standards are statutory principles that must be followed in all FMPs. This is to ensure sustainable and responsible fishery management. The Secretary of Commerce must ensure that any FMPs, plan amendments, and regulations are consistent with the National Standard guidelines before approval (ACT, 1996). The National Standard guidelines are summarized interpretations of the National Standards by the Secretary of Commerce. Fishery management councils (or the Secretary of Commerce) should identify what the FMP is designed to accomplish, and outline management objectives to be attained in regulating the fishery. If objectives are in conflict, priorities should be established among them (*50 C.F.R. §600.305*, 2018).

National Standard 1 focuses on optimum yield.

> *“Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.”*

National Standard 2 focuses on scientific information.

> *“Conservation and management measures shall be based upon the best scientific information available.”*

National Standard 3 focuses on managements units.

> *"To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination."*

National Standard 4 focuses on the allocation of fishing opportunities.

> *"Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (a) fair and equitable to all such fishermen; (b) reasonably calculated to promote conservation; and (c) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privilege."*

National Standard 5 focuses on maximizing efficiency.

> *"Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose."*

National Standard 6 focuses on variations and contingencies.

> *"Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches."*

National Standard 7 focuses on costs and benefits.

> *"Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication."*

National Standard 8 focuses on communities.

> *"Conservation and management measures shall, … take into account the importance of fishery resources to fishing communities by utilizing economic and social data (that meet the NS-2 requirements) … in order to (a) provide for the sustained participation of such communities, and (b) to the extent practicable, minimize adverse economic impacts on such communities."*

National Standard 9 focuses on bycatch.

> *"Conservation and management measures shall, to the extent practicable, (a) minimize bycatch and (b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch."*

National Standard 10 focuses on safety of life at sea.

> *"Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea."*

All National Standards help to shape FMPs, amendments, and regulation. Several of these National Standards are particularly relevant when considering the effects of the Trawl Rationalization Program on the fishery and on the fishery participants; this will be discussed later on. Sometimes these standards can be at odds with one another, and when this is the case, priorities based on fishery objectives are established. For example, National Standard 5 (efficiency) does not necessarily maintain participation of some communities, one of the focuses of National Standard 8 (communities).

Fishing communities are defined as communities that are substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs. This includes fishing vessel owners, operators, crew, and fish processors that are based in such communities. An interesting note, permit holders are not included in the official definition, which under the IFQ system are a new class of participant. Fishing communities are social or economic groups, whose members live in specific a location, that share a common dependency on commercial, recreational, or subsistence fishing or on directly related industries or services (i.e. tackle shops, ice suppliers, boatyards, or product manufactures) (50 C.F.R. §300.345, 2018).

2.1.2 The Pacific Coast Groundfish Fishery Management Plan

As required by the MSA, the PMFC developed the Pacific Coast Groundfish Fishery Management plan. It was initially approved in January of 1982. This FMP provides a framework for the management of groundfish off the West Coast. It has three goals: Conservation, Economics, and Utilization. To help achieve these goals and address social factors it outlines 17 objectives. Two amendments (20, 21) are particularly relevant to the Trawl Rationalization Program. In fact, Amendment 20 (Trawl Rationalization) establishes the Trawl Rationalization Program; this amendment superseded and replaced provisions in Amendment 15. Amendment 21 (Intersector Allocation) established allocations between the different fisheries and sectors within them. Allocations to the different sectors were necessary for implementation of Amendment 20 (PFMC, 2016).

2.1.3. Management Agencies

The Pacific Fishery Management Council

The MSA created eight regional fisheries management councils. Regional council management creates a flexible system that can better meet the needs of unique fisheries and communities. The Pacific Fishery Management Council's (PFMC) region is comprised of Washington, Oregon, California, and Idaho. There are fourteen voting and five nonvoting representatives that serve on the PFMC. Voting members include a representative from each of the four states, a tribal representative, and members from the public who are knowledgeable about recreational or commercial fishing, or marine conservation. Councils are required to create fishery management plans (FMP) for each fishery under their supervision, about 119 species in the case of the PFMC under 4 FMPs (PFMC, 2007). A new requirement (from the MSA reauthorization of 2006) went into effect in 2011 requiring regional management councils to set annual catch limits for all federally managed fisheries; 2010 for overfished species. This can be done either by individual species or by groups of closely related species.

Northwest Regional Office (NWR), National Marine Fisheries Service

The NWR is the main implementation body at the federal level. They are responsible for developing and updating harvest specifications and management measures. The office is also responsible for issuing and administrating permits to individuals and entities to participate in federally managed fisheries. The NWR has been involved in all phases of the Trawl Rationalization Program, in the development of the program, in regulation setting, and in ongoing management activities of the program. The office calculated the initial quota share (QS) allocations and manages the vessel account system.

State Fish and Wildlife Agencies

Washington Department of Fish and Wildlife (WDFW), the Oregon Department of Fish and Wildlife (ODFW), and the California Department of Fish and Game (CDFG) manage state fisheries on the West Coast, i.e., those that are predominately located within 3 nautical miles from shoreline. They are also intimately involved with federally managed fisheries. Washington, Oregon, and California each has a voting seat on the PFMC. They each collect and provide data that is vitally important for fisheries management to the PFMC. The state agencies provide direct input, through the council process, into the development and amending of FMP's. In Oregon, managing resources to increase and preserve benefits to people and local communities is a top goal and is directly reflected in ODFW's mission statement.

> *"To protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations."* – ODFW's Mission Statement

2.2. West Coast Groundfish Fisheries

The Pacific Coast Groundfish Fishery Management Plan (FMP) was approved by the U.S. Secretary of Commerce (Secretary) on January 4, 1982 and implemented on October 5, 1982. Prior to this groundfish were managed by the states for more than 100 years. The Pacific States Marine Fishery Commission (PSMFC) was formed by the three coastal states to address the issues of managing stocks that span across borders. Management of foreign fishing started in 1967 with the first agreement between the US and USSR. With the passing of the MSA (1976), a management plan was developed for the foreign trawl fishery off the Pacific Coast. The regulations that were in effect at the time were incorporated into the FMP (1982), which provided for continued management of the foreign fishery. Joint-venture fishing (mostly whiting) began in 1979 and ended in 1991. Since 1982 the FMP has been amended 32 times in response to changes in the fishery, reauthorizations of the Magnuson-Stevens Act, and litigation that invalidated provisions incorporated by earlier amendments (PFMC, 2016).

2.3. The Catch Share Solution Implemented for the West Coast

In 1976 with the passing of the MSA, US public policy was focused on exploitation and expansion, increasing domestic capacity in the face of growing international encroachment (US Commission on Ocean Policy, 2004). From 1935 to 1975 the US fleet grew from 5000 to 17,000 vessels. With landings remaining relatively consistent over the same time (ranging from 2.9 to 3.8 billion pounds) average catch per vessel dropped 66%, despite tremendous increases in fishing technologies (Grimm et al., 2012). Because of policy and efforts since 1976 capacity increased to roughly 23,000 vessels and non-pollock landings increased by 40%, despite this increase in landings catch per vessel was less than it was pre MSA (Grimm et al., 2012). The Limited Entry Program was instituted as a way to prevent further overcapitalization in the West Coast groundfish fishery (Warlick et al., 2018).

In 1991, the PFMC amended the FMP to introduce limited entry endorsements for trawl, pots, and longlines to limit the size of the groundfish fleet. The fishery still included an open access component for pots, longlines, and other non-trawl gears. It was managed with landing limits. Starting in 1999, nine stocks were declared overfished over the next few years (pacific ocean perch (*Sebastes alutus*), bocaccio (*S. paucispinis*), lingcod (*Ophiodon elongates*), canary rockfish (*S. pinniger*), cowcod (*S. levis*), darkblotched rockfish (*S. crameri*), widow rockfish (*S. entomelas*), yelloweye rockfish (*S. ruberrimus*), and pacific whiting (*Merluccius productus*)). Consequently, the Secretary of Commerce declared the groundfish fishery a disaster in 2000. Congress financed a $46-million capacity-reducing buyback loan for permanent removal of 91 vessels (35 percent of permits) from trawl and associated fisheries in 2003 (P. a. NMFS, 2017).

