April 1, 2008

Donald K. Hansen, Chair
Donald O. McIsaac, Executive Director
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220-1384

Re: Gear Conversion as a Means to Reduce Bycatch and Habitat Impacts in the U.S. West Coast Sablefish Fishery

Dear Chair Hansen and Dr. McIsaac:

With this letter we submit, for the briefing book, the above-referenced report on gear conversion by Dr. Lekelia Jenkins. The report looks at the value and feasibility of gear conversion through a case study of the sablefish fishery, which affords comparison between gears because trawls, longlines and pots (traps) are all used. The report presents evidence that the inherent bycatch rates of trawls are substantially greater than those of longlines and pots in this fishery. Bycatch rates of pots and longlines are quite similar, but there is a consistent trend for the bycatch rates of pots to be the lowest of the three gear types. *The analysis finds that a conversion from trawl gear to either pots or longlines could significantly reduce bycatch and habitat impacts of the sablefish fleet.* Pots may be the preferable gear, at least in the near term, given trawlers' interest in pots (as determined through interviews) and the negligible bycatch by pots of yelloweye and canary rockfish as well as other overfished species.

Dr. Jenkins developed four management scenarios after interviewing 44 people representing a variety of interested parties: (1) permanent uni-directional gear conversion, in which trawlers could make a one-time irreversible shift to pot or longline gear; (2) long-term uni-directional gear conversion—a switch to fixed gear for a multi-year term; (3) pre-declared bi-directional gear switching, allowing a switch between trawl and fixed gear within a fishing season; and (4) unconstrained gear switching. *Her review found the preferable option from an accountability perspective would be long-term uni-directional gear conversion, a scenario that could be overseen effectively with the current management and observer program infrastructure.* It would also have real benefits in reducing bycatch and would probably reduce habitat impacts. Other hook and line gears also show promise and should be analyzed; our study was limited to those gears for which we had data. Because there are significant differences between

scenarios, we conclude that in order to achieve desired results the Pacific Council and NMFS should define the terms of a gear conversion program.

The report also identifies several potential incentives that could help encourage gear conversion and good gear practices, including higher trip limits for those who convert, reflective of the lower bycatch rates of fixed gear, (or under an IQ system, the ability to land a larger portion of a quota); use in an IQ system of a portion of the "adaptive management trust" quota to reward those who consistently meet a defined standard of minimal bycatch and/or habitat impact; a trial period of a couple of years before a trawler must commit to a long-term conversion; low-interest loans to help purchase new gear; and designating areas as open to non-trawl gear but closed to trawl gear as the number of trawlers declines.

We hope the Pacific Council and the National Marine Fishery Service will find this report useful as you conduct and oversee the analysis of alternatives in the Trawl Rationalization Environmental Impact Statement (EIS). Please contact us if you have questions, at 415 875 6100.

Sincerely,

Karen Garrison
Co-Director, NRDC Oceans Program

Cc: Frank Lockhart

Gear Conversion as a Means to Reduce Bycatch and Habitat Impacts in the U.S. West Coast Sablefish Fishery

by Dr. Lekelia D. Jenkins

March, 2008

Acknowledgments

The author would like to thank the following people for reviewing the portions of this report relevant to their area of expertise. The views presented in this document do not necessarily reflect the opinions of those who helped review it. Jim Hastie's assistance in providing data and scientific advice was invaluable. Many thanks also to the 44 people who generously gave their time in the interview process.

Reviewers

Merrick Burden
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Bob Eder
Keith Matteson
Rod Moore
Lance Morgan
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EXECUTIVE SUMMARY

The purpose of this study is to examine the value and feasibility of gear conversion as a means to reduce bycatch and habitat impacts of fisheries. The U.S. west coast sablefish fishery (off California, Oregon and Washington) is an excellent subject for this study, because it employs three different gear types: bottom trawls, bottom longlines, and fish pots (traps). Currently, a permit to use one of these gears does not allow conversion to another gear regardless of potential environmental or economic benefits of doing so. Sablefish is a groundfish that frequents a variety of habitats including muddy, sandy and rocky bottoms. The sablefish fishery spans the west coast.

Since 1998, the management of the fishery has been guided by the need to rebuild overfished groundfish stocks—bocaccio rockfish, canary rockfish, cowcod rockfish, darkblotched rockfish, lingcod (now rebuilt), Pacific ocean perch, widow rockfish, and yelloweye rockfish. Unfortunately, these species often co-occur in the same areas as sablefish and so are caught as bycatch. Managers assume that 100% of many discarded rockfish die, because rockfish species have pressure-sensitive swim bladders. If these fish are brought to the surface from deep waters, the swim bladder often explodes and kills or disables the fish. Minimizing bycatch mortality is important both because of the need to rebuild overfished species and because the Magnuson-Stevens Fishery Conservation and Management Act requires bycatch minimization.

Longlines and pots (traps) are managed together in the limited-entry fixed gear sector with separate gear endorsements (i.e., permits are either endorsed for longlines or pots/traps). The size of the permitted limited-entry trawl and fixed gear sablefishing fishery is nearly the same— about 170 permits each, but only about 120 trawlers actively fish each year. The amount of sablefish landed by each fleet has been around the same order of magnitude in recent years with almost 2300 mt (metric tons) landed by each in 2005.

Using published data from the West Coast Groundfish Observer Program, I graphed the bycatch ratios and standard errors for each gear type over time, per depth category, and for each overfished species. I used some of this data in a snapshot analysis of a spatiotemporal period in which the trawl and fixed gear fisheries were actively operating under similar regulatory conditions. This analysis allowed the most direct comparison of the bycatch rates of the three gear types. I supplemented the results of this analysis by conducting an analysis of data gathered by the Oregon Department of Fish & Wildlife during a study to compare pot and longlines as survey tools for sablefish.

In order to assess habitat impacts of the gear, I drew upon the “Shifting Gears” study. This study used an extensive literature review and expert panel to rank ten gear types according to their impact on physical structure, seafloor organisms, shellfish and crabs, finfish, seabirds and turtles, marine mammals, and sharks. Using this study as a baseline, I conducted interviews with sablefish longliners, trawlers, pot fishers and other stakeholders in the sablefish fishery. Based on these interviews and my own expertise in fishing gear, I adjusted, when necessary, the results of the Shifting Gears study to more accurately represent the sablefish fishery.

To make a qualitative assessment of the potential costs, benefits, problems, and solutions associated with gear conversion, I conducted a series of interviews with a total of 44 individuals, representing trawlers, pot and line fishermen, processors, managers,

scientists and an environmental NGO. I analyzed these data with a loose application of Ground Theory methodology, which allowed me to identify common themes and construct explanatory theories. Based on the initial interview analysis, I composed management scenarios, which I presented in follow-up interviews to key individuals for their feedback. Furthermore, I used the interviews to seek and identify potential conservation technologies that could be applied in the sablefish fishery to reduce bycatch and habitat impacts.

This report presents evidence that the inherent bycatch rates of trawls are substantially greater than those of longlines and pots. Bycatch rates of pots and longlines are quite similar, but there is a consistent trend for the bycatch rates of pots to be the lowest of the three gear types. However, pots may be more susceptible to the bycatch of rounder-bodied fish, such as lingcod. Depending on where the gear is deployed, longlines may have bycatch of yelloweye and canary rockfish--often the most constraining overfished shelf species in recent years. In addition, there is a lack of data on shark bycatch for longlines, which adds to the uncertainties in using this gear.

The Shifting Gears study shows that trawls have a substantially greater impact on habitat than do longlines and pots. With the adjustments I made to tailor the pot impact profile to the sablefish fishery, I show that pots have more severe habitat impacts than longlines. The use of small footrope trawls and selective flatfish trawls on the west coast serve to reduce habitat impacts associated with bottom trawling while reducing rockfish bycatch. In addition, National Marine Fisheries Service is currently developing several conservation technologies for various Alaskan Fisheries. The most promising of these is a trawl modification that greatly reduces bottom contact without reducing the number of fish caught. This technology would be compatible with the west coast groundfishing trawl gear, and holds some potential for reducing habitat impacts on sandy and muddy ocean floor.

Perceived pros and cons of gear conversion varied widely, both within and between stakeholder groups. However, several motifs repeatedly emerged from interviews. Positive effects of gear conversion included that: (1) it would allow for better management of the fish populations by reducing bycatch; (2) it would allow more business options and flexibility for some current trawlers; and (3) sablefish caught with fixed gear would reap a higher selling price, and thus would be a financially workable option for the trawlers who switch gears. The most prominent negative economic impact of gear switching was that with fewer trawlers, less flatfish would be caught. The sale and processing of flatfish is a substantial component of the groundfish trawl industry. Presently, flatfish can only be effectively caught in trawls, so, for certain members of the current fishing industry community to remain viable, some number of trawlers must remain active. The survey also revealed that all major stakeholder groups saw some benefit in gear conversion. Most fixed-gear fishermen and women interviewed were not opposed to trawls switching to fixed-gear, though more than one expressed concern that the ability to make that switch would not relieve the ongoing problem of overcapitalization in the groundfish fishery.[1] Notably, trawlers voiced a unanimous preference for converting to pots rather than longlines.

[1] A recent buyout reduced capacity in the groundfish trawl fleet to some degree, and the PFMC aims to further reduce it via a trawl rationalization initiative that may include management by individual fishing quotas and/or harvest cooperatives. However, targets for capacity reduction have not been updated since

Given the available information, I find that a conversion from trawl gear to either pots or longlines could significantly reduce bycatch and habitat impacts of the sablefish fleet. However, pots may be the preferable gear given trawlers' interest in pots and the potential of longlines to increase the bycatch of yelloweye and canary rockfish. Because the bycatch situation may change in the future, a gear conversion program should have flexibility to allow for use of pot or longline gear as well as other forms of hook and line gear when appropriate.

I presented four different management scenarios to the interviewees: (1) with permanent uni-directional gear conversion, trawlers would be offered an opportunity to make a one-time irreversible switch to pot or longline gear; (2) with long-term uni-directional gear conversion, trawlers would have the opportunity to switch to pot or longline gear for a multi-year term; (3) with pre-declared bi-directional gear switching trawlers would have the opportunity to switch between trawl and fixed-gear within the same fishing season; (4) with unconstrained gear switching, trawlers would be able to switch between trawl and fixed-gear within the same fishing season without needing to declare when they planned to switch or how much fish they planned to catch with each gear type.

Of these scenarios, the preferable option from an accountability perspective would be long-term uni-directional gear conversion. This scenario could be effectively overseen by the current management and observer program infrastructure. It would have a real benefit in reducing bycatch, because trawlers would commit to using fixed gear for several years. Because of the long-term commitment, some trawlers, especially those with the highest volume, are not likely to convert to an alternative gear. Their continued landings should allow the processors and other volume-based shoreside infrastructure to continue operating. Short-term or unconstrained gear switching could only be done in an accountable fashion if 100% observer coverage were maintained.

Incentives are likely to be an important means of encouraging gear conversion. As an incentive to convert their gear, trawlers who switched could receive a higher catch limit of sablefish, reflective of the lower bycatch rates of fixed gear. Other incentives include encouraging good gear practices by using a portion of the "adaptive management trust" quota to reward those who consistently meet a standard of minimal bycatch over a period of time; a trial period during which trawlers could change their mind before making a long-term conversion; and low-interest loans to help purchase new gear.

Future study topics include the following. (1) Explore in more depth the benefits and impacts of various gear-conversion scenarios, including other gear types, such as hook and line and vertical longline. (2) Conduct a GIS analysis of the types of seafloor habitat in the sablefish fishing area and the concentration of each gear type in these habitats. The study should examine the past and present gear distribution, as well as attempt to forecast the gear distribution under different gear switching scenarios. It should also research the impacts of different gears in various habitats and the feasibility of an area-based management system for each gear type. (3) Investigate additional potential incentives to encourage switching to lower impact gears. (4) Examine the feasibility of using the conservation technologies being developed for the Alaskan fisheries in the west coast groundfish trawl fishery.

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the decade-old strategic plan, in which the Council set a goal of 50% reduction in capacity for each groundfish gear group.

PURPOSE OF STUDY

The purpose of this study is to examine the feasibility of gear conversion as a means to reduce bycatch and habitat impacts of fisheries. The U.S. west coast sablefish fishery was selected as the subject of study, because this fishery uses three different gear types—bottom trawls, bottom longlines, and fish pots—with no interchangeability between gear types. This offers a rare opportunity to compare the use of several different gear types in the same fishery. In addition there are five years of available observer data on this fishery (NMFS 2003; NMFS 2004a; NMFS 2004b; NMFS 2005b; NMFS 2005c; NMFS 2005a; Hastie 2006; Hastie and Bellman 2006; Hastie, Cusick et al. 2006; NMFS 2006a; NMFS 2006b). These data will allow the examination of bycatch of overfished and other species by each gear type over time and by depth. Currently, a permit to use one of these gears does not allow conversion to another gear regardless of potential environmental or economic benefits of doing so.

This was a two-phase study; both phases are summarized in this report. Phase I details the relative bycatch and habitat impacts of the three gear types. It ranks the gear according to the intensity of their environmental impacts and includes findings about the most desirable gear to which to convert. Phase II of this study involved a survey of fishermen/women, observers, and managers about gear conversion to determine qualitatively the costs and benefits as well as impediments and their potential resolutions.

NRDC invited a diverse group of managers, government scientists and stakeholders (including representatives of processors, each relevant gear group, gear experts, and conservation NGOs) to review a draft of this report. Their comments were considered in light of the data and incorporated wherever appropriate.

FISHERY OVERVIEW

The U.S. west coast commercial sablefish fishery is managed as part of the west coast groundfish fishery (Pacific Fisheries Management Council and National Marine Fisheries Service 2007). The groundfish fishery ranges the length of the coast from Alaska through California and occurs in nearshore waters shallower than 50 fathoms (fm) to off the continental shelf. Management of this fishery is under the jurisdiction of the National Marine Fisheries Service and its advisors, the Pacific Fishery Management Council (PFMC) and the North Pacific Fisheries Management Council. Each council has its own management framework and regulations. This study focuses on the groundfish fishery in the PFMC's jurisdiction, off California, Oregon and Washington. Sablefish is a species of groundfish that frequents a variety of habitats including muddy, sandy and rocky bottoms. The fishery for this species employs bottoms trawls, bottom longlines, and pots.

Active management of the groundfish fishery began in the 1980s with the determination of optimum yields and trip limits for several species, including sablefish. Since 1998, the management of the fishery has been guided by the need to rebuild overfished groundfish stocks, which are bocaccio rockfish, canary rockfish, cowcod rockfish, darkblotched rockfish, lingcod (now rebuilt), Pacific ocean perch, widow

rockfish, and yelloweye rockfish.[2] Minimizing sablefish bycatch mortality is also important both because bycatch minimization is required by the Magnuson-Stevens Fishery Conservation and Management Act and because the sablefish population is in the precautionary zone, with a predicted downward trajectory in future years under an assumption of average future recruitment.

More than 80 species of groundfish are managed under the fishery management plan. Each species has its own habitat requirements as far as depth, bottom type, water temperature, etc. Some of these species are associated with a diverse range of habitats, while other are restricted in their distribution. Often healthy groundfish stocks will co-occur with overfished stocks. Management measures have recognized and tried to account for problems posed by this overlap. It is assumed that 100% of many discarded rockfish die, because rockfish species have pressure-sensitive swim bladders. If these fish are brought to the surface, the swim bladder explodes and kills the fish. Sablefish do not have swim bladders, so, if properly handled, sablefish can have low discard mortality.

The management program establishes catch limits that take into account both target catch and bycatch of managed species.[3] In order not to exceed optimum yield, the management regime for the commercial fishery applies a suite of tools including time/area closures, gear modifications, and larger trip limits in areas where overfished species are less likely to be encountered. Also fishermen and women are required to sort the catch by species or species group, discard prohibited species (e.g. salmon, Pacific halibut, and Dungeness crab), and discard groundfish that exceed the allotted trip limit. In 2002, fishery managers began using a new bycatch analysis model. The resulting information allowed managers to set trip limits that targeted abundant stocks during times when they are least likely to co-occur with overfished stocks. Also in 2002, the Council began implementing depth-based area closures, where bottom fishing is prohibited to reduce encounters with and mortality of overfished stocks. These Rockfish Conservation Areas (RCAs) have boundaries that may change every two years based on changes in catch levels and rebuilding plans, and may vary seasonally depending on factors like the distribution of the overfished stocks.[4]

In addition to the formation of the trawl and non-trawl RCAs, the Council has adopted several gear restrictions. In 2000, the Council placed restrictions on trawl gear in an attempt to protect overfished shelf rockfish species that inhabit rocky areas. Specifically, it prohibited the landing of shelf rockfish and most flatfish caught using large footrope chafing gear. Because only trawls with a large diameter footrope chafing gear are rugged enough to fish on rocky bottoms, this regulation created an economic

[2] These species were declared overfished at different times during this period as follows: bocaccio, lingcod, and Pacific ocean perch in 1999; cowcod and canary in 2000; darkblotched and widow in 2001; and yelloweye in 2002.

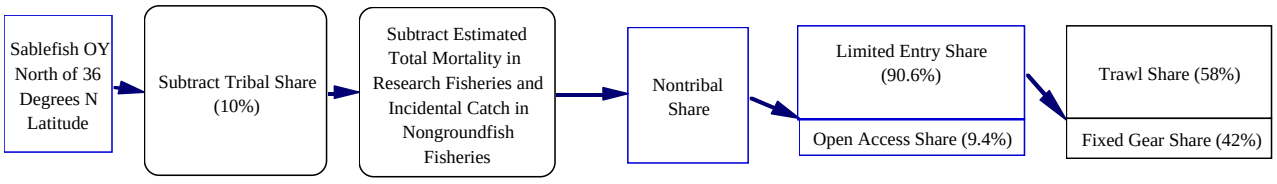
[3] Acceptable biological catches and optimum yields are specified for each managed species or species complex

[4] The commercial non-trawl RCA has changed little since its inception in 2003, largely due to lack of logbooks and other data informing vessel distribution and area-specific catch. The trawl RCA is more flexible and the shoreward and seaward boundaries can change in-season to take advantage of seasonal shoreward/seaward migrations of target and overfished species. This is due to a greater amount of vessel-specific catch and effort data from logbooks and on-board observers. In all circumstances, there is a core area (100-150 fm) that has always been closed since RCAs were first implemented.

disincentive to use that gear on the shelf, effectively ending trawling in shelf and nearshore rocky areas. Beginning in 2003, only small footropes were allowed shoreward of the RCA, thus expressly prohibiting large footrope gear from being used on the shelf. In 2005, the Council mandated the use of the selective flatfish trawls shoreward of the trawl RCA in the fishing areas north of Cape Mendocino.[5] The selective flatfish trawl is also known as the upside-down trawl or pineapple trawl. It is a small footrope trawl with a cut-back head rope and low profile, which allows rockfish to escape.

In August 2002, the National Marine Fisheries Service (NMFS) implemented the West Coast Groundfish Observer Program (WCGOP). The goal of the program is to collect data to improve estimates of total catch and discards in the groundfish fishery. The regulation requires that all vessels fishing for groundfish in the U.S. exclusive economic zone take an observer onboard when notified to do so by NMFS. Adequate coverage of the non-whiting bottom-trawl fleets was the initial priority. Coverage has broadened over time, and subsequent state regulations require that Oregon and California-based fishermen/women, who fish in state-managed fisheries, but may catch federally managed groundfish, also participate in the NMFS observer program. Target observer coverage over the years has ranged from 10 to 20% for both trawls and fixed gear. Actual observer coverage (by weight of total landed catch) has ranged from 8 to 38% for longlines, 6 to 46% for pots, and 13 to 29% for trawls.

In 1994, the federal government instituted a limited-entry permit system in order to restructure the derby fishery for groundfish into a longer season with catch levels more evenly distributed over time. The program limited the number of trawl, longline, and pot permits and placed conditions on the use of the remaining permits. Each permit specifies the type of gear and the length of vessel that may be used for fishing. Although it prevented new entrants, the program did not address the underlying problem of overcapacity in this fishery. Subsequently, the Pacific Fishery Management Council modified the permit system to allow fixed-gear (i.e. longlines and pots) to accumulate or "stack" up to three sablefish-endorsed permits, thus increasing the portion of the total sablefish quota available to each fixed gear vessel. The amount of catch available to each sector is based on an allocation formula established in the Groundfish Fishery Management Plan (FMP), and the total allowable catch is determined by the stock assessment (and the rebuilding plan, in the case of overfished species). The limited-entry allocations are based on the estimated abundance of sablefish north of 36º N. lat. as follows:



In 2003, a federally-sponsored program retired 92 trawl permits and vessels, reducing the size of the trawl fishery by over a third. In 2005, there were 178 limited-entry trawl permits of which 169 were usable in the bottom-trawl fishery, which includes sablefish as a target species. Of these permits about 120 were attached to vessels that

[5] north of 40°10' N latitude

landed fish in 2005 for a total of 2291 metric tons (mt) of sablefish. That same year, there were 230 limited-entry fixed-gear permits, of which 164 were sablefish-endorsed, of these 136 were endorsed for use with longlines and the remaining 28 were endorsed for use with pots. This fishery landed 2243 metric tons mt of sablefish in 2005. These statistics show that the number of permits available for fishing in the trawl and fixed-gear limited-entry sablefishing fleets is nearly the same (Fig. 1). Furthermore, the realized sablefish fishing capacities of both fleets are nearly the same as well (Fig. 2).

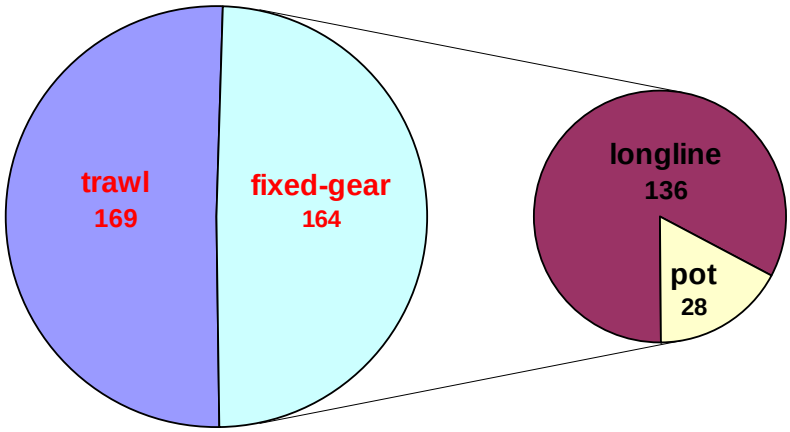


Figure 1: Number of sablefish permits per gear type in 2005 (data from NMFS 2006a; NMFS 2006b)

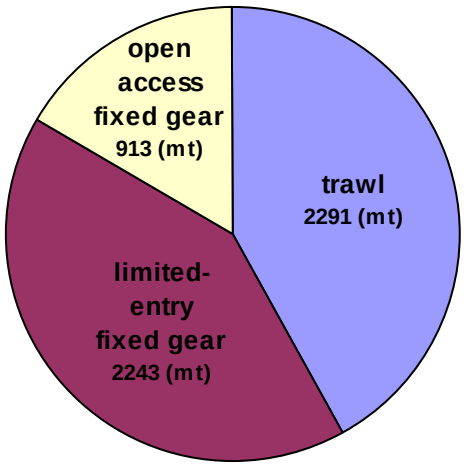


Figure 2: Metric tons of sablefish landed by trawls, limited-entry fixed-gear, and open-access fixed-gear in 2005 (data from NMFS 2006a; NMFS 2006b)

Some non-trawl vessels targeting sablefish are exempt from the limited-entry program and so remain in the open access fishery and subject to trip limits.[6] In 2005, this

[6] There are also limited-entry fixed-gear permits without sablefish endorsements that are subject to limited-entry fixed-gear trip limits, which may be larger than open access trip limits.

fishery landed 913 mt of sablefish, which is over 15% of the total sablefish landings that year (Fig. 2). The observer coverage of the open-access fishery is poor and multiple gears are allowed in this fishery.[7] For these reasons, it is difficult to link the discard rates of the open-access fishery with a specific gear type and so the open-access fishery will not be analyzed as part of this study. Nor will the recreational groundfish fishery be analyzed due to the use of different gear and the limited data on this fishery. The recreational groundfish fishery is mostly restricted to shallow waters—around 30 fm or less—and is managed with a combination of bag limits, gear restrictions, size limits, and time/area closures.[8]

GEAR DESCRIPTIONS

Trawl Fishing Gear and Process

The sablefish bottom trawl fishery operates throughout the year in offshore waters. Groundfish bottom trawl vessels range in length from 35 to 100 feet and average 65 feet. The vessel pulls a single trawl net (Fig. 3), which on an average-sized boat would be about 100 feet wide. The length of a typical tow is about 6 hours and covers a distance of about 12 miles. During a tow, heavy metal doors or boards (Fig. 3) drag along the sea floor. The water moves past them, pushing the doors apart and forcing the mouth of the net to open. A string of floats along the top of the net mouth, called the floatline or headrope, pulls the top of the net open. A weighted line along the bottom of the net mouth, called the footrope, leadline, or bottomline, keeps the trawl in contact with the sea floor. The doors are attached to the net by sweeps also known as bridles. The sweeps are each about 65 fathoms long and are covered in mud gear, i.e. small rubber disks. The majority of the trawls' bottom contact is due to the sweeps. As the sweeps drag along the seafloor they form a mud cloud that is thought to help herd the fish. The mouth of the net intercepts fish that are funneled to and collected in the codend. At the end of a tow, the codend is brought aboard the boat and emptied. In order to trawl along rugged bottom and protect the net from damage, trawlers may use rollers or chafing gear on their nets. Typically for the sablefish fishery, this special gear consists of rubber disks (Fig. 4) three to twelve inches in diameter that are punched from old tires and placed at regular intervals along the footrope. The complex of footrope and chafing gear is referred to as ground gear.

[7] Besides longlines and pots/traps, allowable open access gears also include vertical hook and line gears, which can be used to target sablefish.

[8] There are recreational opportunities in deeper water, such as those targeting Pacific halibut, where groundfish (including sablefish) are incidentally caught.

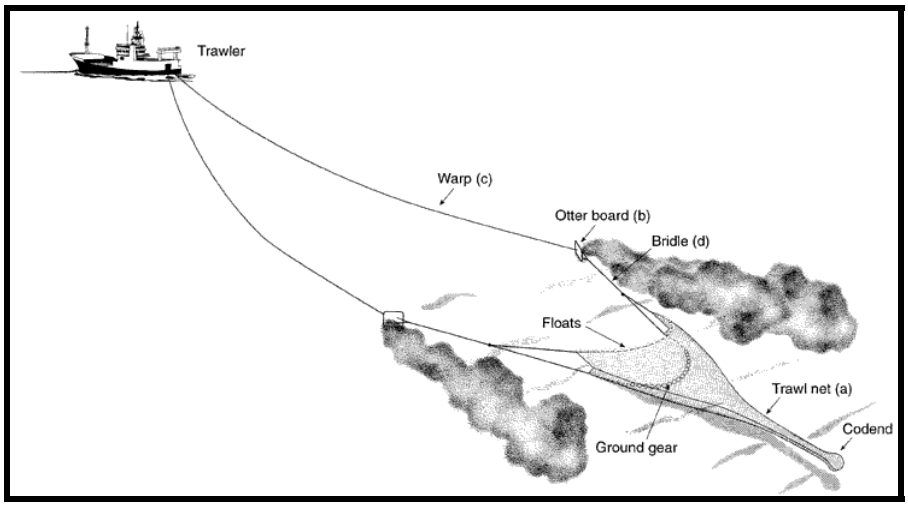


Figure 3: Diagram of bottom trawl gear
(courtesy of Christopher Kubiak)

Figure 4: Photograph of a trawl net with orange floatline and black rubber footrope gear.
(courtesy of Christopher Kubiak)

Trawlers often target multiple groundfish species. This in combination with the low selectivity of trawl gear results in a very diverse catch. A single tow will typically net 15-20 different species. The size and weight of individual fish and total catch vary greatly from tow to tow, but the total catch is often thousands of pounds. A significant portion of the catch from each tow is discarded at sea because it is not marketable, prohibited to bring to port, of small size, or of little value. But due to the extended sorting time—characteristic of trawling—and physical trauma caused by the net, mortality of discarded sablefish in the trawl fishery is likely high, especially relative to fixed gears. Fishery managers assume that 50% of sablefish die after being released from a trawl.

Sablefish Fixed-Gear Fishery

The sablefish fixed-gear fishery consists of pot/trap fishing and bottom longlining (and at least one instance of vertical longline). The primary fishing season

lasts for seven months from April to October each year.[9] Most of the vessels in this fishery operate out of Washington and Oregon ports and fish primarily north of Monterey, CA. The vessels range in length from 33 to 95 feet. Unlike the trawl fishery, the fixed-gear fishery primarily targets a single species—sablefish.[10] However, there are still some discards for much the same reasons as in the trawl fishery. Longlines and pots allow the catch to be sorted soon after it is brought aboard, thus fish mortality is lower for fixed-gear than for trawls. Based on a few limited studies, fishery managers assume a discard mortality of 20% for sablefish targeted by fixed-gear.

Longline Fishing Gear and Process:

A typical longlining vessel in the sablefish fishery is about 50 feet in length. Longlining gear (Fig. 5) consists of a weighted groundline or mainline that sinks to the seafloor (Smolowitz 1998). Attached to the groundline typically at about 40 inch intervals are shorter lines, called gangions, which have baited hooks at the end. An average-sized vessel would deploy or set about 2 miles of line with approximately 3000 hooks. Once set, the gear, which is marked with floats, would be left to fish or soak for about six hours. The gear is then mechanically hauled in. A fisherman/woman will sort the catch as it comes onboard. Most unwanted fish will be discarded directly into the water without ever coming onboard the boat.

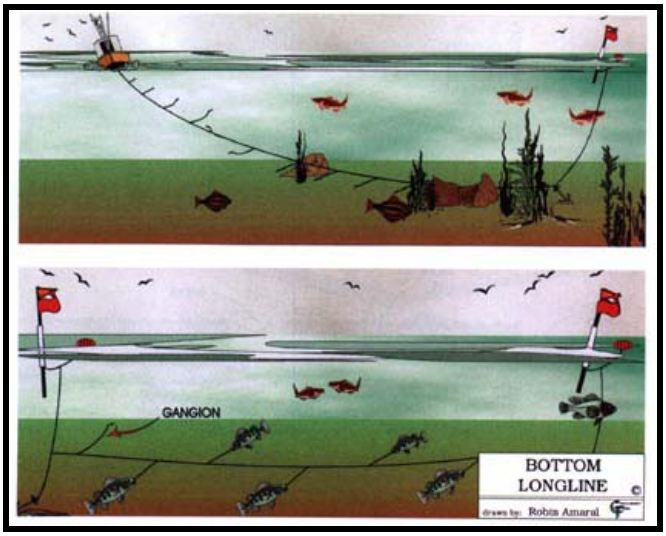


Figure 5: A bottom longline being set (top) and the gear once fully deployed (bottom). (from Smolowitz 1998)

[9] The primary sablefish fishery is open only to limited-entry fixed gear permittees with sablefish endorsements. Other limited-entry fixed gear fishermen can participate in the limited-entry daily trip limit fishery year-round (unless the allocation is taken). Once a limited-entry fixed gear fisherman with a sablefish endorsement catches their tier limit in the primary season, they can then participate in the daily trip limit fishery.

[10] While sablefish is a primary target for the limited-entry fixed gear sector, slope rockfish are also targeted in significant numbers, especially in southern California.

Pot Fishing Gear and Process:

The pot fishery for sablefish uses fish traps which are often conical (Fig. 6) in shape, but may also be rectangular (Fig. 7). The conical pots are the preferred gear, because they are collapsible and stackable and so allow fishermen/women to carry more gear on their vessels. A typical conical pot is 54 inches in diameter at it base, has a steel frame covered in synthetic mesh, is equipped with two 4-inch escape rings to allow undersized fish to exit the pot, and has a biodegradable escape area, also called a rot cord, rot panel or escape panel.[11] The rot cord helps to prevent continued fishing if the gear is lost (i.e., ghost fishing). The baited pots are set on the ocean floor along a trotline typically with about 40 pots spaced at 120 to 150 feet intervals. Typically a pot vessel will make five individual sets for a total of about 200 pots fishing simultaneously. Fishermen/women leave the pots, which are marked with floats, to soak for 15-20 hours before hauling in the gear. Some pot fishers bring their gear into port after each fishing trip, while others may leave their gear unattended in the water and return at a later time to rebait the pots.