In 2002 Rockfish Conservation Areas (RCA) were implemented to reduce the catch of darkblotched rockfish. Darkblotched rockfish were declared overfished in 2000 and management measures at the time were inadequate to keep the catch within the optimum yield (OY). The RCAs are a form of depth-based management, where different depths and areas are closed to certain gears, and this can be further varied by time in some cases. The initial RCA spanned from the 100 fathom (fm) depth contour to the 250 fm contour north of the 40° 10′ N. latitude. Bottom trawling for nearshore flatfish were authorized shoreward of the 100 fm line and bottom trawl in general was authorized outside of the 250 fm depth contour. In 2003, PFMC and NMFS implemented trawl RCAs that provided protections for several overfished species (NMFS, 2014). RCAs were an important management tool before there was a disincentive to catch and discard unwanted species. Currently, fishers can discard unwanted fish but those discards are still debited from their allotment. From 2004 to 2010, an annual average of 5000 metric ton, or one-fifth of total catch, of targeted stocks were discarded (Somers et al., 2019). Without RCA's protecting areas known to have high incidence of overfished species impacts to those species may have been greater than they were. The trade-off to this protection of over-fished species is the reduced access to co-occurring healthy stocks, a point commonly used against RCAs. A bonus that is understated (or absent) in the literature or conversation is that RCA's may play in important evolutionary part by reducing the genetic consequences of fisheries induced evolution (Miethe, Dytham, Dieckmann, & Pitchford, 2009). Since the non-whiting groundfish trawl fleet accounts for all fish caught, the PFMC is in the process of opening RCA's. Most stocks that were declared overfished and protected by the RCA's have been declared rebuilt or making progress toward rebuilding. This could increase access to stocks that have been protected by the RCA's.

The PFMC initiated work developing an Individual Fishing Quota system to improve the West Coast Trawl Fishery in 2003. Under its previous management structure (landing limits and RCAs), the West Coast Limited Entry Trawl Fishery was considered "economically unsustainable" (P. a. NMFS, 2010c). In 2011, Amendment 20 to the groundfish FMP transitioned the limited entry trawl sector of the commercial fishery to a catch share system, a type of limited access privilege program under the MSA. The Trawl Rationalization Program brought together cooperatives for the mothership and catcher-processor fleets that target and process Pacific whiting at sea, and the Individual Fishing Quota (IFQ) program for the shore based trawl fleet that targets both pacific whiting and other groundfish species (P. a. NMFS, 2017). The goal of the program was to:

> "Create and implement a capacity rationalization plan that increases net economic benefits, creates individual economic stability, provides for full utilization of the trawl

> sector allocation, considers environmental impacts, and achieves individual accountability of catch and bycatch (P. a. NMFS, 2010c)."

Costello et al. suggested that ITQs can reduce the likelihood of fishery collapse (2008). ITQs without proper structure can offer greater incentives to high-grade and consequently increase discards if limits are not imposed on catch rather than landings (Anderson, 1994). If limits are imposed on catch and not on landings then the discards have been show to decrease (Branch, Rutherford, & Hilborn, 2006; Somers et al., 2019). Overall, variability in landings, discard rates, and ratios of catch vs quota has been shown to decrease in fisheries managed under an ITQ program (Essington, 2010; Melnychuk et al., 2012). Essington suggests that this consistency in ITQ fisheries may increase over time and could be an indicator of more effective fisheries management (2010). Kaplan suggests that ports that have overlap with bycatch species may decrease landing while ports that do not overlap with bycatch species may increase landings (2014). ITQs naturally lead to concentration of QS, one of the goals of the program was consolidation of the fleet (Copes & Charles, 2004). It was understood that some vessels (hypothesized to be the less productive or efficient vessels) would leave the fleet while other vessels (hypothesized to the more productive or efficient vessels) would buy the permits from the departing vessels and increase their QS (P. a. NMFS, 2010c).

This research project focuses solely on the shore based non-whiting groundfish trawl fishery. As such, the whiting fishery is not included in any data gathered, analyzed, or reported in the results section.

Initial Permit Holder Allocations

Quota share (QS) is the quota issued to a permit holder under the Trawl Rationalization Program, it is the "unit" of an IFQ. QS is a percentage of the total allowable catch assigned to a specific sector of the fishing industry; in this case, to the non-whiting groundfish trawl fleet. Initial allocations for the non-whiting groundfish trawl fleet were done in two steps. Before any QS was distributed, ten percent of the total QS was set aside for the Adaptive Management Program (explained below). The first step in allocating the QS was to determine the percentage of QS that would have been issued to the permits that were part of the buyback program in

2003. The QS that would have been issued to those permits, about 44 percent of the initial QS, was distributed evenly across remaining permit holders. The second step was to allocate the remainder of the QS allocation based on the permit holders' historical catch during the 1994-2003 seasons, dropping the worst three seasons. QS for bycatch was allocated using a model using estimates of catch in the area being fished (based on years after 2003) against historical roll-up data.

Stocks that were considered overfished were allocated based on the need to cover incidental catch without exceeding the acceptable harvest level. Once a stock is considered rebuilt, the quota for those stocks is allocated based the historical catch from 1994-2003. This process was designed so that it would be fair and equitable (required per MSA NS #4)(P. a. NMFS, 2010a). The time period of 1994-2003 was chosen as a reference period because it was the most current catch data between when the limited entry program started and the buyback program in 2003 (P. a. NMFS, 2010c).

Quota Share and Vessel Accounts

Quota pounds (QP) are deposited into owners' Quota share (QS) accounts January of each year. These QP must then be transferred into vessel accounts for fish caught under the program. QP must all be transferred to vessel accounts by September first. When a landing is made the fish caught (harvest plus discards) are debited from the vessels account, the vessel must have enough QP to cover the catch before the fisherman can make another trip using gear that falls under the groundfish IFQ. Remaining QP at the end of the year can be carried over to the next year, within certain limits. If a landing is not able to be fulfilled using the balance currently in a vessel's account then the debt carries forward until enough QP are obtained, even if it requires the vessel to wait until the next year's allocation (P. a. NMFS, 2010a). Current balances for both accounts (QS and QP), as well as a roll-up view for the program as a whole, are publicly available via NOAA's website. While historical account balances are not available, viewing current balances can give insight into the current status of this fishery. The publicly viewable accounts were the source of data for this research.

2.3.1. The Adaptive Management Program

In the non-whiting sector, 10% of the quota shares are set-aside for an Adaptive Management Program (AMP). Currently the QS are passed through the program and are divided equally amongst all QS holders (www.pcouncil.org, 2018). The stated purpose of the AMP is to, "(A) mitigate against the effects of the program on adversely impacted communities, (B) provide incentives to use habitat and bycatch friendly gear, and (C) to mitigate against adverse effects of the program on processors" and, "…to address such objectives as community and processor stability, new entry, conservation, and other unidentified/unforeseen adverse consequences" (P. a. NMFS, 2010a). There are current discussions on what to do with the program's QS or QP. Nayani and Warlick analyzed 6 policy alternatives against the goals of the AMP and found that there may be flexible alternatives that could help the program server its' intended purpose (2019). Nayani and Warlick also point out the dangers of maintaining the status quo and the possible reliance of fishers on the pass through QP. This is important because the AMP could be an important tool to help address the low attainment of the non-whiting groundfish trawl quotas.

2.3.2. Key Data Sources

There are many significant sources of fisheries data, including current and historical data. There is data being collected specific to the Trawl Rationalization Program, and this data is crucial in the review of the successes and challenges associated with the Trawl Rationalization Program. Below are major sources for fisheries data on the West Coast.

Pacific States Marine Fisheries Commission

The PSMFC, mentioned before, is responsible for maintaining consolidated multistate commercial fishing catch data for the West Coast and Alaska. For the West Coast, data managed by Pacific States includes the following:

- **Catch Data**

Pacific Fisheries Information Network (PacFIN) and the Recreational Fishery Information Network (RecFIN) store consolidated data about commercial and recreational catch, respectively. For commercial catch, state fish ticket systems are interfaced to PacFIN from state agencies. Logbook data is also consolidated in PacFIN. Data from difference sources are combined to create value added data. There are various summary reports publicly available on the PacFIN website (PSMFC, 2018).