Figure 6: Conical sablefish pot
(from http://www.ladnertraps.com/bcod.htm)

[11] Escape rings are voluntarily used by most of the fishery. Escape panels are mandated by a regulation that states "Traps must have biodegradable escape panels constructed with 21 or smaller untreated cotton twine in such a manner that an opening at least 8 inches (20.3 cm) in diameter results when the twine deteriorates." (50CFR660.382)

Figure 7: Rectangular sablefish pot
(from http://www.ladnertraps.com/bcod.htm)

METHODS

Bycatch Analysis

Without designing an experiment specific to the purpose, analyzing the comparative bycatch rates of different gear types is difficult. The existing observer data are collected for the purpose of monitoring the effectiveness of fishing regulations. Because trawls and fixed-gear are often regulated differently (i.e., different time/area closures and retention allowances for bycatch species), the bycatch data are not directly comparable between gear types.

With the advisory help of Jim Hastie, of NOAA Fisheries, I identified data that would yield the most direct comparison between gear types. This data subset consists of data collected during April to October 2004 in the northern fishing area (north of 40°10' N lat). This was a time and place when both trawl and fixed gear fleets were actively fishing. Furthermore the subset only includes data from depths greater than 150 fm, because this was the only depth category used in both trawl and fixed gear reports that was also outside of the RCAs. The limitation of this approach is that it is only a "snapshot" analysis. Subsequent sections of this report will examine trends over time, depth, and by overfished species in order to identify potential weak points in this snapshot analysis.

I supplemented the results of this analysis by conducting an analysis of data gathered by the Oregon Department of Fish & Wildlife (ODFW) during a study to compare pot and longlines as survey tools for sablefish. ODFW conducted this study in May 1999 in a 2200 square mile area from north of Newport, Oregon up to Tillamook Bay and ranging from 124º 20' W to 125º 20' W. Using one boat equipped with longline gear and another equipped with pots, ODFW made six sets at three different depths (200, 600, and 900 fathoms) for a total of 18 sets for each gear type. Each gear type was assigned to sample sites on an alternating basis. Pots had a soak time of at least 24 hours and longlines had a soak time of at least 6 hours.

Using bar charts to allow visual comparison, I graphed the bycatch ratios (a calculation of the pounds of each bycatch species that are caught for every hundred pounds of target species) of each gear type. When available I included the standard errors as recorded in the West Coast Groundfish Observer Program (WCGOP) reports. The

error bars give a measure of the consistency of the observed levels of bycatch used to calculate the bycatch ratio.

I conducted much of the bycatch analysis in this report using the published data from the WCGOP. In order to best determine the level of bycatch characteristic of each gear, I used bycatch ratios rather than total bycatch. Total bycatch is not a good measure of gear performance because the amount of bycatch is directly linked to the amount of fishing effort. On the other hand, a bycatch ratio is a measure that allows the balanced comparison of bycatch rates.

$$\text{Bycatch Ratio} = \frac{\text{total pounds of bycatch}}{\text{total pounds of target species}}$$

Because the bycatch rates in the sablefish fishery are often very small, the WCGOP reports record the bycatch ratio as per 100 pounds of target species.

$$\text{Bycatch Ratio X } \frac{100}{100} = \frac{\text{pounds of bycatch}}{\text{100 pounds of target species}}$$

For longlines and pots, the bycatch ratio is calculated using just retained sablefish, because this is the gross majority of the target catch. For trawls—which target a dozen or more species—the bycatch ratio is calculated using all the retained target species.

Habitat Impact Analysis

There is little data available on the impacts of west coast groundfish fishing gear. Thus an analysis would have to draw from studies of similar gear in other areas. In 2003, the Marine Conservation Biology Institute completed “Shifting Gears”, a comprehensive review of gear impacts in U.S. waters. Using data compiled from over 170 sources, an expert panel of 13 fishermen, managers, and scientists examined ten commercial gear classes, including bottom trawls, bottom longlines, and pots. The panel’s analysis was reported using a five-point scale, to assess the impacts of each gear on physical structure, seafloor organisms, shellfish and crabs, finfish, seabirds and turtles, marine mammals, and sharks.

Using this study as a baseline, I interviewed sablefish longliners, trawlers, pot fishermen, and other stakeholders in the sablefish fishery. Based on these interviews and my own expertise in fishing gear I adjusted, when necessary, the results of the Shifting Gears to more accurately represent the sablefish fishery.

Gear switching feasibility analysis

In order to make a qualitative assessment of the potential costs, benefits, problems, and solutions associated with gear switching, I conducted a series of unstructured and semi-structured interviews (see Appendix Two for a copy of the interview instrument). I built the sample populations using the survey method of snowballing, in which interviewees recommend other potential interviewees. With a combination of face-to-face, phone, and e-mail interviews, I surveyed a total of 44

individuals, representing trawlers, pot fishers, hook and line fishers, processors, managers, scientists and environmental NGOs (see Appendix One for a detailed breakdown of sample population demographics). I took written notes of the face-to-face and phone interviews and, when possible, also recorded the interviews for future reference. I analyzed these data with a loose application of Ground Theory methodology, which allowed me to identify common themes and construct explanatory theories.

FINDINGS & DISCUSSION

Gear Comparison Snapshot Analysis

In order to minimize the effects of variables such as fishing depth and season, I sought to identify a period in time where both trawls and fixed-gear were actively operating under similar regulations. This occurred from April to October 2004 in the northern fishing area (north of 40° 10' N lat.) in waters deeper than 150 fathoms. During this spatiotemporal period there were 206 observed longline sets and 130 observed pot sets. The number of observed trawl tows could not be quantified in time for this report.

A comparison of bycatch ratios for each gear type shows that trawls consistently have the highest bycatch rates, as much as three orders of magnitude more bycatch in the case of deepwater species like darkblotched rockfish and Pacific ocean perch (Table 1). Bycatch rates of longlines and pots are approximately the same with negligible differences— amounting to roughly 1/1000 of a pound of bycatch for every 100 lbs of target fish, except in a few specific instances of interest.

Overfished Species (2004 status)	Bycatch Ratio (lbs. of bycatch species caught per 100 lbs. of retained target catch)			Relative Ranking
	Longline	Pot	Trawl	
Bocaccio	0	0	0-.001	T>L,P
Canary	.07	0	.009-.01	L>T>P
Cowcod	0	0	0	T=L=P
Darkblotched	.068	.033	2.196-6.291	T>L>P
Lingcod	.363	.659	.106-.201	P>L>T
Pacific ocean perch	.006	.003	1.706-1.471	T>P>L
Widow	0	.001	.013-.14	T>P>L
Yelloweye	.037	0	0-.004	L>T>P

Table 1: Comparison under similar regulatory and spatiotemporal conditions (April-October 2004, north of 40° 10' N lat., >150 fm) of bycatch of eight overfished species by longline, trawl, and pot gear (data from NMFS 2005c; NMFS 2005a)

The notable exceptions to these trends are lingcod, canary rockfish, and yelloweye rockfish. Longline bycatch of canary rockfish and yelloweye rockfish is an

order of magnitude greater than the bycatch of these species caught using other gear. This difference is very important give the low allowable catch levels for these species and can be credited to the fact that longlines can more easily access the rocky habitat that these species inhabit. The prohibition on large diameter footropes in shelf habitat effectively eliminates trawling in areas where canary and yelloweye are located.

Due to the lack of readily comparable data for trawls and substantially higher bycatch for trawls, the remainder of this report will focus on determining the relative differences between longlines and pots.

Simultaneous comparison of pots and longlines

Data collect by the ODFW allowed the direct comparison of species bycatch rates by longlines and pots. Based on the reported poundage of fish caught, I was able to calculate a bycatch ratio for each bycatch species. Because this was data from a research rather than commercial fishing cruise, there was no discard of sablefish. Thus, the bycatch ratio is based on total pounds of sablefish caught not pounds of sablefish retained. For this reason, the bycatch ratios may be an underestimate of what would have occurred in a commercial setting. Also the deepest depths observed in the study were beyond those typically set in by commercial longliners and so may not be representative of a commercial situation. Compared to pots, longlines had 100 times as much total bycatch per 100 lbs of sablefish (Fig. 8). Most of the bycatch, in terms of number of species, occurred in the 200 fm depth zone (Fig. 9). In terms of pounds of bycatch, most occurred in the 600 fm depth zone. At all the observed depths, longlines had the highest level of bycatch, both in number of species and pounds caught. Notably in this study, the only bycatch of an overfished species—darkblotched rockfish—was caught by a longline. At 200 fm, pots did have bycatch of two species—rosethorn rockfish and redbanded rockfish—that were not caught by longlines. Bycatch at 400 fm and 600 fm was minimal for pots but more substantial for longlines, especially of two grenadier species (Fig. 10).

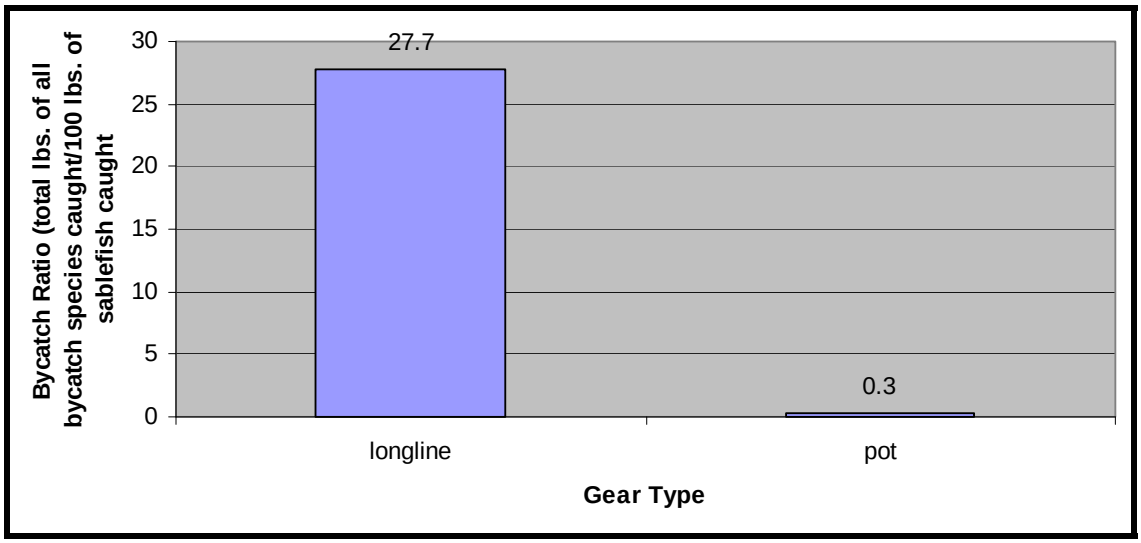


Figure 8: Bycatch ratios of pots and longlines for the sum total of all bycatch species during a simultaneous comparative gear study (data from Matteson, Hannah et al. 2001).

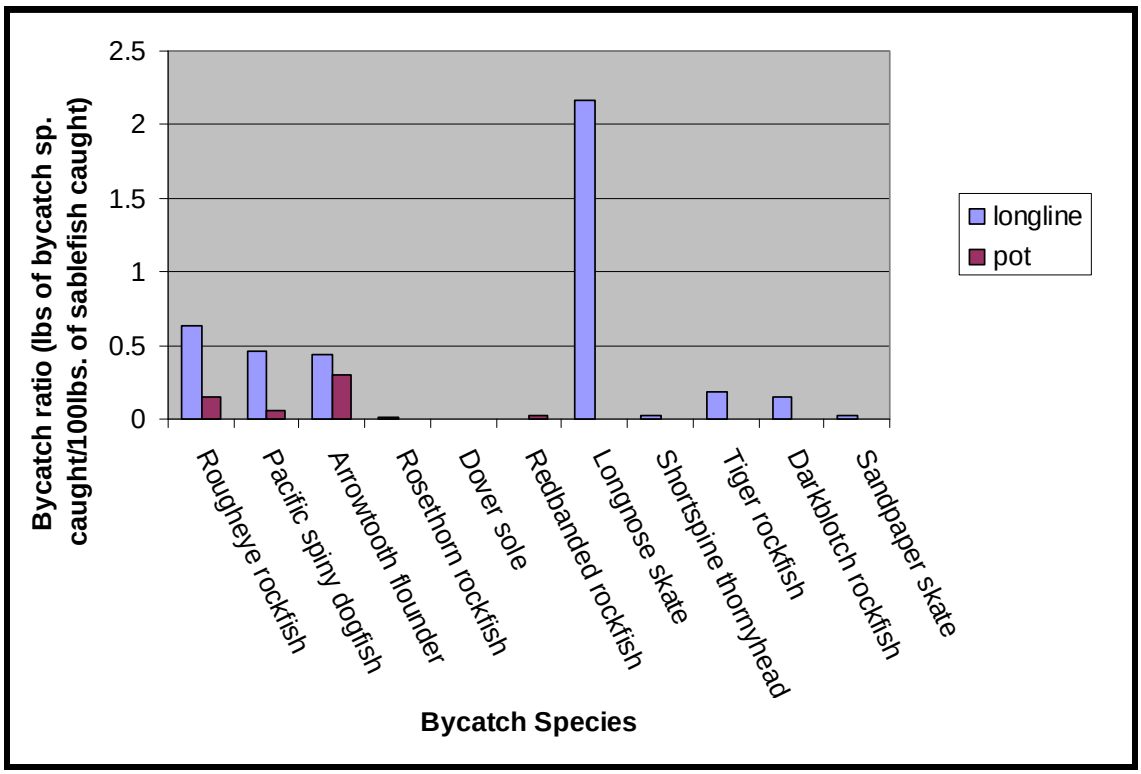


Figure 9: Bycatch ratios of pots and longlines set in 200 fm during a simultaneous comparative gear study (data from Matteson, Hannah et al. 2001).

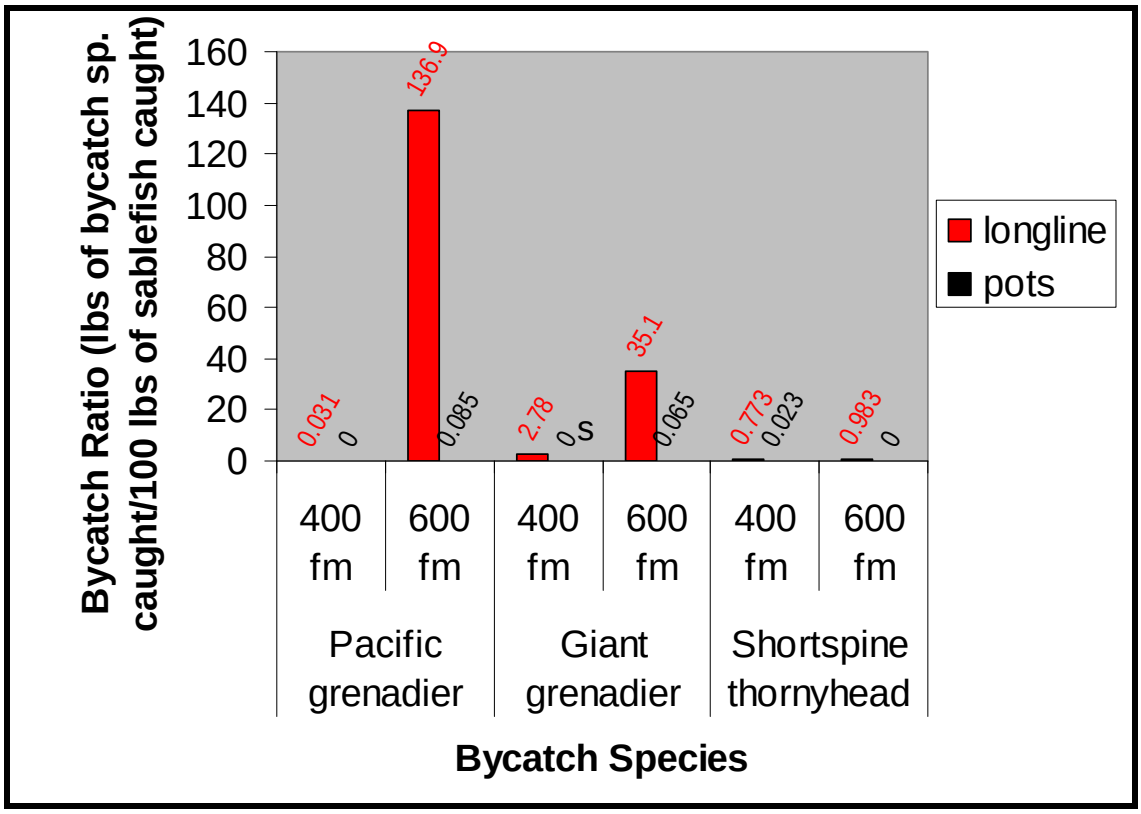


Figure 10: Bycatch ratios of pots and longlines set in 400 fm and 600 fm during a simultaneous comparative gear study (data from Matteson, Hannah et al. 2001).