One of the requirements of the Trawl Rationalization Program was that catch information be electronically reported by first receivers within 24 hours of landing. A first receiver is a person who receives, purchases, or takes custody, control, or possession of catch onshore directly from a vessel. The E-Ticket system is a mandatory reporting requirement for all commercial catch and discards under the Trawl Rationalization Program. Data submitted updates in the Vessel Account system nightly (PSMFC, 2018).

- **Shore-based landings data**

When catch from a fishing trip is offloaded, a catch monitor records landed weights and may subsample species groups to get composition data. The port sampler later enters this data into a system, along with any additional comments they have about the data. The data from these records is electronically submitted weekly and stored in tables along with the E-Ticket data (PSMFC, 2018).

- **Electronic Monitoring Program**

Due to the high cost of observer coverage and reduction of bycatch, a new system of vessel monitoring is being considered. It is currently being tested under an experimental fishing permit (EFP). Instead of having a human observer on board doing the monitoring, vessels are now outfitted with cameras, GPS, and sensors to collect the data (PSMFC, 2018).

Northwest Fisheries Science Center (NWFSC), National Marine Fisheries Service

The NWFSC is one of six regional centers in the United States that conducts scientific, economic, and social data collection and analysis for NMFS. The NWFSC administers most of the economic and social data collected about the Trawl Rationalization Program. The following divisions within the NWFSC have notable roles in relationship to the Trawl Rationalization Program:

- **Fishery Resource Analysis and Monitoring Division (FRAM)**

The FRAM division is responsible for the research needed to manage West Coast groundfish. There are four programs in FRAM: Economic and Social Science Research, Fisheries Observation Science, Groundfish Ecology, and Population Ecology. Research includes but is not limited to stock assessments for federally managed stocks, rebuilding analysis, discard estimation and economic impacts (NMFS, 2018).

- **Conservation Biology Division**

The Conservation Biology Division (CBD) focuses on the conservation of marine species and the ecosystems upon which they depend. There are three programs under the CBD: Ecosystem Science, Genetics and Evolution, and Mathematical Biology and Systems Monitoring Programs. Interestingly, human systems are studied alongside natural ecosystems. These "coupled social-ecological systems" are used to inform the stewardship of fisheries, protected species, and ocean ecosystems (NMFS, 2018).

2.4. Planned Evaluation of the Program by the PFMC and NMFS

Amendment 20 required the PFMC to complete a review of the Trawl Rationalization Program within the first five years from the program's start date (P. a. NMFS, 2010a). After the initial review, formal reviews will be conducted every four years that the program remains in effect. The West Coast Groundfish Trawl Catch Share Program Five-year Review was published in

December of 2017. It has over 500 pages and is a wealth of information about the trawl fishery and the performance of the Trawl Rationalization Program.

2.5. Commercial Fishery Participant

To understand the complexities of the issues that are faced within the Trawl Rationalization Program, it is helpful to understand some basic relationships that exist between different fishing groups. As participants in one fishery also take part in others, changes to employment within the trawl fishery warrant consideration when analyzing the program's effects on the broader picture of West Coast fisheries. Vessels may leave and join fisheries as they see fit, maximizing earnings with consideration of other priorities. In 2009 and 2010, about 65% of the non-whiting groundfish trawl fleet revenue came from groundfish. This decreased to an average of 31% from 2011 to 2015. Participation of non-whiting groundfish trawl vessels in the Pacific Pink Shrimp fishery nearly doubled to 50% after trawl rationalization (NMFS, 2017). They provide evidence to suggest several reasons a) avoidance of the fishery due to complexity to participate, b) ability of permit owners to sit out and still recover costs by leasing quota out, c) ability to fish quota when convenient (allowing fishermen to focus solely on another fishery for a portion of the year and not lose access to fish). The increased participation in the Pacific Pink shrimp fishery may be due to better than average catches starting 2011 to 2015 (P. a. NMFS, 2017). The decrease in trawl fleet revenue from groundfish could be indicator of increased flexibility of fishermen. Landings and fishing effort (both vessel numbers and days at sea) decreased, days spent in other fisheries increased by 15- 20% decreasing days spent in the fishery to less than half of total time at sea (Errend, Pfeiffer, Steiner, Guldin, & Warlick, 2019).While the revenue from groundfish decreased as a percentage there is evidence that it generally increased during the same time period (Errend et al., 2019).

As stated above, vessels may leave or join the non-whiting groundfish trawl fleet as they see fit. Even if a vessel is part of the fleet they may choose to fish in a different fishery. This issue is discussed in great detail in the 5 year review of the Trawl Rationalization Program. Reasons for deciding or not participating fully in the non-whiting groundfish trawl fishery vary and depend on several factors including both endogenous and exogenous factors (NMFS, 2017). Each day that a boat is able to go out and fish but is prevented from doing so, for whatever reason, it is losing money for the fishermen. This is one factor that leads fishermen to participate in other fisheries, a chance to go out and make some money.

An example of an endogenous factor that restricts a fisherman could be their lack of confidence of catching the desired target species. The program in some ways restricts a fishermen's ability to do test fishing, or forces them to be more strategic about it. Test fishing now comes with a cost, because all fish caught regardless if they are retained or not are counted against their individual allotment. This is a change from previous management regimes, when only landed fish were counted against a vessel allotment (NMFS, 2017). If a fisherman uses up most of the quota of one species while looking for a second species it could impact the ability to fish a third species that they have familiarity with and know how to target and catch.

An example of an exogenous factor that restricts fishermen could be processing capacity (Guldin et al., 2018). This is a bottleneck that was expressed by fishermen several times in the 5 year review. As an example, if a port (the sum of the processors if more than one is present) can only process 20 tons of a certain species a week and there are four vessels that can land 10 tons each trip and they can make multiple trips each week, then there is not enough processing capacity for the vessels to fish their potential capacity. While vessels are waiting their turn for a chance to make a landing they may take part in other fisheries (P. a. NMFS, 2017). Most of the time fishermen coordinate with processors before fishing to schedule a landing so they know the processor can take the fish that they catch.

Chapter 3: Methodology

3.1. Input output models

Input-output (IO) analysis was developed by Professor Wassily Leontief in the 1930's (Leontief, 1936). In 1973 Professor Leontief received the Nobel Prize in Economic Science for his work. Input-output may be referred to as the Leontief model or interindustry analysis. The fundamental purpose of the input-output framework is to analyze the interdependence of industries in an economy. Essentially, an input-output model estimates changes in an economy based on changes in demand of a product. The basic model consists of a system of linear equations, with each equation describing the distribution of an industry's product throughout the economy. This basic model can be expanded on, with most of the extensions intending to incorporate additional detail of economic activity, such as over time and space, to accommodate limitations of available data or to connect Input-output analysis to other kinds of analysis tools (Miller & Blair, 2009). One important extension to the model is to be part of an integrated framework of employment and social accounting metrics associated with industrial production and other economic activity (Miller & Blair, 2009); this is an important extension to the model that we use to ask, how many jobs and much income could be supported with full attainment of the non-whiting groundfish trawl quota.

The availability of high-speed digital computers has made input-output analysis a widely applied and useful tool for economic analysis. Without modern computers the computational requirements of input-output models make them very difficult and impractical to implement (Miller & Blair, 2009). Input-output analysis is one of the most widely applied methods in economics (Baumol, 2000). This computation capacity also allows for scalability on many levels, for example, spatially (county, state, region, nationally, or any other geographic designation), number of producing sectors (how many products and producers are tracked within the model) (Miller & Blair, 2009).

An important use of the information in an input-output model is to assess the effect on an economy of changes in elements that are exogenous to that economy. Input-output multipliers, are summary measures derived from the model, and are often employed in impact analysis. Commonly used types of multipliers are those that estimate exogenous change effects on (a) outputs of the sectors in the economy, (b) income earned by households in each sector because of the new outputs, (c) employment (jobs, in physical terms) that is expected to be generated in each sector because of the new outputs and (d) the value added that is created by each sector in the economy because of the new outputs (Miller & Blair, 2009).

Input-output models tend to overestimate the effect of policy change because some of the assumptions that have to be made for the model to work (Miller & Blair, 2009). There are three main assumptions that must be made for input-output models to work. First, input-output models are demand driven, as demand increases it is always met with an increase in supply. Second, input-output models assume that prices and costs remain fixed regardless of changes in demand. The third assumption of input-output models is that there is no substitution in production of one product for another. This final assumption doesn't contribute to the model overestimating the effect of policy changes (Leonard, 2011).

For a detailed review of the use of input-output models in fisheries refer to Seung and Waters (2006). There is an important consideration that must be addressed in input-output models before they are appropriate for use in fishery management (Steinback, 2004). Due to the nature of fishery management the amount of product is controlled by the TAC (as an input into the economy). However, IO models are designed to estimate the changes in an economy based on changes in demand of a final product, not the availability of resources to create the final product (Leonard, 2011).

The IO-PAC Model

The Northwest Fisheries Science Center (NWFSC) developed an input-output model for Pacific Coast fisheries (IO-PAC). The IO-PAC is a customization of the Impact Analysis for Planning (IMPLAN) regional input-output software (Minnesota IMPLAN Group Inc., Hudson, Wisconsin). The development of the IO-PAC model used a similar methodology as the Northeast Fisheries Science Center's Northeast Region Commercial Fishing Input-Output Model (NERIOM) (Steinback & Thunberg, 2006). The IO-PAC model is designed to estimate changes in economic contributions and impacts resulting from policy, environmental, or other changes that affect fishery harvest. The model is also spatially flexible, estimates can be calculated for the entire West Coast, by individual states (Washington, Oregon, and California), and by port area (there are 18 port areas on the West Coast)(See Fig. 3.1)(Leonard, 2011).

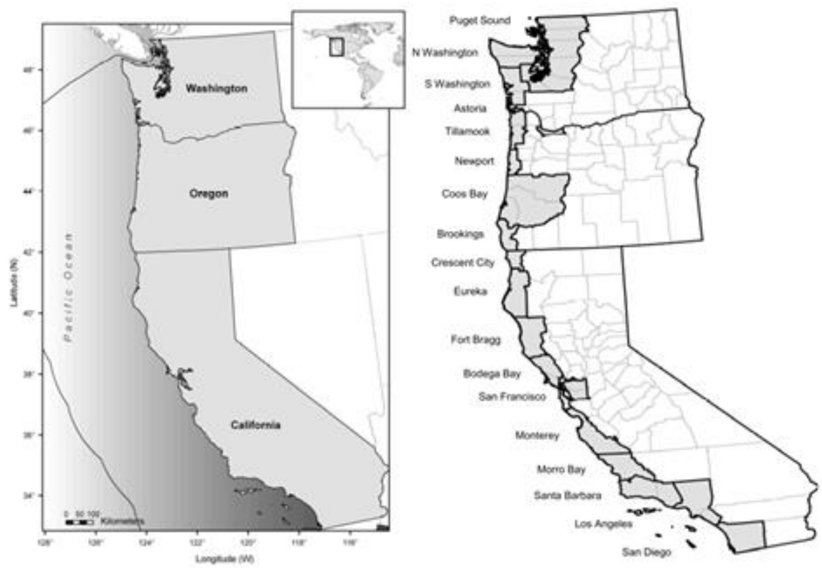

Figure 3.1 A map of geographic levels in the IO-PAC model from Leonard (2011).

The IO-PAC model uses the same approach as Steinback and Thunberg (2006) by handling production changes rather than final demand changes in the input-output framework. This is a problem that arises due the requirements and constraints of the model, which typically works from changes in demand, and the nature of fisheries management, which is restricted by a finite supply of fish. Data for the IO-PAC model comes from three main sources: IMPLAN, PacFIN, and the NWFSC cost earnings surveys.

For this study, we used the IO-PAC model, which is specifically designed to estimate the economic effects of changes in fishing harvest for various types of vessels, fish species, and gears over multiple geographic areas along the Pacific Coast. IO-PAC covers the major fisheries, such as, commercial groundfish, salmon, Dungeness crab, highly migratory species, coastal pelagic species, and shrimp fisheries on the West Coast (Leonard, 2011). The IO-PAC is commonly used in economic analyses for West Coast recreational and commercial fisheries such as the biennial harvest specifications and management measures for groundfish fisheries by the PFMC. Using the same model for this analysis as fisheries managers use for analyzing policy alternatives maintains relatability from this analysis to possible future decisions.

3.2. Methods

Data were accessed via NOAA's IFQ accounts available to the public online. Figure 3.2 below provides a flow chart of the methods. Step one, from the vessel accounts, several pieces of important information were derived: total catch (including discards), and allocation; unused quota was determined from allocation minus catch. Total catch and discards were used to generate discard ratios, to be used when estimating the amount of harvest (fish landed for sale) from the unused quota. Carryover quota was excluded, under the assumption of full exploitation there would be no carryover from year to year. It is assumed that there will be full exploitation because that is the focus of this research; to estimate the potential jobs and income at full exploitation. It is important and simplifying to generate the data using the vessel accounts because this is the "net", rather than the "gross" quota that is fishable by the fleet; meaning that all set asides or deductions have been accounted for. An example of a set aside is the QS for the AMP (at the current time this is given to permit holders).

Step two, the current non-whiting values were computed based on ex-vessel revenue of landings from PacFIN. These had to be computed by gear, species, and area to be used as inputs into the IO-PAC model. This fine-level of partitioning is essential given the differential values of different fish stocks, and because the "multipliers" of the IO-PAC model also vary by species, gear, and area. Results estimate the current number of jobs and local income supported by the fishery. Results were combined regionally (entire West Coast) for confidentiality. The jobs and income outputs were provided at the West Coast level since it would be too speculative to generate local impacts given that there would have to be major increases in landings for full attainments to occur. With major increases in landings some ports may benefit more than others; it is outside the scope of this research to forecast which ports and to what level they would benefit. In general, all benefits will be accounted for somewhere within the region, this is one reason why this analysis was combined to the region level.

Step three, to determine the values of the uncaught quotas, the calculated uncaught quota from above were adjusted with the discard/landing ratio to estimate harvest (fish that could be landed and sold). Essentially this is the amount of unattained quota that could be landed. This is important because not all catch is landed; some is discarded because it is unmarketable. Landings were assumed to be distributed the same as the actual landings. For example, if Newport Oregon accounted for 24% of midwater trawl canary rockfish landings, then it was assumed that 24% of the uncaught canary rockfish quota that was assigned to midwater trawl would be landed into Newport. It was assumed that landings were distributed the same as actual landings because this research is focused on the economic potential to the region and not on the changes to individual ports. It is outside the scope of this research to forecast changes in landing distributions from port to port. Effort shifts have occurred since the implantation of the IFQs, generally from smaller ports to larger (Guldin et al., 2018; P. a. NMFS, 2017). If capacity were to increase due to increased attainment of quota, there may be a shift back to smaller ports, but this is just speculation. If this were to occur the effort shift would still be accounted for within the region. However, the benefits to the economy may change due to different multiplier for different port areas. Ex-vessel revenues were calculated based on gear, species, and area using the same price per pound as the utilized quota. These ex-vessel revenues were inputted into the IO-PAC model. The results (jobs and income that could be supported by the fishery) were combined for confidentiality and to match the regionality of results from the actual landings above. Estimates of catching the full IFQ allocations are the sum of current and potential landings.

Finally, in step four, we put the potential economic benefits associated with catching the full trawl quotas in perspective to the value of other commercial fisheries. This could be helpful for the PFMC and other entities to prioritize future efforts to increase attainments by reducing regulatory burdens, improving markets, and eliminating bycatch constraints.