Bycatch comparison by gear over time using observer data

A comparison of the bycatch ratio for each gear type for the period of 2001-2005 reveals that bycatch rates remain similar within each gear type. In other words, time (and any associated changes in the ecosystem or management measures) had little effect on bycatch rates for the fixed gear sablefish fishery. Discard rates of sablefish remained approximately the same (Fig. 11). The spike in discards of sablefish by pots in 2004 is likely an artifact of observing a pot fisherman that did not use escape rings. Although escape rings are not mandatory, most pot fishers use them, so the bycatch rates for pots in 2004 are likely not representative of the pot fishery as a whole.

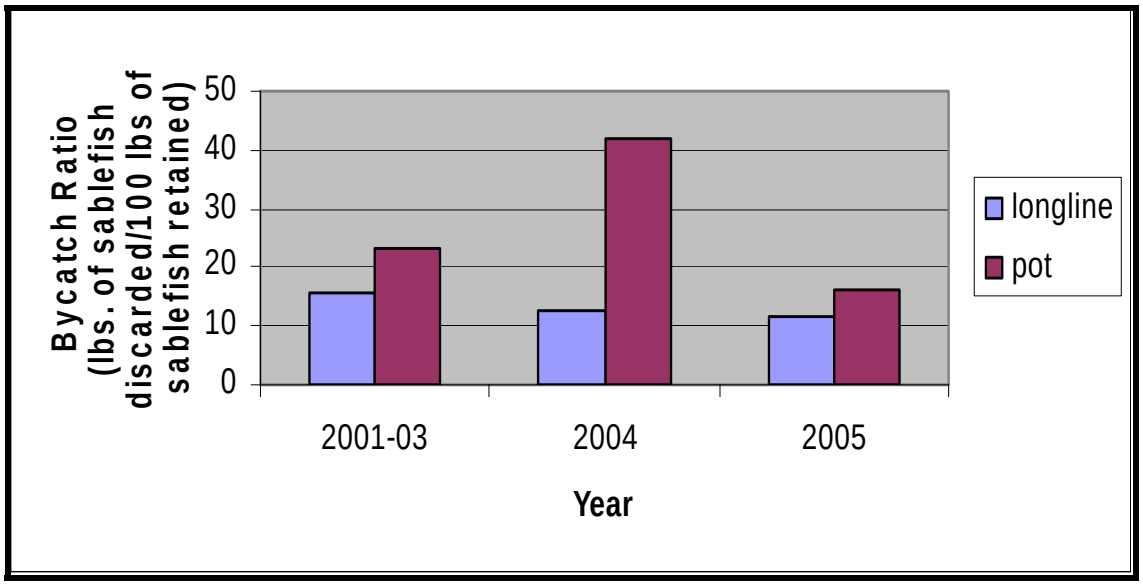


Figure 11: Comparative discard rates of sablefish by longline and pots from 2001-2005 (data from NMFS 2004b; NMFS 2005a; NMFS 2006b)

Bycatch rates for many of the overfished species remained approximately the same over time with the exception of canary rockfish, darkblotched, and lingcod. (Widow rockfish and cowcod rockfish were also analyzed but bycatch ratios were too small to be included in the graphs below.) Relative to other years, there were marked increases in bycatch of canary rockfish in 2004 and of darkblotched rockfish in 2005 by longlines (Fig. 12). While the rates of bycatch more than tripled, the difference between these and other years remained small at about 0.3 lbs of canary for every 100 lbs. of retained sablefish and about 0.1 lbs of darkblotched for every 100 lbs of retained sablefish. These increases in bycatch rates could be due to any one or combination of reasons, but is probably due to changes in the depth of the RCA.

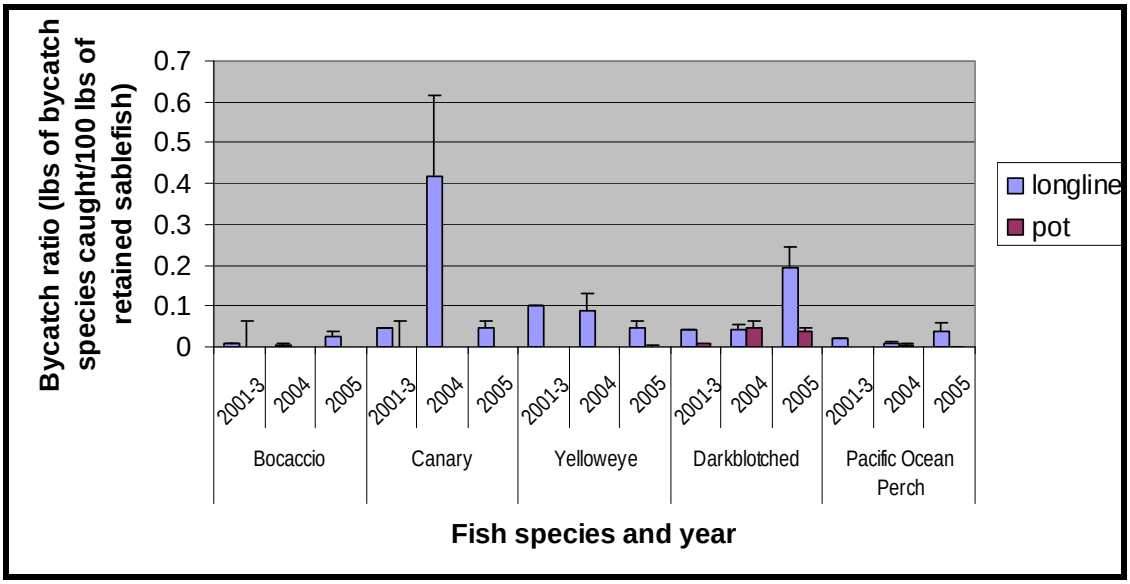


Figure 12: Comparative bycatch of five overfished species by longlines and pots from 2001-2005 (data from NMFS 2004b; NMFS 2005a; NMFS 2006b)

The bycatch of lingcod varied by as much as 0.5 lbs of lingcod per 100 lbs of retained sablefish (Fig. 13). Notably in 2005, bycatch of lingcod by longlines was nearly twice that of pots, an almost exact reversal of the pattern from 2004. The high lingcod bycatch rates by pots in 2004 are likely due to the observation of a pot fisher who did not use escape rings. The steadily increasing bycatch of lingcod by longlines is indicative of the increasing population size, which was declared rebuilt in 2005.

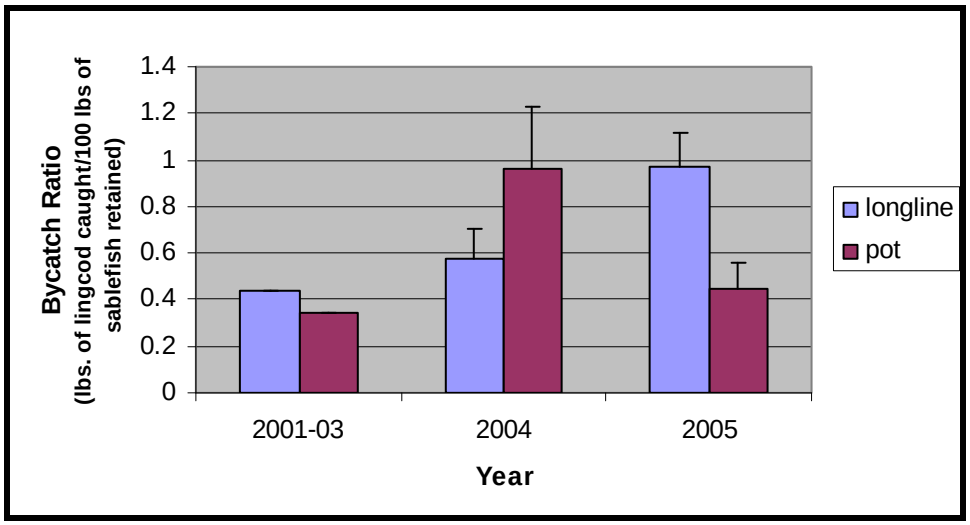


Figure 13: Comparative bycatch of lingcod by longline and pots from 2001-2005 (data from NMFS 2004b; NMFS 2005a; NMFS 2006b)

Bycatch comparison by gear and depth

Discards of sablefish (fish thrown out because they are too small or otherwise not marketable) are fairly consistent across depths (Fig. 14). This is indicative of the fact that sablefish are the target of the fishery, are widespread, and frequent a variety of habitat types. In contrast six of the eight overfished species (according to their 2004 status) show strong bycatch trends across depths (Figs. 15-20). (Bycatch of cowcod rockfish and bocaccio rockfish was too limited to graph.) These strong depth trends confirm that depth-based area closures must be considered in any analysis of the west coast groundfish fishery. This limits our ability to make direct comparisons between gears, because depth-based area closures differ for trawls and fixed gear.

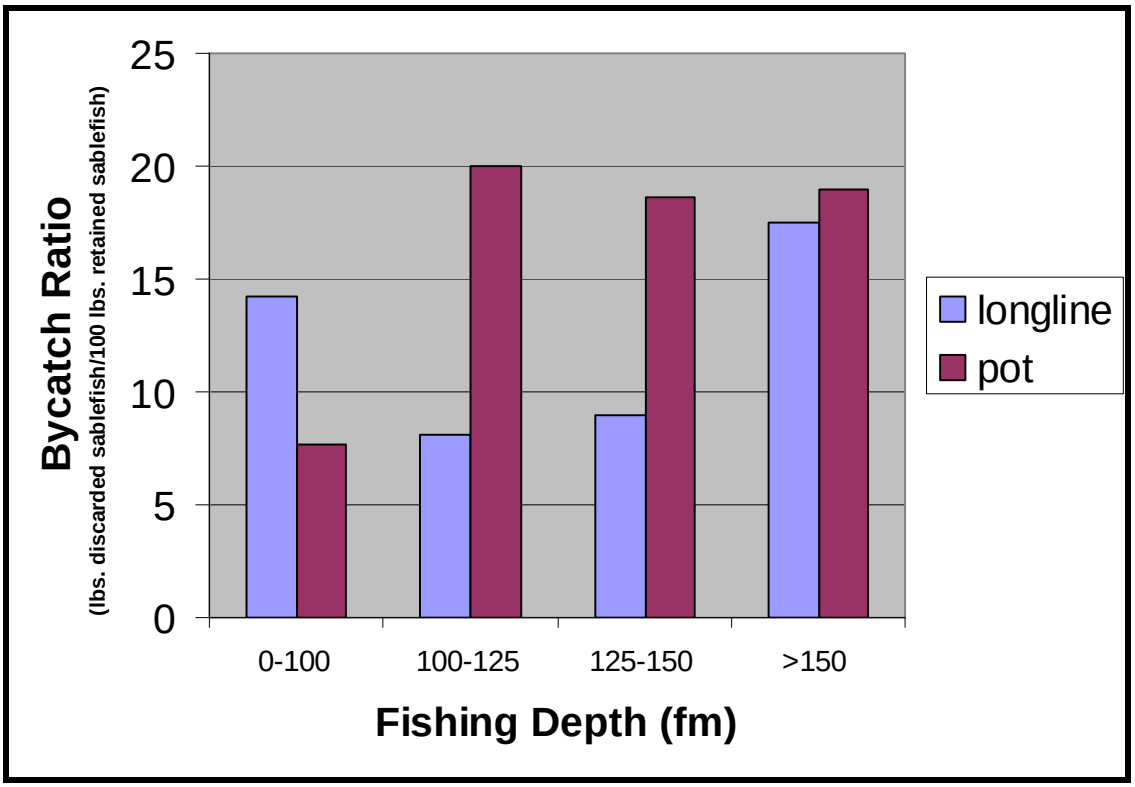


Figure 14: Comparative bycatch by depth of sablefish by longlines and pots during the period of 2001-2003 (data from NMFS 2004b)

Notably, at the depth (> 150 fm) of the direct gear comparison (Table 1), bycatch rates of overfished species were quite low except for Pacific ocean perch and darkblotched rockfish (Figs. 19-20). These were also the two species for which trawls had the greatest relative bycatch rates. This may suggest that in the direct gear comparison (Table 1) catch rates of the other six overfished species were too low in deep water to make a *discernable* difference in gear bycatch rates. In other words, the bycatch rates for these six species as depicted in Figure 8 may underestimate the inherent bycatch rates of the gear. This underestimate would most likely be greatest for trawls, because of their lack of selectivity. To determine the validity of these conjectures, future studies should attempt to identify and analyze bycatch in spatiotemporal areas in shallower depths, where trawls and fixed-gear are actively operating under similar regulatory conditions.