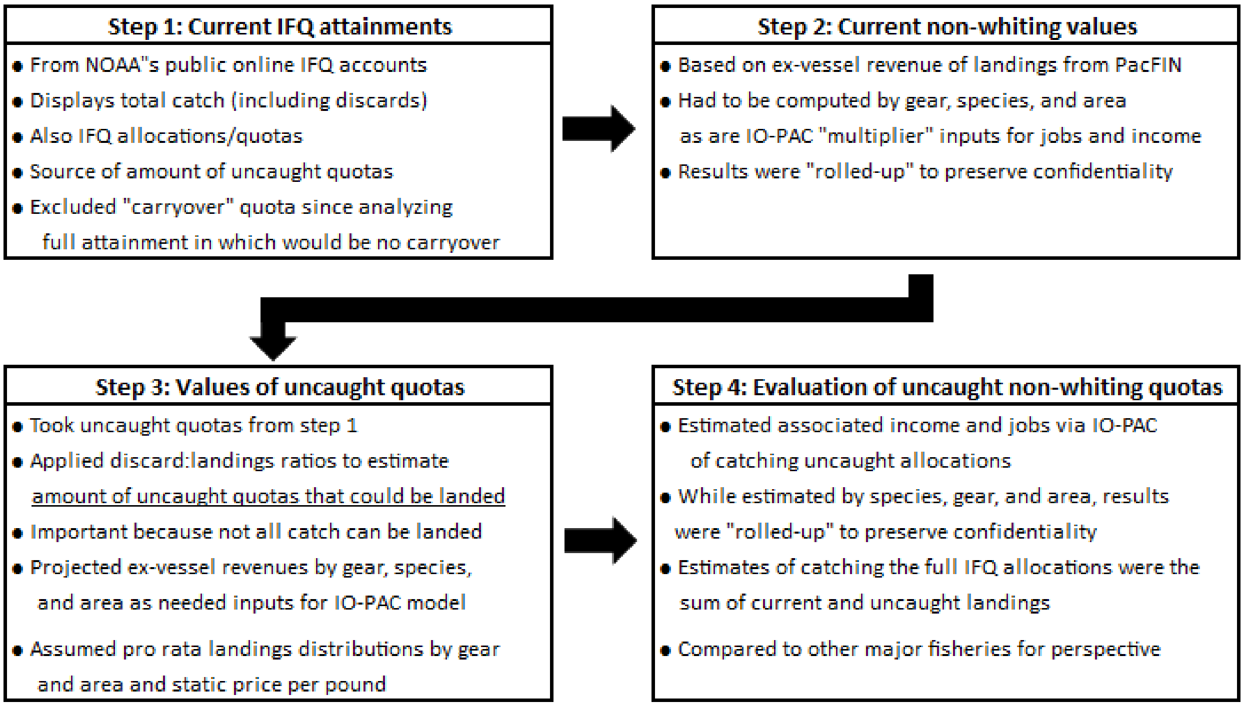

Figure 3.2 A flowchart of methods.

3.3. Limitations

The main objective of this analysis is to provide potential benefits associated with higher or full non-whiting attainments for 2017. For the scope of this project it was impractical to precisely project the actual benefits since it may require considering large-scale changes to markets, potential ocean and climate changes, as well as fishing and processing practices. Furthermore, it would be too speculative to project which port or state these benefits could accrue. Since the fishery is managed at the federal level, fishery participants are free to move from port to port or state to state as they see fit. Proximity to fishing grounds, current port infrastructure, fuel prices, land availability for future port infrastructure, local and state regulations and taxes are some of the factors that participants would have to consider as landings increased.

The analysis focused on benefits to the entire West Coast for 2017 using the IO-PAC model and did not run projections through time. With the IO-PAC model, changes in ex-vessel price, landing distributions, gear usage, and areas all change the outcome because the economic multipliers are calculated based on fine scale economic indicators that vary from port to port. It is difficult to predict the changes in the fisheries, communities, processing capacity, markets, or other factors that could change the inputs to the model. These, in addition to potential ocean and climate changes, and quota changes due to stocks becoming exploited vastly complicate projections. While it is possible to run this analysis under different sets of assumptions or “scenarios” because of this multitude of potential factors affecting projections, it is outside the scope of the goals for this research. The model itself may even have to be adjusted if fishing communities (especially fishery reliant communities) change significantly.

Data from a single year, 2017, was used in this analysis. 2017 may be more reflective of the future, many species have now been declared rebuilt and others have had large increases in quota. This can be viewed as a transition from the disaster era to the recovered era. The fine scale break down by gear, species, and area (required by the model) would not allow using the average of years or multiple years without introducing uncertainty in the results. Table 3.1 provides a comparison of IFQ quota remaining at the end of each of the last four years. In general, 2017 is representative, at least in the terms of attainment verses uncaught quota, of the fishery. Widow rockfish show a dramatic increase in unattained quota, this can be attributed to the recent “successful” rebuilding of this fish stock and the increased allowable catch (PFMC, 2018a).

Table 3.1 IFQ quota remaining at the end of year. Does not include carry over from previous years. Weight is expressed in mt. Source NOAA's IFQ accounts.

IFQ Species	2017	2016	2015	2014
Arrowtooth flounder	9,674	1,613	1,524	1,732
Bocaccio rockfish South of 40°10' N.	211	42	43	70
Canary rockfish	760	23	-2	31
Chilipepper rockfish South of 40°10' N.	1,810	1,121	1,014	755
Cowcod South of 40°10' N.	1	1	1	1
Darkblotched rockfish	326	170	163	181
Dover sole	38,635	38,785	39,742	15,739
English sole	9,004	6,259	8,824	5,023
Lingcod North of 40°10' N.	740	823	948	916
Lingcod South of 40°10' N.	534	397	416	456
Longspine thornyheads North of 34°27' N.	1,885	2,155	2,194	913
Minor shelf rockfish North of 40°10' N.	907	1,062	1,058	474
Minor shelf rockfish South of 40°10' N.	190	188	183	71
Minor slope rockfish North of 40°10' N.	1,104	1,070	991	605
Minor slope rockfish South of 40°10' N.	377	375	354	280
Other flatfish	6,724	5,458	6,837	3,354
Pacific cod	988	646	654	960
Pacific halibut (IBQ) North of 40°10' N.	43	56	49	80
Pacific Ocean perch North of 40°10' N.	104	70	69	72
Petrale sole	-7	134	40	64
Sablefish North of 36° N.	-112	111	-4	104
Sablefish South of 36° N.	668	584	550	447
Shortspine thornyheads North of 34°27' N.	810	816	863	689
Shortspine thornyheads South of 34°27' N.	50	48	49	47
Splitnose rockfish South of 40°10' N.	1,649	1,636	1,591	1,508
Starry flounder	624	747	750	741
Widow rockfish	5,473	583	606	340
Yelloweye rockfish	1	1	1	1
Yellowtail rockfish North of 40°10' N.	1,780	3,231	3,143	1,775

Chapter 4: Results and Discussion

4.1. Results

The overall results can be found in Table 4.1. Catch is the total weight of fish (quota) impacted, which is, amount landed plus discards. Harvest is the total poundage of fish caught and kept (Blackhart, Stanton, & Shimada, 2005). The non-whiting fleet caught nearly 60 million pounds of fish for an ex-vessel value of 36 million dollars. This is estimated to support 1030 jobs and 83.5 million in wages. The non-whiting groundfish trawl fleet had roughly 187 million pound of quota remaining at the end of 2017. That quota, using at proportional discard rate and status quo price per pound, was worth 67 million in ex-vessel revenue. That unrealized quota is estimated to support 1961 jobs, or 162.5 million in wages. Dover sole is the stock with the most quota on the table, it could support 1063 jobs alone. The roughly 75% of quota that is unrealized is only worth twice the ex-vessel value of the harvested fish. This is because most high value stocks are typically fully exploited.

Table 4.1 Ex-vessel value, wages, and jobs are shown both for actual landings and potential landings. Wages and ex-vessel value are shown in thousands of dollars.

	Value of 2017 IFQ catch for baseline					Value of uncaught 2017 IFQ				
IFQ grouping	Catch lbs	Harvest lbs[1]	Ex-vessel value	Income[2]	# of Jobs[2]	Uncaught quota	Potential lbs harvested[3]	Ex-vessel value[4]	Potential Income[2]	# of Jobs[2]
Arrowtooth flounder	3,035,967	2,235,820	$217,669	$522,562	6	21,326,436	15,705,729	$1,529,037	$3,670,787	44
Bocaccio rockfish South of 40°10' N.	202,154	195,389	$96,264	$231,081	3	464,524	448,980	$221,202	$530,995	6
Canary rockfish	559,313	510,262	$217,753	$522,787	6	1,676,395	1,529,376	$652,659	$1,566,919	19
Chilipepper rockfish South of 40°10' N.	244,044	248,114	$135,185	$324,560	4	3,990,595	4,057,148	$2,210,545	$5,307,194	63
Cowcod South of 40°10' N.	843	1,227	$518	$1,244	0	2,243	3,264	$1,379	$3,311	0
Darkblotched rockfish	400,730	391,970	$163,845	$393,300	5	718,336	702,633	$293,703	$705,018	8
Dover sole	16,196,041	16,111,998	$6,894,893	$17,056,277	202	85,174,712	84,732,732	$36,260,128	$89,698,681	1063
English sole	560,878	454,874	$139,800	$335,516	4	19,850,841	16,099,088	$4,947,851	$11,874,742	142
Lingcod North of 40°10' N.	1,365,279	1,306,575	$1,219,534	$2,925,145	35	1,632,346	1,562,159	$1,458,091	$3,497,343	42
Lingcod South of 40°10' N.	54,044	54,012	$56,985	$136,626	2	1,178,120	1,177,421	$1,242,227	$2,978,347	36
Longspine thornyheads North of 34°27' N.	1,797,148	1,806,512	$846,164	$2,093,314	25	4,154,892	4,176,540	$1,956,278	$4,839,610	57
Minor shelf rockfish North of 40°10' N.	531,539	336,370	$108,072	$259,447	3	1,999,588	1,265,385	$406,553	$976,010	12
Minor shelf rockfish South of 40°10' N.	5,084	3,298	$801	$1,801	0	418,644	271,541	$65,934	$148,313	3
Minor slope rockfish North of 40°10' N.	364,057	283,419	$84,731	$199,401	3	2,433,168	1,894,225	$566,299	$1,332,689	20
Minor slope rockfish South of 40°10' N.	123,562	132,526	$87,913	$210,734	3	830,378	890,619	$590,802	$1,416,200	17
Other flatfish	1,612,342	1,242,299	$462,239	$1,109,646	13	14,824,001	11,421,799	$4,249,860	$10,202,176	122
Pacific cod	94,842	94,121	$53,537	$128,534	2	2,179,006	2,162,441	$1,230,016	$2,953,087	35
Pacific halibut (IBQ) North of 40°10' N.	79,235	1,591	$0	$0	0	95,666	1,921	$0	$0	0
Pacific ocean perch North of 40°10' N.	206,893	204,385	$69,211	$166,159	2	230,284	227,493	$77,036	$184,945	2
Pacific whiting	324,307,384	317,882,600	$23,728,661	$69,186,260	821	49,479,767	48,499,534	$3,620,296	$10,555,788	125
Petrale sole	6,066,861	6,031,264	$6,891,580	$16,545,559	197	0	0	$0	$0	0
Sablefish North of 36° N.	5,574,933	5,497,925	$12,698,903	$26,335,484	344	0	0	$0	$0	0
Sablefish South of 36° N.	249,530	217,244	$539,738	$1,106,422	17	1,471,839	1,281,404	$3,183,617	$6,526,172	100
Shortspine thornyheads North of 34°27' N.	1,634,160	1,641,743	$1,172,862	$2,899,963	35	1,785,871	1,794,158	$1,281,748	$3,169,187	38
Shortspine thornyheads South of 34°27' N.	0	0	$0	$0	0	110,231	110,231	$0	$0	0
Splitnose rockfish South of 40°10' N.	28,675	22,053	$3,152	$7,567	0	3,634,967	2,795,593	$399,537	$959,229	11
Starry flounder	15,151	20,326	$6,142	$14,746	0	1,375,745	1,845,647	$557,689	$1,338,930	16
Widow rockfish	13,050,990	9,709,546	$2,843,758	$6,827,444	81	12,065,614	8,976,456	$2,629,048	$6,311,959	75
Yelloweye rockfish	367	347	$211	$492	0	2,058	1,946	$1,183	$2,761	0
Yellowtail rockfish North of 40°10' N.	5,437,061	4,566,380	$1,339,266	$3,215,327	38	3,923,987	3,295,607	$966,563	$2,320,537	28
Total	**383,799,107**	**371,204,191**	**$60,079,386**	**$152,757,401**	**1851**	**237,030,254**	**216,931,070**	**$70,599,281**	**$173,070,930**	**2086**
Total non-whiting	**59,491,723**	**53,321,591**	**$36,350,725**	**$83,571,141**	**1030**	**187,550,487**	**168,431,536**	**$66,978,985**	**$162,515,142**	**1961**

1. harvest can exceed catch which includes discards due to different estimation sources/types for catch and harvest
2. model-based projections from the NMFS' IO-PAC fishery economic model developed by Leonard and Watson
3. since some of the quota would be discarded, assumes status quo discard ratios with higher catches
4. assumes status quo price per pound

4.2 Discussion

By mid-2011, the very significant reforms required by the 2006 MSA had been implemented by the eight regional fishery management councils for all 478 of the federally managed fish stocks. An analysis of the consequences of this implementation concluded that by 2012, 64% of analyzed overfished stocks were rebuilt or showing significant rebuilding progress (Sewell, Atkinson, Newman, & Suatoni, 2013). Currently, in 2018 most West Coast stocks have been declared rebuilt and the associated increases in TAC have started to be allotted to the different fleets (PFMC, 2018c). As we enter the recovered era from the disaster era efforts should be focused on increasing attainment, this is a goal of the MSA NS #1, and of the West Coast groundfish IFQ program (P. a. NMFS, 2010c).

4.2.1 Comparison with other major fisheries

The results from this study show that, in 2017, if full utilization of the non-whiting groundfish trawl fishery occurred, the ex-vessel revenue would have been more than highly migratory species (mostly tunas), salmon, and shrimp fisheries combined for the West Coast; 103 million compared to 76 million (Fig. 4.1). However, the Dungeness crab fishery dwarfed the potential of the groundfish trawl fleet; 172 million in ex-vessel revenue. It’s important to remember that this is just a snapshot in time and all fisheries vary year by year. The whiting fishery (not shown in fig. 4.1) has a highly variable TAC, fluctuating from higher to lower ex-vessel values than the non-whiting fishery. Fishery participation shifts may happen if full utilization were to occur, possibly reducing the capacity of other fisheries. Fishermen that are encountering constraining stocks (either bycatch species or species that are caught disproportionate to the other species in a targeted complex) shift effort from trawling to other fisheries to increase boat days and overall revenue (Errend et al., 2019; P. a. NMFS, 2017). There is evidence to suggest that boats are taking advantage of economy of scale, fishing fewer fishing days while increasing revenue, allowing fishermen time to shift effort to other fisheries (Errend et al., 2019).

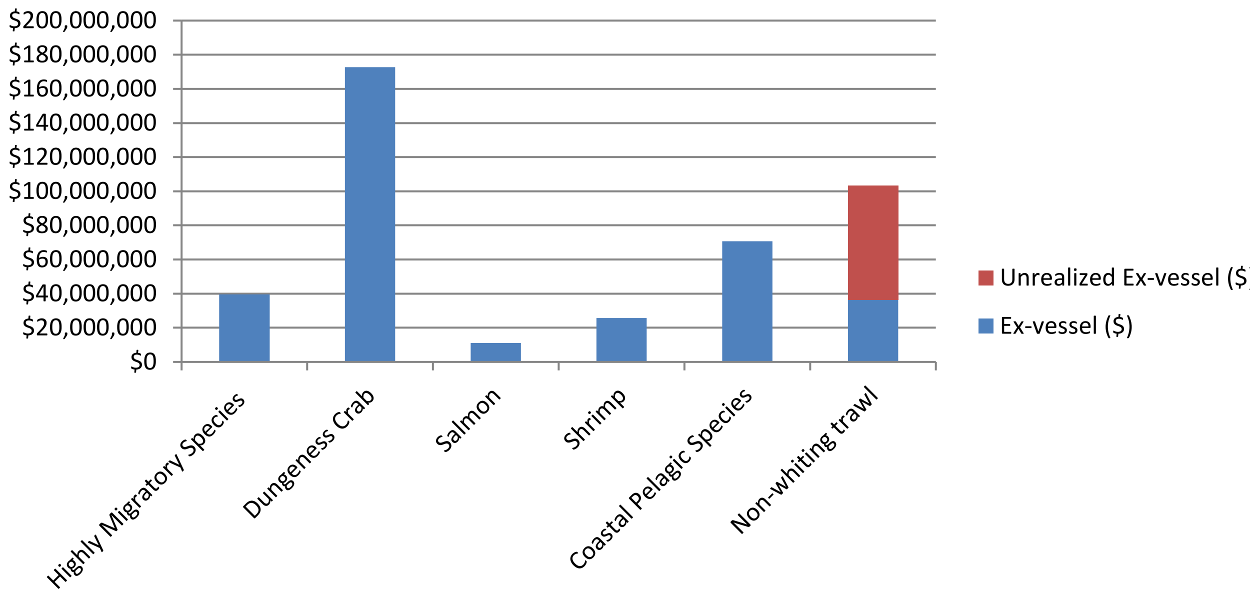

Figure 4.1 Comparison of the non-whiting groundfish trawl fishery with other major West Coast fisheries in 2017. Landing and ex-vessel data queried from PACFIN October 2018.