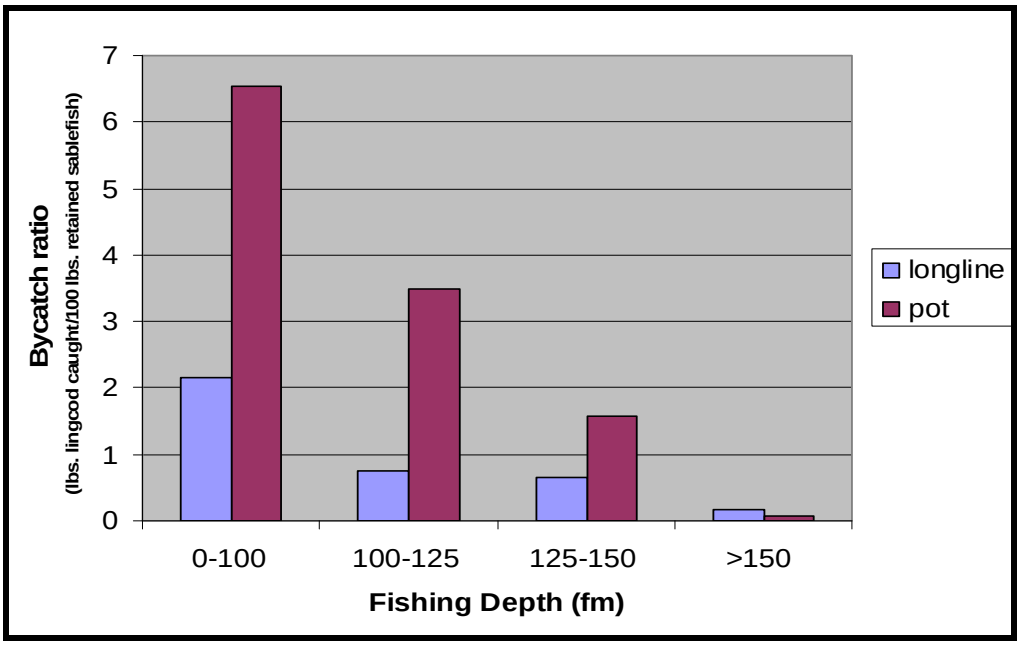


Figure 15: Comparative bycatch by depth of lingcod by longlines and pots during the period of 2001-2003 (data from NMFS 2004b)

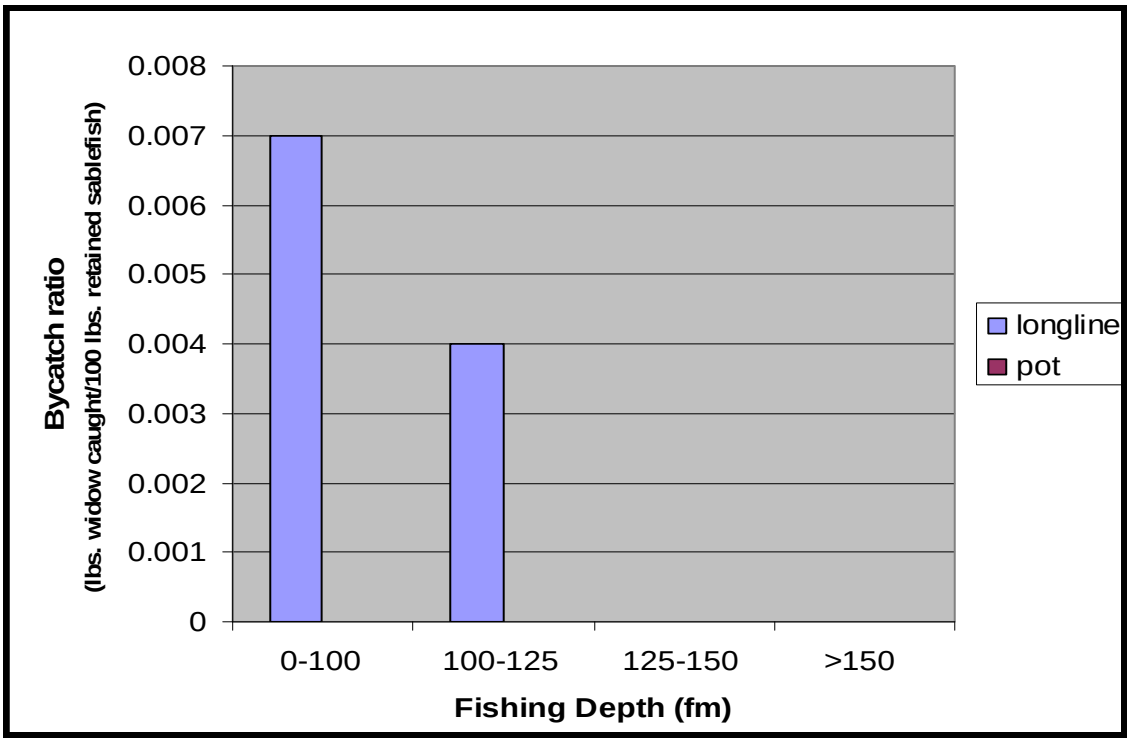


Figure 16: Comparative bycatch by depth of widow rockfish by longlines and pots during the period of 2001-2003 (data from NMFS 2004b)

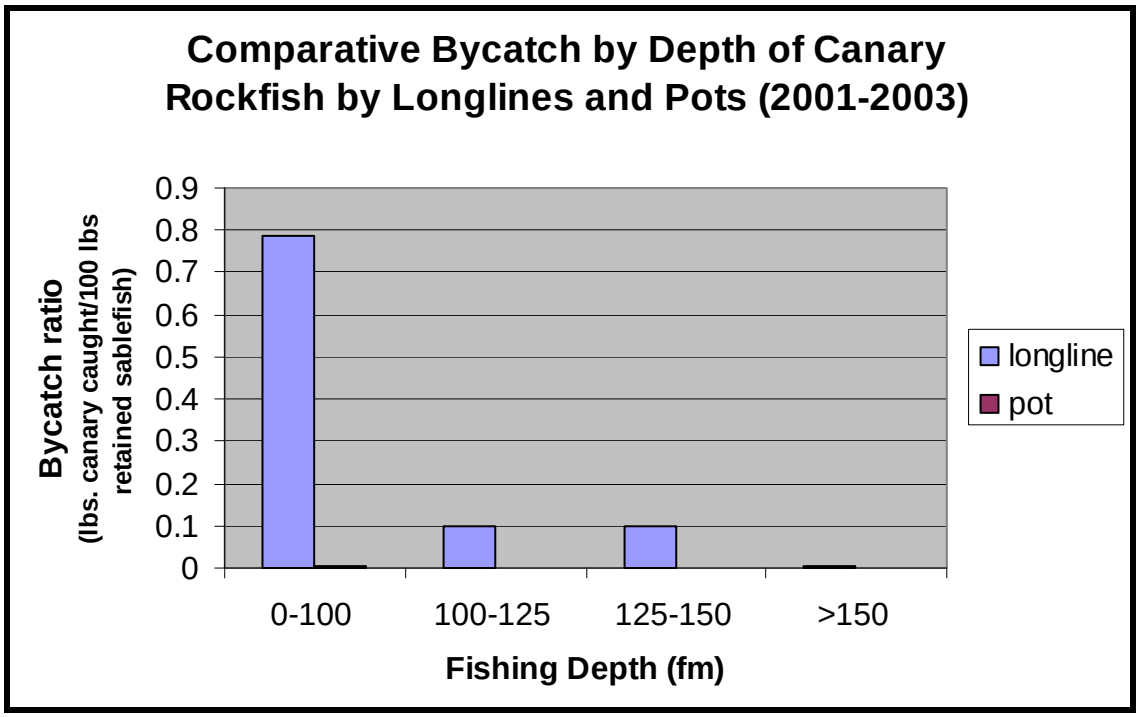


Figure 17: Comparative bycatch by depth of canary rockfish by longlines and pots during the period of 2001-2003 (data from NMFS 2004b)

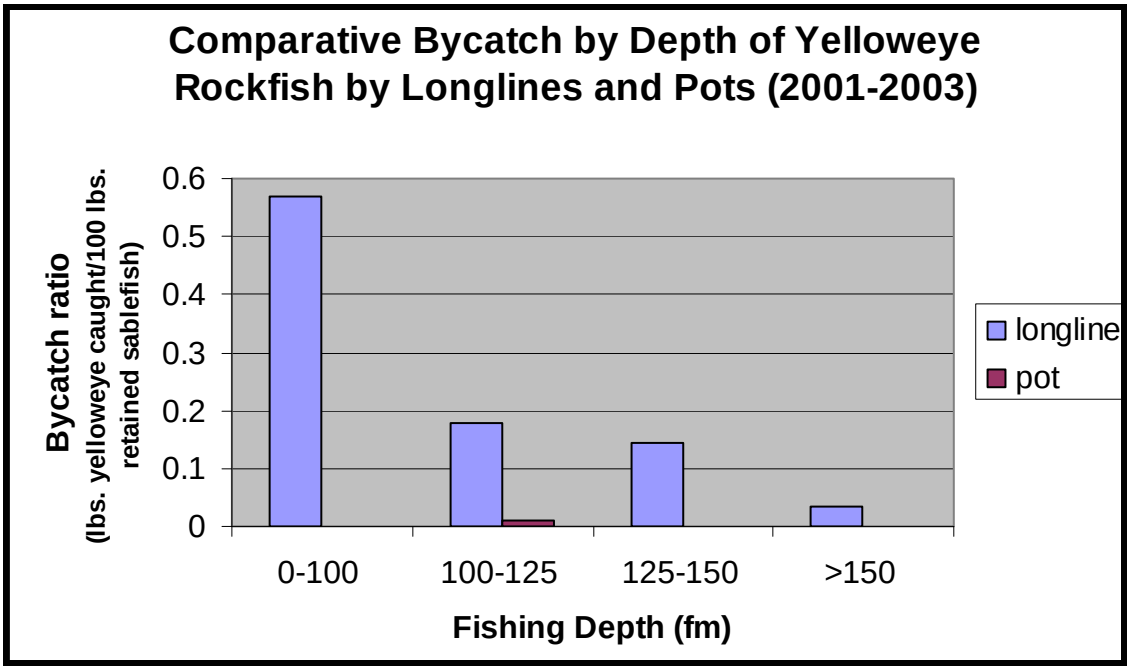


Figure 18: Comparative bycatch by depth of yelloweye rockfish by longlines and pots during the period of 2001-2003 (data from NMFS 2004b).

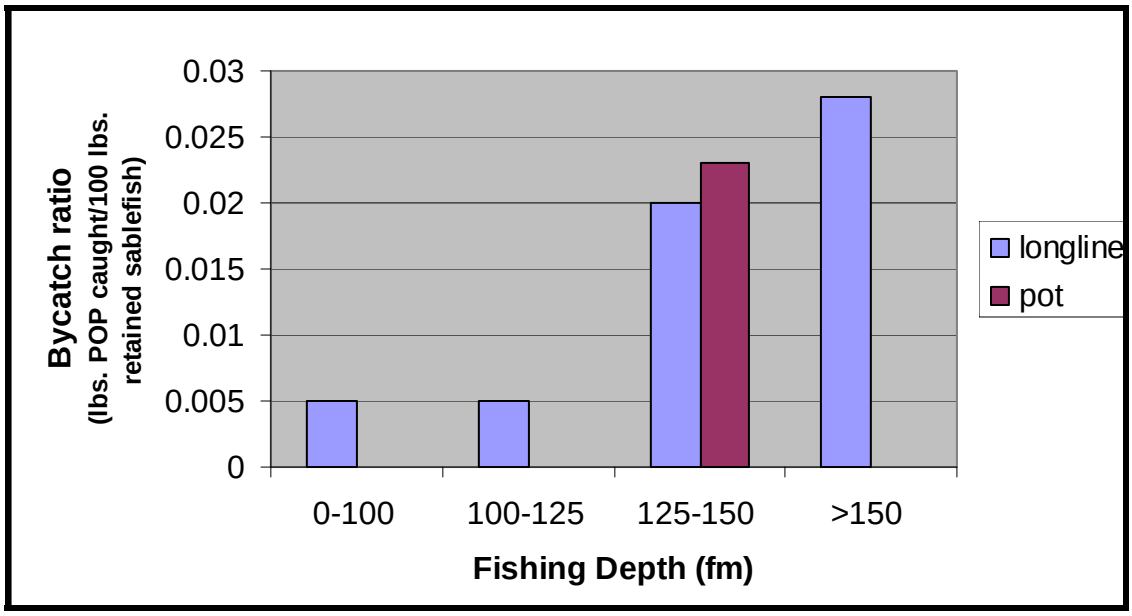


Figure 19: Comparative bycatch by depth of Pacific ocean perch (POP) by longlines and pots during the period of 2001-2003 (data from NMFS 2004b).

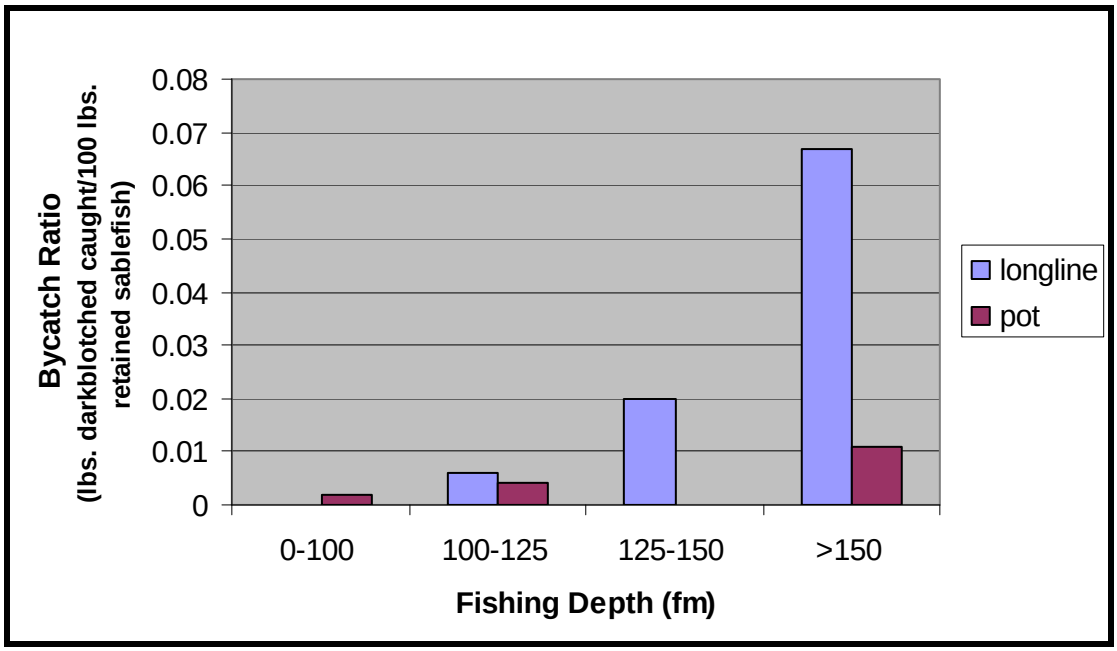


Figure 20: Comparative bycatch by depth of darkblotched rockfish by longlines and pots during the period of 2001-2003 (data from NMFS 2004b).

Habitat Impacts

Because of the lack of research in the northeastern Pacific, habitat impacts of bottom longlines, bottom trawls, and pots must be extrapolated from studies done in other areas. The "Shifting Gears" study did just this. The study considered gear impacts on

physical structure, seafloor organisms, shellfish and crabs, finfish, sharks, marine mammals, as well as seabirds and turtles. The study found that on a 100 point scale—with 1 being the least severe—the cumulative impact scores for bottom trawls, pots and traps, and bottom longlines were 91, 38, and 30, respectively (Morgan and Chuenpagdee 2003).

The breakdown of the bottom trawl impact score shows that bottom trawls were rated as having the highest possible severity score for habitat impacts (Fig. 21). The bottom gear on trawls tends to smooth and compact the seabed and harm invertebrates such as sponges and corals (National Research Council 2002). Trawls also increase turbidity, reducing primary productivity and contributing to anoxia. Additionally they disturb hard structures, such as boulders, reducing the available feeding and sheltering habitat. The study also gave finfish bycatch by bottom trawls the highest impact score. This corresponds with and supports the findings in the sablefish fishery that bottom trawls had higher bycatch ratios of most of the overfished species, which are all finfish.

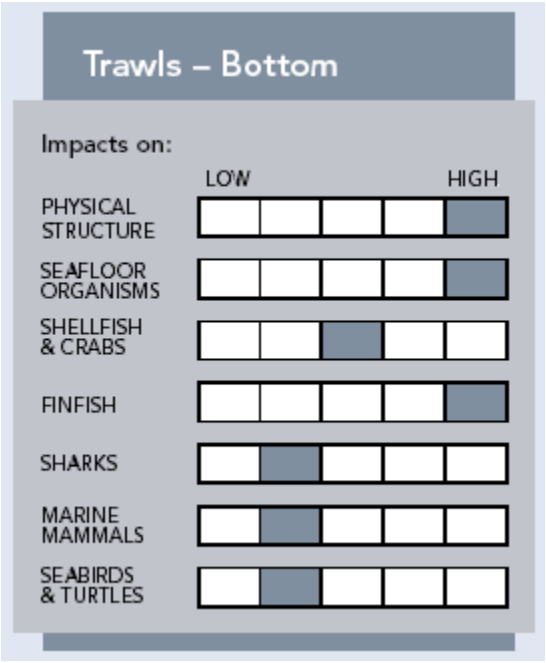


Figure 21: Impact rating of bottom trawls as agreed by 13 expert "Shifting Gears" workshop participants (from "Shifting Gears" by L. Morgan and R. Chuenpagdee 2003)

The breakdown of bottom longlining impact score shows that its habitat impacts were rated low. The report does note that hauling in of the line may cause hooks to snag, abrading rocks, corals, and sponges. This damage is magnified if the gear is hauled in mechanically. The impact score breakdown reveals that the areas of greatest concern are finfish (Fig. 22). The available synthesized data on the sablefish fishery does not include useful information on shark bycatch and seabird bycatch, so the appropriateness of this rating can not be determined. Given the present global concern for the health of shark and seabird populations, this would be crucial future research to conduct.