4.2.2 Obstacles to full obtainment of quotas

Inflexible regulations, lack of developed markets, and bycatch constraints are three of the biggest obstacles (P. a. NMFS, 2017) that could be overcome via greater partnership by communities, regulators, NGO's, industry, and researchers. Other issues, such as catch-quota balancing (Kuriyama, Branch, Bellman, & Rutherford, 2016), add to the complexity of the problem. Below we discuss some of these issues in context of the fishery and quota attainment.

Dover sole, which from this research analysis, has the largest potential to increase landings, is often targeted in a deep water complex called the DTS complex which consists of Dover sole, both Longspine and Shortspine thornyheads, and sablefish. Since most of the Dover sole landed is caught as part of this complex, it could be source of significant improvements of attaining quota. Typically most Dover sole quota is unattained because sablefish quota assigned to this fishery "runs" out before full attainment occurs (P. a. NMFS, 2017). Sablefish commands a higher ex-vessel value then the other species in the complex. This poses the question: "What is stopping a vessel from just targeting sablefish?" One possible answer is "Nothing, except the fact that it is caught with other species (unless the boat gear switches)." That doesn't mean that a trawl fisherman can't target certain areas, depths, or times to maximize sablefish catch while reducing the other species. However, as long as a processor is willing to take the catch of Dover sole it is valuable and worth harvesting.

Quota prices complicate this matter further, if quota prices are low enough, it may be worth leasing further sablefish QP to catch more Dover sole. Sablefish quota price is high because fixed gear harvest is worth more (higher ex-vessel value) and gear switching boats (boats allowed to use fixed gear to catch their trawl sablefish QP), driving quota prices high and leaving a smaller profit margin for trawl caught sablefish. The quality of trawl-caught fish is lower compared to fish caught with more selective gear, affecting the ex-vessel price (Parker, Rankin, Hannah, & Schreck, 2003). Ultimately, reducing the likelihood that sablefish quota would be leased to gain "access" to more Dover sole (P. a. NMFS, 2017; Russell, Oostenburg, & Vizek, 2018). Even with all of this, it is not the true problem; even if all of the sablefish TAC was assigned to the non-whiting groundfish trawl fleet and used in DTS complex targeting full attainment of the Dover sole quota would be unlikely to occur (P. a. NMFS, 2017).

Developing markets for Dover sole could also help with the attainment of the Dover sole quota. Currently, Dover sole's ex-vessel value doesn't provide enough incentive or even enough payback to try and solely target Dover sole. DTS targeting boats need the value of the sablefish (the most valuable fish in the sector) to make their trips "worth" the effort of fishing (P. a. NMFS, 2017). If ex-vessel prices were to increase significantly for Dover sole, fishermen might be incentivized to find ways to catch just Dover sole, or to reduce their catch of sablefish; In effect spreading their sablefish quota "jelly" over more of the Dover sole "toast".

Developing markets for seafood can be difficult and complex. Low demand and low utilization can create cycle that traps the fleet with perpetual low attainment Figure 4.2. Groundfish processing is not automated and requires experience filleters. It is hard to maintain a large enough workforce to handle large landings when landings are intermittent. When there is low demand for processed product ex-vessel value drops, reducing the likelihood of landings. With uncertain landings it is hard to secure premium markets, further feeding into the cycle (Guldin et al., 2018).

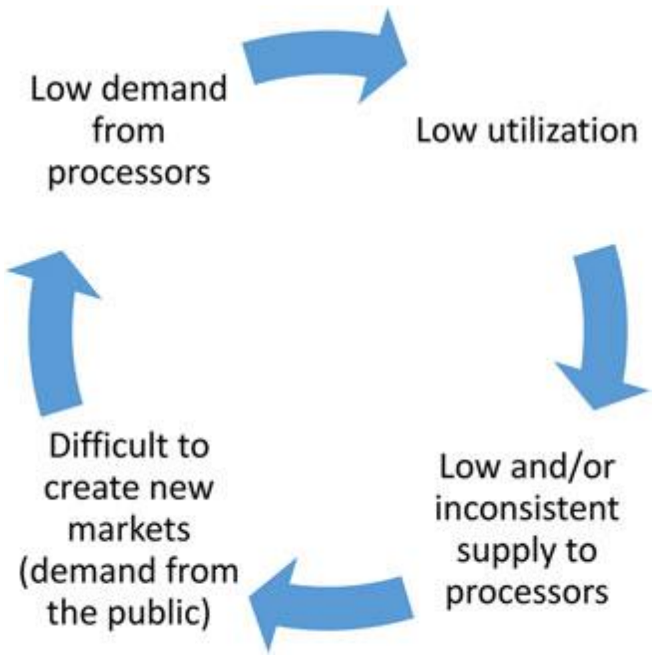

Figure 4.2 A visual representation of the low demand and low utilization cycle (Guldin et al., 2018)

An example of an inflexible regulation is the restriction on transferring quota from one sector to another (P. a. NMFS, 2010b). For instance, the whiting fleet has refined their fishing techniques and have reduce their bycatch of sablefish for some recent years, not utilizing the quota allotted to them (P. a. NMFS, 2017). Being able to transfer this sablefish quota over to the non-whiting groundfish trawl fleet once the whiting season is over might free up quota to allow some fishermen to continue targeting the DTS complex. This could be important towards the end of the year when sablefish quota becomes hard to find in the non-whiting groundfish trawl fleet. In and of itself this is not an end/fix all but could a part of the solution. Sometimes there is not a single solution to a problem but rather multiple reasons each contributing “a little bit” to the problem.

The requirement and associated costs of having an observer aboard is another obstacle; one that can possibly reduce fishing days and, therefore, economic benefits. This is especially true since fishermen must request observers ahead of time, and they must pay for the observer whether they fish that day or not. Observer cost can be significant because the cost of an observer can be more than the cost of a single crewmember (generally not including the captain but sometimes more than the captain). The scenario could be that a fisherman plans on heading out next Monday and so he requests an observer. However, when Monday rolls along there is unexpected weather and it is not a good day to go out. The current system encourages the fisherman to go out anyway because he has already paid for the observer (or would have to eat the cost of paying for an observer even though he didn't fish that day). This consequence may not have been predicted but it directly goes against National Standard 10 (which focuses on increasing human safety at sea). Electronic monitoring (EM) is currently being tested; this might eventually replace the requirement for a live observer on every trip thereby reducing costs and increasing safety. Another solution, at least on the cancelled fishing trip front, would be to not hold the fisherman 100% percent accountable for the cost of observers on days that the trip is cancelled for safety reasons. In addition, the cost of an observer aboard can increase the risks of other actives, such as test fishing. A captain already knows that they may not catch much while exploring, and the added cost of an observer might push a captain to not pursue this activity. Overall, this might prevent innovation or shifts in the fishery that could lead to increased attainments. With the reduced cost of catch accountability via EM, captains may decide to take on more crew, even though median crew increased after the implementation of IFQs (Steiner, Russell, Vizek, & Warlick, 2019).