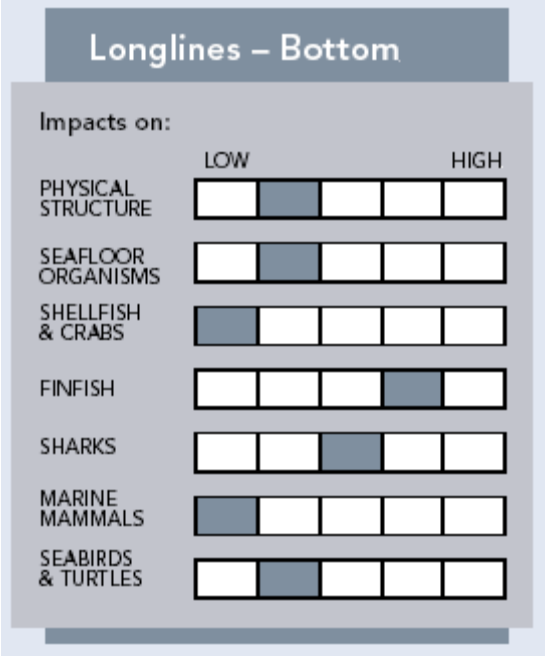


Figure 22: Impact rating of bottom longlines as agreed by 13 expert "Shifting Gears" workshop participants (from "Shifting Gears" by L. Morgan and R. Chuenpagdee 2003)

Of the three gear types and their use globally, pots vary the most in their form and function. Thus, the general impact profile for this gear type (Fig. 23) is not as directly applicable to the sablefish fishery. I therefore adjusted the profile for the sablefish pot fishery (Fig. 24), based on interviews with pot fishers and my understanding of how the specifics of sablefish pot fishing differ from the pot fishing considered in the Shifting Gears report. I did not use the Shifting Gears methods in making these adjustments.[12]

[12] The Shifting Gears study drew on the combined expertise of a panel of 13 fishers, managers, and scientists. Using the Shifting Gears methods would be an extensive process beyond the scope of this project. Such an endeavor would involve reconvening the panel to analyze the sablefish fishery and reanalyzing the data. Rather my approach was to make illustrative changes to the graphs that were indicative of a general increase or decrease in impact. I did not attempt to add or subtract value from the actual data set. Recognizing that their report was an average and might not correctly represent individual fisheries, the authors of the Shifting Gear report recommended the judicious tailoring of their findings.

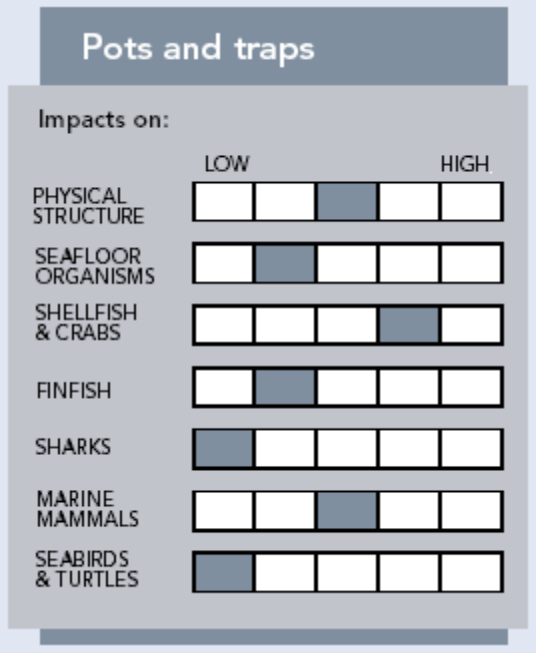


Figure 23: Impact rating of pots and traps as agreed by 13 expert "Shifting Gears" workshop participants (from "Shifting Gears" by L. Morgan and R. Chuenpagdee 2003)

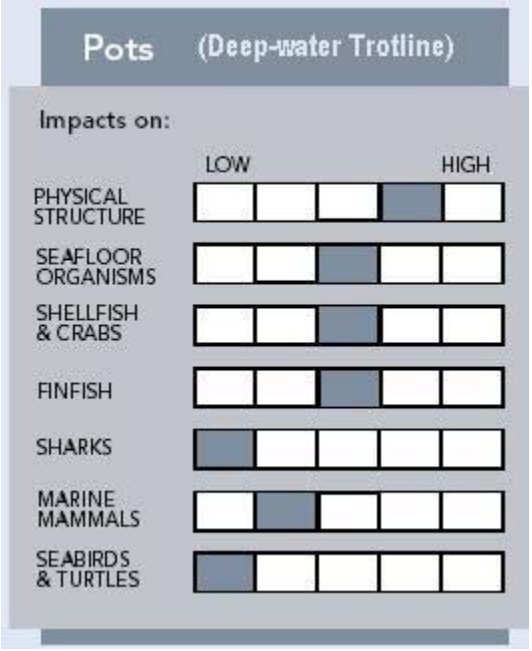


Figure 24: Impacts rating of pots as adjusted for conditions in the sablefish fishery (derived from "Shifting Gears" by L. Morgan and R. Chuenpagdee 2003)

I increased both the physical structure and seafloor organisms impact score, because the sablefish pot fishery uses trotlines. The "Shifting Gears reports aggregated both trotline and individually set pots, but notes that trotlines "tend to cause more damage during hauling than single pots." The increase in these two scores reflects this greater potential to cause damage. Also some portion of the pot fishery moves their pots with

every set. This distributes the impact of gear to a larger area. It is unclear whether this distributed impact is worse than concentrated impacts for these specific habitats, and so should be a topic of future study. Sablefish pot fishers explained that the extent of habitat impact is directly related to the fisher's skill. Skillful fishermen/women can retrieve that gear by picking it directly off the seafloor. Less skillful fishermen/women will drag the pots off the bottom, causing increased damage.

I decreased the shellfish and crabs bycatch score, because in the sablefish fishery all crabs must be discarded and the bycatch ratio is low (e.g. 0.009 lbs. of tanner crab per every pound of sablefish and 0.001 lbs of Dungeness crab for every pound of sablefish). I also decreased the marine mammal bycatch score, because the Shifting Gears report considered the entanglement of right whales in lobster pots lines. There is no recorded take of marine mammals in the sablefish fishery.

I increased the finfish bycatch impact score, because of the depth at which the sablefish fishery operates. Typically pots allow for live release of fish; but because rockfish have swim bladders, they die upon being brought to the surface. This partially negates the positive benefit of live release that pots often have. Also much of the research considered in the Shifting Gears report took place in warm climates, which facilitates the quick disintegration of rot cords. The deep waters of the sablefish fishery are cooler, so the rot cord will disintegrate more slowly, and so have a greater potential to ghost fish. Also the pots in this fish have only one rot cord, so if a pot becomes partially submerged or encrusted with organisms, the rot cord may be obscured and the pot may begin to ghost fish again.

Gear Modifications to Reduce Bycatch and Habitat Impacts

One of the secondary goals of this study was to seek out technologies or practices that could potentially reduce bycatch and habitat impacts in the sablefish fishery, especially in the trawl fishery. The survey identified three technologies that Dr. Craig Rose of NOAA's Alaska Fisheries Science Center and his colleagues are developing for Alaskan fisheries. These technologies may be of use to the west coast groundfish fishery. Also the survey identified scientific evidence to warrant an interest by fishermen in modifying pots to increase their efficiency and ability to catch a wider range of species. To read about the details of this research, please see Appendix Three.

Perceptions, Pros, and Cons of Gear Switching

In the following section, I summarize how the interviewees defined gear conversion,[13] how they view the pros and cons of gear switching, and any concerns they may have about the subject. When applicable, I include the responses of other stakeholder groups to certain concerns and offer my own analysis of the validity of these concerns. Most of the individuals interviewed for this study are community or industry leaders who are or have been active on state and federal advisory boards, industry groups, or community groups. Thus it is reasonable to assume that they are more knowledgeable

[13] The term "gear switching" was used in the interviews. For the sake of clarity In the report, I use the term "gear conversion" for long-term and/or unidirectional changes in gear, and "gear switching" for bi-directional or unconstrained changes in gear.

than the constituents they represent about potential management options, such as gear conversion. So the views summarized below are likely of a detail and depth beyond that of the average stakeholder.

Trawlers and Affiliates

Pros	Cons
May decrease discards	May increase discards
Will increase business options	Too time consuming to convert vessel
More places to fish	Initial investment too costly
More convenient places to fish	Continued investment not worthwhile
More flexibility in when to go fishing	Not enough potential profit
Increased value of fish	

Table 2: Summary of the pros and cons of gear conversion as opined by the trawling community

Of the trawlers and their affiliates (hereafter referred to as trawlers) that I interviewed, all were aware of the concept of gear conversion or switching. They viewed it as a way to increase their business options, by being able to fish a portion of their sablefish allocation using fixed gear. With this perception the trawlers assumed that gear conversion or switching would occur as part of an individual quota (IQ) system that would guarantee them access to a share of the quota. Many of these trawlers also assumed that the quota would be transferable. With a few exceptions, the trawlers believed that an ideal gear switching system would allow them to move between fixed-gear and trawling fisheries at will. They believed that without this level of freedom, gear switching would not be worth the time and financial investment. In my expert opinion as an interviewer, I believe that this stance was at least in part gamesmanship, trying to establish an advantageous position for future discussions. When pressed for their views on a more restricted gear conversion scenario many agreed that they would at least consider other options.

The exceptions to most common perceptions of gear conversion included those of two small boat trawlers whose fishing operations had been severely restricted by the RCA. Because of these restrictions, trawling had become a much more costly and dangerous endeavor, as they had to travel a much greater distance to reach legal fishing grounds. They were quite interested in gear conversion as a semi-permanent or permanent uni-directional switch. They were willing to switch gear for the length of the two-year management cycle or even longer. In the course of my interviews, I heard rumor of at least one other trawler who might be interested in a permanent gear conversion. Yet another trawler expressed interesting in having his permit bought out as The Nature Conservancy has done in Morro Bay. [14] However, I believe his interest was simply in a profitable means to leave the fishery not in lease-backs as a means of gear switching.

All the trawlers showed a preference for pots rather than longlines as a target for gear conversion. They stated that pots are an easier gear to fish. They perceive that pots

[14] The Nature Conservancy (TNC) has purchased 6 limited entry trawl permits from trawlers based in Morro Bay, CA. In partnership with Environmental Defense, TNC has obtained an experimental fishing permit from PFMC that allows the leasing of most of these permits back to fishermen as fixed-gear permits, within the context of a research protocol.

would allow them more flexibility as to when they fish their gear, because pots can be left unattended—unlike longlines. This is especially attractive to small trawlers who cannot contend with severe weather, which can thus cost them fishing time. However, my interviews with pot fishers reveal that there is a limit to this flexibility. Unattended gear may be lost to weather or gear conflicts. Also, if the gear is left for too long it will yield poor quality fish. Notably, one trawler has purchased a pot permit in order to increase his allowable sablefish catch. He fishes this permit on another boat, so does not practice gear switching, per se. However, he seems quite satisfied with this arrangement as a viable way to catch sablefish.

Only one trawler was not interested in any form of gear conversion. This trawler fished on a boat with a substantial fishing history and so participated in numerous fisheries. In order to pursue these fisheries, he had to change the gear on his boat. By his estimate, he changes fisheries and gear 90% more frequently than other trawlers. Because of this full schedule, he would only have a couple of weeks each year during which he could switch to using pot gear, which would be his preferred gear. The trawler explained that the financial cost and fishing time that he would lose in converting his vessel to operate for such a short time would not be worthwhile for him. He states, unlike all the other trawlers that I spoke to, that he catches his full limit of sablefish while trawling and makes a substantial profit. So for him, increased revenue from gear switching would only come from the increased value of the fish. This potential increase in revenue would not be worthwhile given the initial and recurring investments. In addition to the initial $10,000 investment to buy pots, he estimated that the time to convert the vessel to a pot fishing boat would be 3-7 days and would cost $500 for the price of a crane rental to remove the winch from the boat deck. These same time and financial costs would be repeated when converting the boat back to trawling. For these reasons, he was not interested in gear switching. I believe that he is an exceptional case, both in the history of his boat that allows participation in so many fisheries and his high level of catching success as a trawler. Thus his views, while noteworthy, are probably not representative of most trawlers.

Several trawlers expressed concern that gear switching would result in an increase in discards. This they believed would result from trawlers switching between gears within the same fishing season. Trawlers would be limited in how much of their sablefish allocation they could catch with fixed-gear, because a portion of this allocation must be set aside to account for the sablefish bycatch they will encounter while trawling for Dover sole and thornyhead. If the trawler does not set aside enough sablefish to allow the capture of the full allocation of these other species, the trawler will be forced to discard sablefish in order to catch and retain Dover sole and thornyhead.

When I presented this concern to managers and other trawlers, they discounted it on several points. First, this same problem occurs with the current trip limit system. Trawlers often exceed their trip limit and are placed in a position of discarding some fish in order to catch others. These dissenters believe that in comparison to current discard practices, gear switching as part of an Individual Quota (IQ) program would likely decrease discards. Second, if gear conversion were part of an IQ program, discarding would only occur on the final trip during which one or more of the allocations were exceeded. That is because once a fisherman exceeds his allocation, the fishing season will be over for him/her. Third, an IQ program may include a measure that makes quota

holders accountable for any exceedance of their allocation. This would serve as a disincentive to exceed allocations.

It was very difficult to elucidate the basis of the concerns about increased discards. Even with repeated follow-up questions and interviews, the individuals who voiced this opinion had difficulty detailing their concerns. My sense as an interviewer is that perhaps these individuals have a hunch that gear switching may create loopholes that allow or encourage discards or high-grading of fish. This speaks to doubts about the enforceability and structure of a gear switching program. Additionally, the dissenters to the idea of increased discards support their view by pointing to potential structural elements of a gear switching program. Thus, this study was not able to define the true risk of increased discards. However, I can say with certainty that the viability of a gear conversion program will depend heavily on how well the enforcement and accountability mechanisms function.

Pot Fishers and Affiliates

Pros	Cons
More judicious use of the resource	May reduce value of fixed-gear caught fish
May reduce discards	May increase competition for pot fishers
More ecologically sound	Inequitable; pot fishers cannot gear switch
May reduce gear conflicts with trawls	Over-crowding of fishing grounds

Table 3: Summary of the pros and cons of gear conversion as opined by the pot fishing community

Of the pot fishers and their affiliates (hereafter referred to as pot fishers) with whom I spoke, the majority were unfamiliar with the concept of gear conversion. Because they had not previously considered the option, their perceptions of the concept were vague. The few that had some understanding of the concept, knew it only in the context of The Nature Conservancy's efforts in Morro Bay, CA. Thus for the gross majority of the pot fishers, I had to define gear conversion in order to initiate the conversation. Their unfamiliarity with the topic may have affected the depth of their responses.

With the exception of two individuals, the pot fishers believe that there is space in the fishery both geographically and in the amount of sablefish available for the trawlers to convert to other gears. These fishermen did not foresee any conflicts. In fact, several thought that it would be better for the resource, because trawls "waste" so many fish as bycatch. With gear conversion, these previously "wasted" fish would remain in the water to grow, reproduce, and be available for other fishermen/women to catch. Also several interviewees saw an added benefit in that they might lose less pot gear from having it intercepted by trawls. They reasoned that gear conversion would reduce the trawl effort and thus reduce the degree of gear conflict.

Those who objected to gear conversion supported the concept as being a more ecologically sound practice, but were concerned that it would come at a cost to established pot fishers. Specifically, this cost would be the over-crowding of fishing grounds. There may not be enough geographic space for new entrants in the fishery. Even if space is available the increase in gear may also result in an increase of pot gear entangling with each other. The small number of comments on this topic indicates that

space may only be an issue for a portion of the pot fishery. Specifically those concerned are from areas where fishing grounds are limited by topography and/or regulations and where the boats are smaller and so cannot travel far to fish. Over-crowding may be further heightened by a tendency of pot fishers to concentrate their fishing during the time when the price of hake—the preferred bait—is lowest. Typically, this is a three month window from June to August, during the seven month fishing season.

Another perceived cost to established pot fishers is a reduction in value of fixed gear caught fish, because trawlers-turned-pot-fishers would flood the market with their fish and drive down prices. In discussions of this concern with other fixed-gear fishermen and processors, they all discounted it. They pointed out that the prices for sablefish are driven by the global market. West Coast caught sablefish is only a small percentage of what is caught globally, so even major changes in the composition of the West Coast sablefish fishing fleet are unlikely to affect prices.

Other concerns centered on fairness. One individual felt that fixed-gear fishermen/women should also have the option of gear switching to another fixed-gear or even trawling, so that they also could increase their business options.[15] Another concern was that pot fisher's stakes in the fishery should be protected and that they should be compensated for the increased competition. One individual offered several mechanisms to protect existing fixed gear fishermen from competition from new entrants. These mechanisms could include season restrictions on the new entrants, such as fishing only during the five months not included in the existing fixed-gear fishing season. Managers could also consider opening restricted areas to be used by the existing fixed-gear fleet only. Another mechanism would be restriction on the amount of gear new entrants may use.

The favored form of compensation was an increase of the fixed-gear industry's allocation of sablefish, preferably to the historical level of 48%. Many of the interviewees were opposed to compensation. Several of the fixed-gear fishermen opined that competition is part of the fishing industry and they did not think that compensation is necessary. Trawlers opposed the idea, because most likely the increase in fixed-gear allocation would come at the expense of the trawl allocation. One manager opposed the idea on the basis that it would be a bad precedent to set, because fish are a public resource and exploiters of this resources should not be compensated for losses as though fish were private property. Notably, if gear switching were to occur—even without an IQ system—it is likely that the program could allow trawlers to bring their portion of the sector allocation with them when they switch to the fixed gear sector. Future research should thoroughly investigate potential negative impacts, especially over- crowding of fishing grounds, of gear switching on the fixed-gear fishery.

Longliners and Their Affiliates

Pros	Cons
More judicious use of the resource	Not enough space on fishing grounds
May reduce discards	May not reduce discards
	Less fish to support shoreside infrastructure

[15] Reportedly, PFMC will explore allowing limited-entry fixed gear fishermen to switch from longlines to pots/traps with potential implementation in 2009.

Table 4: Summary of the pros and cons of gear conversion as opined by the longlining community

Like the pot fishers, most of the longliners and their affiliates (hereafter referred to as longliners) with whom I spoke, were unfamiliar with the concept of gear conversion. Because they had not previously considered the option, their perceptions of the concept were vague. Again, the few that had some understanding of the concept, knew it mostly in the context of The Nature Conservancy's efforts in Morro Bay, CA. Thus for the gross majority of the longliners, I had to define gear conversion in order to initiate the conversation. Their unfamiliarity with the topic may have affected the depth of their responses.

In general, longliners were supportive of gear conversion, but less so than pot fishers. Like pot fishers, they thought that it would be a better, less wasteful use of the resource. However, one longliner reasoned that trawlers who are used to a much larger amount of discards may continue these "dirty" fishing practices even with fixed gear. There may be merit to this concern, because the cleanest of fixed-gear results not only from the more selective nature of the gear, but also how it is fished. For example, if a longliner chose not to sort fish on deck rather than at the side of the boat, mortality of discarded fish would likely increase significantly. Because many longliner boats are small and lack deck space, there is an incentive to sort the catch as it is being hauled in. Trawl vessels have more deck space. Feasibly, the catch could be sorted on deck and there would be an incentive to do this because the haul in time could increase and the line could be reset faster.

Unlike pot fishers, several longliners expressed concern about geographic space to accommodate more fixed-gear fishermen/women. This issue may be particularly valid for ports near a non-trawl RCA or which have mostly small vessels that cannot safely travel to distant fishing grounds. Longliners were especially concerned about gear switching resulting in more pot fishers, because it is difficult to set a longline in an area where pots are set as well. Notably, one longliner opposed the idea of gear switching on the basis that it would result in trawlers landing less fish and thus have negative effects on shore-side infrastructure.

Processors

Pros	Cons
Will increase trawlers' business options	Less fish to support shoreside infrastructure
Will increase the supply of fixed-gear quality sablefish	Will reduce supply of flatfish
	May increase competition from small processors
	May result in the loss of skilled workers

Table 5: Summary of the pros and cons of gear conversion as opined by the processing community

Most processors and their affiliates (hereafter referred to as processors) with whom I spoke were familiar with the concept of gear conversion and support it on the basis that it would give trawlers more business options. Their primary concern was

guaranteeing that they would have an adequate supply of fish to maintain their workers and meet market demand. As a means of mitigating this problem, one manager suggested that in addition to conversion to fixed-gear, bottom trawlers be allowed to use mid-water trawls. This would potentially increase the amount of whiting available to the processors and offset losses from a reduction in groundfish landings. However the processors also feared that a reduction in the number of trawlers would affect the supply of flatfish, which are not caught in mid-water trawls. Also they thought that an increase in longliners, who often process their own fish onboard their boats, might reduce the processing load available to support their workers. Because the processors assumed that gear conversion would occur in conjunction with an IQ program, a couple of them were concerned that trawlers would start their own processing operation by using their allocation as collateral for a start-up loan. They felt the only way to guarantee their supply of fish would be to have a processor allocation of 10-15%.

Currently flatfish, which make up a significant portion of the fish processors market, can only be commercially caught with trawls. However, the large processors that I spoke to only had 5 or 6 trawlers that regularly supplied them. Given that there are only about 4 large processors on the West Coast, it would seem that a viable flatfish market could still be sustained by just a fraction of the 169 active trawl permits currently operating in the groundfish fishery. In further support of this reasoning, many of the trawlers and processors I spoke to said that the global market for common flatfish such as Dover sole is often flooded, during which times processors do not purchase these fish. This suggests that under the present system processors are often over-supplied with some species by the present trawl fleet.

Regarding the maintenance of workers, I do not believe this will be a significant issue with gear conversion. All the trawlers I spoke to expressed interest in switching to pots, which legally are not allowed to process fish on-board their boats, so the amount of sablefish needing to be processed is likely to remain stable. The standard way to process sablefish is a “J cut” in which the head and the guts of the fish are removed and the rest frozen whole. This is a very simple means of processing fish, which does not require much skill. The most skilled workers in processing plants fillet fish; they frequently process flatfish. Assuming that some portion of the trawl fleet will continue to capture flatfish, it should be possible to maintain the skilled workforce in processing plants.

The trawlers with whom I spoke were divided in their interest in processing their own fish. A couple said that they would consider the option as they would any new business option that might be profitable to them. Others clearly stated that they had no interest in fish processing. No one stated that they would definitely pursue processing if that option was available to them. Based on a conversation with a small-scale processor, I doubt that processing by single fishermen or even cooperatives would be a major challenge to the larger processors, because fisher/processors must divide their time between business responsibilities at sea and on land. Also the money generated by these small processors is more likely to remain in the community, thus benefiting it as a whole.

Concerning a processors’ allocation, most of my interviewees outside of the processing community opposed this idea. Much as with compensation for pot fishermen, a processors’ allocation may be an inappropriate use of a public resource. Allocations to fishermen and women serve as a management tool, but a processor allocation could be viewed as simply protection against competition. While processors present their concerns

as being about the welfare of fishing communities, many of the interviewees pointed out that first and foremost processors are trying to preserve their personal interests. Most of the interviewees believed that a realistic gear conversion scenario (i.e. with some trawlers still trawling), would allow fishing communities to continue to operate productively. A determination of the number and distribution of trawlers necessary to supply the flatfish market and help support fishing communities would require a detailed economic analysis beyond the scope of this study. Future research to make this determination should be a priority in any further assessment of gear conversion.

Gear Suppliers

Pros	Cons
	May lose money on unwanted stock
	May not have enough time to supply initial demand
	May reduce overall revenue

Table 6: Summary of the pros and cons of gear conversion as opined by gear suppliers

Most of the gear suppliers I spoke with were unaware of the gear conversion concept. Once explained to them, the majority were neutral in their opinions, because they serve many aspects of the fishing community from trawlers and longliners to fish processors. However, it should be noted that trawl gear is more expensive gear than longlines and most pots are imported, so the gear suppliers definitely have a larger financial dependency on trawls in comparison to other gear types. The gear suppliers' greatest concern is being given adequate advance notice of large-scale gear changes. They forecast that they would need six months to a year to reduce their inventory of obsolete gear and stock sufficient amounts of the newly desired gear. The one net shop owner I spoke with believed that gear conversion would reduce the number of nets that the business sells but was not overly concerned, because the owner believed there would always be a need for trawlers. Also, the number of operating net shops has declined greatly in recent years, so the remaining shops serve a large area and have a healthy demand for their service.

Managers

Pros	Cons
Would reduce overall bycatch	Bycatch of yelloweye and canary rockfish may increase
Trawlers may be able to access full allocation	May impair processors' ability to supply their markets and keep staff employed
Will allow trawl permit holders to access the trawl RCA	May add complexity, difficulty, and expense to the observer program
	Would require a major education program
	May not be politically feasible

Table 7: Summary of the pros and cons of gear conversion as opined by managers

Of the federal and state fisheries managers with whom I spoke, all were aware of the gear conversion. Only one supported the idea outright and most others abstained from

offering an opinion on the overall merit of gear conversion. The managers believed that gear conversion would decrease overall bycatch. They also thought it would increase business options for trawlers by allowing them to increase the places they can fish and their ability to catch their full allocation.

However, each also voiced specific concerns about the concept. Several managers mentioned that switching to longline gear could result in increased bycatch of yelloweye and canary rockfish, two overfished species that have often constrained shelf rockfish catches in recent years. The trawl RCA and gear restrictions currently protect these fish from trawls, but the populations still remain vulnerable to longlines, which can access their rocky habitat. An increased use of longlines may put the recovery of these species in jeopardy unless appropriate steps are taken to minimize this bycatch.

One manager, expressed concern that a decrease in trawl-caught fish may impair processors' ability to supply their markets and keep their staff employed. I addressed this concern in the previous "Processors" section. Several managers mentioned that depending on the final format of the gear conversion program, the observer requirements could result in a more complex, more costly, and more difficult-to-implement observer system. I will discuss this concern further in the "Management Scenarios and Incentives" section below. A successful gear conversion program will likely also need an education effort to inform the industry about the new program and assist the learning curve for the new gear. This may require a significant investment of resources. Notably, one manager mentioned that because of the diverse stakeholders and the political power of some of these interests, especially processors, gear switching may not be politically feasible at this time. None of the stakeholder groups, including processors that I interviewed, were uniformly or vehemently against gear conversion. In fact, all of them saw some benefit in it. I believe that all stakeholder groups are open to discussing and negotiating the issue of gear conversion.

Management Scenarios and Incentives

In the following section, I will outline several potential management scenarios for gear conversion. I created these management scenarios based on some of the ideal gear conversion scenarios offered by the interviewees. I then presented these scenarios to other interviewees, especially managers, for their responses. The scenarios detailed below are not an attempt to prescribe potential gear conversion regulations. Rather, it is an attempt to divide the range of gear conversion possibilities into clearly delineated and analyzable categories, which can yield insight into the fuller range of possibilities. I will also discuss incentives that might be helpful to encourage participation in gear conversion. One conclusion emerges clearly from this analysis: the Council and NMFS must define the terms of a gear conversion program in order to achieve desired results.

Permanent Uni-directional Gear Conversion

In this management scenario, trawlers would be offered an opportunity to make a one-time irreversible conversion to either pot or longline gear. In terms of reducing bycatch and habitat impacts, this would likely be the most beneficial scenario, because it would permanently reduce the number of limited-entry trawl permits and likely reduce trawl effort. Notably, it is possible (but unlikely) that under this and all other listed

scenarios total fishing effort could increase, for example, if permitted trawlers who are currently inactive decide to switch gears and become active fixed gear fishermen/women.

The permanent uni-directional scenario would be the easiest for the present management and observer system to orchestrate and monitor. It should not require significant additional resources. However, like all the scenarios it could and likely would cause some instability in how the fishery operates. For instance, trawlers who switch gears may relocate to areas that are more conducive to fixed-gear fishing. Initially, it may be difficult for the observer program to predict where fishing effort will be focused and as a result may have logistical issues in placing observers. It may take several years for the instability in fishing operations to even out into a predictable pattern. These logistical issues could be minimized by setting a deadline for trawlers to take advantage of gear conversion, so that trawlers cannot switch during the middle of a fishing season and/or the opportunity to convert to another gear does not remain available indefinitely.

The permanent uni-directional scenario may not be as appealing as other gear conversion options for fishermen/women because it would not substantially increase their fishing flexibility. A permanent uni-directional switch would offer trawlers an additional option of how to fish, but once committed to converting; their flexibility in day-to-day fishing decisions would be reduced. Specifically, based on current market demands, trawlers can attempt to target the most desirable of a range of fish species, while pot fishers can only effectively target sablefish. Because of this lack of flexibility a permanent uni-directional gear conversion may be attractive primarily to trawlers who are severely restricted under the present management system. Such individuals may include small boat trawlers who cannot travel to distant fishing grounds and whose closer fishing areas are restricted by conservation areas or not producing highly marketable fish.

Long-term Uni-directional Gear Conversion

This scenario would offer trawlers the opportunity to convert to pot or longline gear for a multi-year term. This scenario would offer many of the same benefits and raise similar issues as a permanent gear conversion scenario. It should reduce bycatch and habitat impacts by reducing trawl effort. It also may be a more attractive scenario to trawlers because it is not a permanent commitment. Thus, trawlers can make business decisions that are responsive to management and market changes. For example, the current high price for sablefish is driven by the demand for it in Asia; if tastes change or for some other reason the price of sablefish falls, fishermen/women will be able to change their fishing practices on a commensurate time-scale.

The management and observer issues presented by the long-term scenario are much the same as with the permanent gear conversion scenario. However, the repeated opportunity to convert to another gear could result in recurring disturbances in the fishing patterns of the industry, causing logistical problems for the observer program. A two-year commitment term to a gear type would probably be most compatible with the existing two-year management cycle. But a two-year term might create considerable flux in the groundfish fishery and thus be too unpredictable to allow an adequate sampling design. A longer term, such as 5 years, would potentially allow the fishing patterns to stabilize for a few years and thus permit adequate monitoring by the observer program. Sampling design could be less problematic to the extent gear switching occurs as part of an ITQ program with 100% observer coverage.

Pre-declared Bi-directional Gear Switching

In this scenario, trawlers would have the opportunity to switch between trawl and fixed-gear within the same fishing season. Before the beginning of the fishing season, trawlers would be required to declare the portion of their sablefish allocation that they intend to catch with fixed-gear. Thus, this scenario assumes that an IQ program is in place. The pre-declared bi-directional scenario should offer reductions in habitat impact and potentially reductions in bycatch as well. However, bi-directional gear switching is a scenario that caused some interviewees to raise concerns about the potential of increasing discards over the status quo. As previously stated, I believe these concerns are not reflective of an inherent flaw in bi-directional gear switching but rather are rooted in concerns about the potential adequacy of monitoring and enforcement measures.

The current observer and data reporting programs are unlikely to be able to handle this type of management scenario. Both personnel and timely data reporting are lacking. Currently, fishermen/women are required to give the observer program 24 hours of notice before leaving on a fishing trip. A representative of the observer program estimated that under this scenario the observer program would need at least four or five days notice, because gear switching would introduce another degree of complexity that must be considered in observer placement and sampling design. For example, a rise in sablefish prices may trigger trawlers to convert to fixed-gear and relocate from trawling grounds to fixed-gear fishing grounds. Without adequate notice the trawling areas would be overstaffed with observers and the fixed-gear fishing grounds understaffed. This complexity would also place limitations on the fishermen/women, because they would have to abide by their declaration of when and where they intended to fish.

The representative of the observer program with whom I spoke anticipated that under this scenario the number of reporting phone calls from fishermen/women to the observer program would increase to such a level that an additional staff person would be needed to respond to them. Also the current catch reporting procedures are too slow to provide up-to-date information on the industry's fishing activities, thus further limiting the observer program's ability to monitor the total catch. These issues will have to be resolved before an IQ program can be implemented. Given these difficulties and uncertainties, the observer program representative with whom I spoke suggested that 100% observer coverage would be the only option that could guarantee adequate coverage and confirm that fishermen/women are using the declared gear.