The Adaptive Management Program was built into the Trawl Rationalization Program to provide a resource for innovation. Currently, the QS that is an assigned to the program is not used for innovation but rather it is passed on to the current permit holders evenly (P. a. NMFS, 2017). One possible change to this might be to provide the resources for attainment of more quota by covering quota used in test fishing. In other words, the QS could be assigned in such a way as to incentivize competition for the exploitation of the under-utilized stocks. Using the DTS example above, vessels could earn bonus QP by taking part in scientific research focused on targeting primarily Dover sole with little bycatch of other species, including thornyheads and sablefish. Nayani and Warlick analyzed 6 policy alternatives against the goals of the AMP and found that there may be flexible alternatives that could help the program server its' intended purpose (2019). Allocation or auction of QP (limited time) rather than QS (permanent) allows the council to focus on AMP objectives and allows them to change the focus from year to year. There is a decision between allocation vs auction to the highest bidder. Allocation could benefit those that show the greatest need. Auction to the highest bidder could increase economic efficiency (Nayani & Warlick, 2019).

One of the complaints is how ITQ is owned, this creates a larger hurdle for newcomers to enter the fishery then when it was open access. Nearly everyone interviewed by Carothers (2015) in Kodiak, AK expressed concern about upward mobility within the fishery, moving from crew to captain then owner. With ITQ's and permit ownership, an additional cost was created for joining the fishery or even moving up. QP can be leased which can reduce the capital requirements of buying a permit, however, even this can be burdensome; Red crab lease fees were 70% of the ex-vessel value out of Kodiak, AK in 2011. This only leaves 30% of the ex-vessel revenue to pay the boat (expenses), captain, and crew (Carothers, 2015).

One way to tip the balance of the equation a little more towards (possibly) fulfilling NS8 and to alleviate the additional cost of entering the fishery is to follow the advice of Macinko (2014). Macinko proposes to allow the local communities decide how to assign, divide, or whatever they come up with for the quota rights. They may come up with a management technique that is better balanced toward the communities while achieving the standards for sustainable fisheries. I imagine being from an island, living in close, unescapable proximity to your neighbors would foster a different philosophy about sharing than the typical fisheries manager. Rent from fisheries could possibly go directly back to the community vs going into the pocket of an investor. Maybe a hybrid between Community Based Management and ITQs (Copes & Charles, 2004). Communities may help implement solutions that offset limitations to fulfillment of quotas or perceived negative consequences of IFQ implementation.

Some potential solutions have already been identified by fishery participants or management. Unfortunately, each faces certain hurdles before they are implemented. This research could be used as a catalyst to help push these efforts forward. An example of a barrier to implementation is the Omnibus Process at the PFMC. The Omnibus Process is essentially a wish list of items the Council would like to address. Due to limited time and resources, they cannot get to all of these at once and this creates a priority of items for the Council to focus on.

Sometimes items jump or skip up the list due to pressure from stakeholders or other entities, or due to perceived benefits. In this instance this research could be used as evidence to elevate solutions that address some of the many issues that are at play in the fishery.

This is a complex issue almost like a spider web in a pathway with many strands going many different directions and interacting with other strands within the web. Changing one thing or pulling one strand off the web doesn't remove the whole web, rather it most likely just changes the shape of the web. To resolve this issue of low attainment, many different things would need to change; most or all the strands of the web must be detached before the web is gone and the path is clear. This paper only highlights some of the issues faced by the non-whiting groundfish fleet. The complexity of the reasons behind the low attainment really make it hard to move forward on the path. Using the DTS complex as an example of this complexity, if a bottom trawl net was designed tomorrow that was able to target solely Dover sole, it would still be unlikely that Dover sole would be fully attained. This "new" net addresses the constraint that the fleet faces with the imbalance of sable fish quota vs Dover sole quota, but it doesn't address the issue of low ex-vessel value. Currently, as stated above, it is not worth a vessel's time and resources to target just Dover sole, they need sablefish to make their trips profitable.

4.2.3 Considerations

This analysis was performed using data from a single year, 2017, it is a snap shot in time. It is an estimate of jobs and income that could have been supported by the fishery, it should not be construed that the fishery would continue to support this estimate. There are several factors that need to be considered when looking toward the future. Many of the underutilized stocks are at or near carrying capacity. If quotas start being attained for these stocks their populations will decrease and subsequently the quotas for those stocks will decline until they reach maximum sustainable yield (MSY). Table 4.2 shows the difference from what the results were for 2017 and what they would become if adjusted for MSY using Dover sole (Wetzel, 2011) as an example, it is a decrease of roughly 30%.

Table 4.2 A comparison of estimates of unattained landings in 2017 and MSY unattained landings of Dover sole.

	Uncaught lbs	Uncaught Jobs	Uncaught income ($)
Actual 2017	85,174,712	1063	89,698,681
Long-term MSY	60,430,027	754	63,639,707

The estimated jobs and income that could be supported using the quota adjusted to MSY are more realistic and useful for long term planning than the 2017 estimates provided in this document. Moreover, it is important to note that each stock is at different population levels relative to their MSY, and adjustments will differ from the Dover sole projections, some may even increase rather than decrease. At full attainment, Dover Sole provides the largest estimate of possible supported jobs for 2017, the decrease to 1063 jobs overtime would likely suggest a future decrease from the 2017 jobs and income estimates for the fishery regardless of other stocks' adjustments. However, to better inform stakeholders future research would need adjusted projections for each individual stock under the non-whiting groundfish trawl fishery.

Changes in processing practices also could affect these estimates. Currently, processing of groundfish is done by human filleters, with increased landings processors may automate reducing the need for workers. Changes to fish populations could also occur affecting the quotas, this could be driven by many factors including climate change. Furthermore, factors such as ocean currents and temperatures, food availability, changes to larval dispersal, range expansion of other species such as the Humboldt Squid, are only few of the effects climate change could have on this fishery. As the science progresses and our understanding of the ocean and these fish species increases there may be adjustments to quotas. These are just a few examples of what should be considered looking toward the future.

Chapter 5: Conclusion

The results of this study, albeit limited in many ways, indicate that the unrealized economic benefits in the non-whiting groundfish trawl fishery for the US West Coast for 2017 could have supported an additional 1961 jobs, or $162.5 million in wages. For many coastal towns, commercial fishing is a major livelihood and these jobs and wages could have had a significant impact. Jobs supported by this fishery go beyond fishing crews and processors to support the entire local economy.

There are, however, complex issues keeping the non-whiting groundfish trawl fishery from reaching its allocations. These include but are not limited to geopolitical market constraints, bycatch issues, quota allocation inefficiencies and lack of processing and port infrastructure. However, as directed by the Magnuson-Stevens Act and the Pacific Coast Groundfish Fishery Management Plan's goals of economics and utilization, it is important to assess these issues. Moreover, managers among other stakeholders have interest in increasing attainments of underutilized fish stocks because it could help diversify, stabilize, and enhance income, jobs, and overall community benefits. There is a long history of commercial fishing on the West Coast and today the non-whiting groundfish trawl fleet provides an important portion of the commercial fishing revenue and could provide more.

Achieving optimum yield in the non-whiting groundfish trawl fishery will require more than just elevating catches. It will require collaboration between regulators, NGO's, industry, and researchers as the problems and solutions to them are complex and cross social, political and spatial boundaries. We hope this document can provide a basic understanding of the complexity and the potential benefits of increasing yields of underutilized stocks in the West Coast non-whiting groundfish trawl fishery. While limited to only a snapshot in time (for 2017), we hope that this understanding could create a movement to address this fishery's constraints and increase attainments.

Further research projecting jobs and income estimates in unutilized quota could be a next step to better understanding how the non-whiting groundfish trawl fishery may be affected through time when operating at a level closer to full attainment. This would require considering that the quota is currently above maximum sustainable yield (MSY) for many stocks, and therefore quota may be decreased as the fishery reaches full attainment. Each individual stock would need to be projected based on their MSY, because they are at varying population levels relative to their MSY. Any future projections would be susceptible to uncertainties in future climate and ocean conditions, processing practices, rebuilding of overfished stocks, and market changes among many other potential social, economic and ecological factors.

Chapter 6: Bibliography

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