Unconstrained gear switching

In this scenario, trawlers would have the opportunity to switch between trawl and fixed-gear within the same fishing season without needing to declare when they planned to switch or how much fish they planned to catch with each gear. Like the pre-declared bi-directional scenario, this scenario assumes that an IQ program is in place. The pros and cons are also similar to the pre-declared bi-directional scenario, but would be more extreme. There would be even more uncertainties to hamper the development of an adequate sample design for an observer program. Also without a declaration process, it will be difficult for enforcement to insure compliance with various RCAs, because fixed-gear and trawl vessels are subject to different RCAs. Thus, in the absence of a method by

which to determine what level of monitoring coverage would be effective in such a dynamic system, 100% observer coverage would be the only option that could guarantee adequacy and provide sufficient information for managing the fishery.

Incentives

Incentives are likely to be an important means of stimulating gear conversion and achieving its full potential to reduce bycatch and habitat impacts. Several interviewees proposed incentives for encouraging gear conversion. One is an increase in sablefish catch for trawlers who convert to fixed gear, commensurate with the lower level of that gear's discards. Under the current system, managers set the actual catch limit for each gear sector taking anticipated discards and discard mortality for that sector into account. In effect, they set trip limits by taking a percentage off the top of the quota. Because trawls have more discards than fixed gear, a greater percentage is taken from the top. To create an incentive for conversion, managers could increase the trip limit of a trawler who converts, to reflect the lesser discard and discard mortality rates of fixed gear. Under an IQ program, if trawlers fish their quota with fixed gear, more of that quota is likely to be landed catch and less will be discarded, due to the lower bycatch rates of fixed gear. The catch increase would provide an incentive to fish a trawl allocation with fixed gear, because in doing so trawlers would increase their sablefish catch without increasing total sablefish mortality or affecting someone else's quota. This idea was well received by the fishery managers with whom I spoke. However, one individual pointed out that this incentive program would help decrease bycatch, but did not guarantee a reduction in habitat impacts, thus he proposed an additional incentive program.

This manager reasoned that a reduction in the amount of trawling would not necessarily have a functional reduction in habitat impacts if the remaining trawling occurred over the same geographic area. For example, if a particular area is trawled over 5 times a week rather than 8 times a week, it may not be any healthier. To insure a habitat benefit, he proposed that the trawl RCA increase in conjunction with the decrease in the number of trawlers. The decreasing area available for trawling would also serve as a further incentive for more trawlers to switch to fixed gear. Other managers found this idea interesting, but believed that it or any other major regulatory change would have to be phased in 4 or 5 years after the gear conversion program had begun. They emphasized that it is important to be able to monitor and evaluate each component separately, so they should not be enacted all at once. An alternative version of this idea is to designate areas that are open to non-trawl gear but closed to trawl gear.

Another suggestion was an incentive system that rewards low-impact performance over time, not just the conversion to fixed gear. For example, a portion of the "adaptive management trust" quota could be used to reward those who consistently meet a defined standard of minimal bycatch and/or habitat impact over a year or two, based on observer data. A system like this could encourage trawlers who switch gears to learn the best practices for deploying their new gear, and help address concerns that the ability to minimize habitat impacts from pots, for example, depends on the skill and care of the pot fisher.

Some trawlers may be reluctant to make a long-term commitment to fixed gear due to uncertainties about the economics or other factors. A trial period of one or two years during which a trawler could change his mind could help lower the barriers to gear

conversion in any of the longer-term scenarios above. Finally, another possible incentive is low-interest loans to help trawlers who wish to convert purchase fixed gear.

CONCLUSION

Bycatch

This report presents evidence that the inherent bycatch rates of trawls are substantially greater than that of longlines and pots for most groundfish species. Bycatch rates of pots and longlines are quite similar, but there is a consistent trend for the bycatch rates of pots to be the lowest of the three gear types. The most important difference between the bycatch rates of pots and longlines is that longlines have a small bycatch of yelloweye and canary rockfish while pots have none. Given the low population levels of these species, any bycatch, even small levels, is of concern and should be considered in evaluating options for gear conversion. Also, in considering gear switching to longlines, the lack of synthesized data on shark and seabird bycatch in the longline sablefish fishery introduces uncertainty that must be accounted for.

Expert opinion and presented data support that the one species for which pots have a substantially greater bycatch than longline is lingcod. Fishery managers conjecture that this greater bycatch results from a rounder body shape or behavioral characteristics of the fish. If pots are truly more susceptible to rounder-bodied fish, this should also be a consideration in gear conversion. While lingcod are presently considered recovered, they only gained this status in 2005. In addition, there may be other rounder-bodied fish populations that are currently healthy, but could succumb to added fishing pressure if more people switched to pots.

Habitat Impacts

The Shifting Gears study shows that trawls have a substantially greater impact on habitat than do longlines and pots. The study ranked longlines and pots closely, but finds slightly more severe impacts for pots. With the adjustments I made to tailor the pot impact profile to the sablefish fishery, the difference is even greater, with pots having more severe habitat impacts than longlines. The work of Dr. Rose on modified trawl sweeps could potentially reduce the habitat impacts of trawls, but the impact would remain substantially higher than fixed gear. Future research should explore the feasibility of using this gear in the west coast groundfish trawl fishery. An additional useful future study would be a GIS analysis of the types of seafloor habitat in the sablefish fishing area and the concentration of each gear type in each habitat. The study should examine the past and present gear distribution, as well as attempt to forecast the gear distribution under different gear conversion scenarios.

Most Preferable Gear

My research suggests that with appropriate management, conversion to longlines or pots could result in reduced bycatch and habitat damage relative to trawl gear. However, the potential ecological risks and the uncertainties about regulatory capacity to

handle them are lower with pots than with longlines. In taking a precautionary approach to yelloweye and canary rockfish bycatch, pots would be the best gear to switch to, especially given trawlers overwhelming preference for pots. On the other hand, while pots have less bycatch than longlines, their habitat impacts are less easily managed. Also, pots may have lasting habitat impacts, but the significance of any such impacts is unknown, and reducing it could require innovation. Furthermore, habitat impact of this gear varies with the skill of the user. If trawlers were to switch to pots, many would likely lack this skill. With only 28 active licensed pot fishers, with varying skill levels, there is only a small pool of expert pot fishers to instruct new pot fishers in how best to use the gear. Also, there is little incentive for experts to teach and for novices to learn as long as reducing habitat impacts does not affect their profit margins. At a minimum, training may need to be required for first time pot fishermen, and escape rings should be mandatory.

Longlines have greater bycatch of some overfished species than pots, but this is directly related to the accessibility of rocky habitat to longlines. Time/area closures with associated gear restrictions have proven to be effective measures to reduce trawling in rocky habitat. Similar measures may be effective for longlines, for example, reconfiguring the non-trawl RCA or closing hot spots for vulnerable species. Also, restricting or prohibiting the use of line-strippers may help further reduce mortality of bycatch, including species of concern such as sharks.

The assessment of this study is that longlines and pots have substantially lower bycatch and habitat impacts than trawls. This is true for most overfished species and for sablefish themselves. Minimizing bycatch mortality of sablefish in addition to that of overfished species is important both because bycatch minimization is required by the Magnuson-Stevens Fishery Conservation and Management Act and because the sablefish population is in the precautionary zone, with a predicted downward trajectory in future years under current conditions in the fishery. The costs of continuing the current distribution of gears, in terms of bycatch and habitat alteration, are high.

Based on the available information, I recommend adoption of policies that allow and encourage trawlers to switch to longlines or pots. In weighing the above uncertainties and concerns—on the basis of bycatch alone—pots may be the preferred conversion target because of the lack of yelloweye and canary rockfish bycatch. Further analysis is warranted—of the tradeoffs, of potential bycatch and habitat impact mitigation measures, and of the adoption of a flexible gear conversion system that could allow fishermen/ women to switch to longlines or other hook and line gears if more information supports such changes or if the nature of bycatch problems or other factors change.

Pros and Cons of Gear Conversion

Perceived pros and cons of gear conversion varied widely, both within and between stakeholder groups. However, several motifs repeatedly emerged from interviews. As positive effects of gear conversion, many people mentioned that it would allow for better management of the fish populations by reducing bycatch. Also, they mentioned that gear conversion would allow more business options and flexibility for trawlers. In addition, sablefish caught with fixed gear would reap a higher selling price, and thus likely to be financially workable for trawlers who switch gears. As for potential negative impacts of gear conversion, a repeated message was that with fewer trawlers less

flatfish would be caught. The sale and processing of flatfish is currently a substantial component of the groundfish trawl industry. Presently, flatfish can only be effectively caught in trawls, so if some number of trawlers remains active, communities dependent on such operations are more likely to remain viable.

Most Preferable Management Scenario

The findings of this study suggest that the most preferable management scenario would be long-term uni-directional gear conversion. This scenario could be effectively overseen by the current management and observer program infrastructure. An IQ program would not be necessary to implement this scenario, though it could prove to be helpful. This scenario is likely to have a real benefit in reducing bycatch, because trawlers will have to commit to using fixed-gear for several years. Because of the long-term commitment, some trawlers, especially those with high-volume operations, will chose not to switch gears. Their continued landings should allow the processors and other shoreside infrastructure to operate healthily. Future studies should explore in more depth the benefits and impacts of gear conversion scenarios.

Incentives are likely to play an important role in encouraging gear conversion. One promising incentive is to provide trawlers who convert to a cleaner gear with a higher trip limit of sablefish, reflective of the lower bycatch rates of fixed gear (in an IQ program, a larger portion of an individual's quota would likely be landed if caught with fixed gear). Another is to encourage good gear practices in an IQ program by using a portion of the "adaptive management trust" quota to reward those who consistently meet a defined standard of minimal bycatch and/or habitat impact over a period of time. Incentive ideas also include a trial period of a year or two during which trawlers could change their mind before making a long-term conversion, low-interest loans to help purchase new gear, and designating areas that are open to non-trawl gear but closed to trawl gear as the number of trawlers declines. Future studies should examine whether and how incentives should be implemented.

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APPENDIX ONE: SAMPLE POPULATION DEMOGRAPHICS

The categories and numbers below summarize the composition of the sample population. Some categories may sum to more than the total number of 44 people interviewed. In these cases an individual may represent more than one affiliation or was interviewed more than once using different methods. Some sub-categories may not sum to the total of the mother category, because some people who were interviewed were affiliated with the category but not participants themselves.

By State:

- California – 11
- Oregon – 15
- Washington – 18

By Affiliation:

- Environmental NGO – 3
- Trawl – 10 (limited entry – 9, open access – 0)
- Pot – 6 (limited entry – 4, open access – 1)
- Hook & Line – 8 (limited entry – 5, open access – 1)
- Manager/ Government Scientist – 9 (state – 3, federal – 6)
- Processor – 5 (large – 3, small – 1)
- Gear Supplier – 4
- Other – 1 (harbor master)

By Interview Format:

- Face to Face – 29
- Phone – 19
- E-mail – 4

By Interview Type:

- Unstructured – 11
- Semi-structured – 39

APPENDIX TWO: GEAR SWITCHING INTERVIEW QUESTIONS

The survey instrument below was used as a guide not a script for interviews. I changed the phrasing, order, and suite of questions asked to suit the knowledge and comfort level of the interviewee. I directed the follow-up questions to a sub-set of the original sample population in order to elucidate concepts that emerged from the first round of interviews. The interviewees were not shown this document.

General:

1. What do you think that "gear switching" means as a concept?
2. Ideally, what would the best gear switching scenario look like?
3. Is gear switching better suited for some types of target fish, not others?
4. What do you see as the pros and cons of gear switching?
5. Can you think of ways to mitigate the cons?
6. Given this ideal situation are you generally for or against gear switching?
7. Are there gear types—other than longlines and pots—that would be a good target for gear switching?
    a. If so, describe this gear.
    b. Do you know anyone who has or fishes with this gear? If so, who?
8. Ideally, what would be the best design for an IQ program?
9. What do you see as the pros and cons of an IQ program?
10. Can you think of ways to mitigate the cons?
11. Given this ideal design are you generally for or against an IQ program?
12. Are you aware of bycatch reduction devices, either ideas or prototypes that would help reduce the bycatch of trawls, longlines, or pots?
    a. If so, how does this device work?
    b. Who is making and/or using this device?
13. Are you aware of any technologies, techniques or practices that could help reduce the impact of trawls, pots, or longlines on sea floor habitats?
    a. If so, how does this device or practice work?
    b. Who is making and/or using this device?

All Fishermen/women:

1. Tell me about your fishing operation.
    a. Describe your boat and gear?
    b. Do you have a mortgage on your boat (good question, but if people are uncomfortable answering financial questions, drop it)?
    c. How many crew members do you employ?
        i. How long have they worked for you?
        ii. Are they relatives or close friends?
    d. When, where, and for what species do you fish?
    e. What fishing permits and endorsements do you hold?
    f. Where do you sell your fish?
    g. Is your operation profitable?

    h. Do you want to remain in fishing for the foreseeable future? Using your present gear type?
    i. Do you believe that your vessel and operation is representative of other vessels using the same gear? If not, how do they differ?
2. Have you ever fished with longlines or pots? If so, how would you rate your skill level with this gear?
3. If you were to switch gears would you rather switch to pots, longlines, or another type of gear? Why?
4. What incentives would convince you to switch gears?
5. What resources would you need to ease your transition to a new gear type?
6. What would be reasons why you would not switch gears?
    a. What could be done to mitigate these obstacles?
7. If you were to switch gears how would it affect your fishing operation?
    a. Would it reduce your crew size?
    b. Would it change when, where, and for what species you fish?
    c. Would it change where you sell your fish?
    d. How would it affect your profit?
    e. Would you be able to meet all of your overhead costs? Mortgage? Insurance? Boat maintenance?
    f. Would the cost of conversion be an inhibiting factor?
8. Do you believe that your opinions are representative of other fishermen/women using the same gear type? If not, how do they differ?

Follow-up interview questions:

1. *How many pounds of fish do you catch on average in each tow/set?*
2. *Would increased access into the RCA convince you to switch?*
3. *Do you believe that gear switching may result in increased discards? If so, why?*

<u>Longliners and Pot fishers:</u>

1. How do you feel about trawlers switching gear and joining the fixed gear fishery?
    a. Do you believe that there is enough room (geographically, fish allocation, and market) for trawlers to switch gear?
2. Would you be willing to help newly converted fishermen/women learn how to use the fixed gear properly?
    a. Would you be willing to work with state government, federal, government, Sea Grant, and/or non-profits to do so? If so, which?
3. What would be the most effective way to transition trawlers into the fixed gear fishery?
4. What measures do you believe should be in place to ease the impact of the transition on your business? Would geographic or depth limits on new entrants help?

Follow-up Interview Questions:

1. *Would increased sablefish allocation to you help ease the impact of new entrants into the fishery?*

2. *Would the opportunity to process fish on-board your vessel help ease the impact of new entrants into the fishery?*

Processors:

1. Tell me about your business.
    a. How many people do you employ?
    b. How many of these are seasonal workers?
    c. What are the sources of your fish?
        i. What portion of it comes from trawls, longlines, pots, or imports?
        ii. How many of each type of vessel routinely sells to you?
    d. What products do you produce?
    e. How much does each product contribute to your revenues (general estimate)?
    f. What are the markets for your product?
    g. Do you believe that your business is representative of other processors? If not, how does it differ?
2. How would gear switching in the sablefish fishery affect your business?
    a. What species of fish would you likely receive less of? How much less, if 30% (or even 50%) of sablefish trawls converted to fixed gear?
    b. What species of fish would you likely receive more of? How much more, if (30% of sablefish) trawls converted to fixed gear?
    c. Would there be a change in the quality of fish? If so, how would this affect your revenue?
    d. Would this affect you ability to retain workers?
3. Are there measures that could mitigate negative effects of gear switching?
    a. Increased imports?
    b. A minimum number of trawlers?
    c. Specialty markets?

Gear Suppliers:

1. Tell me about your business.
    a. What types of services do you provide?
    b. How many and what types of vessels do you routinely supply?
    c. Do you believe that your business is representative of other gear suppliers? If not, how does it differ?
2. Do you assist in seasonal conversion of vessels, switching between fisheries? If so, describe this work.
3. In your opinion what percentage of the fleet does their own seasonal conversion and what percentage uses the services or a gear supplier or shipyard?
4. If whole sale gear switching were to occur, what would be the implications for your business?
    a. Would there be enough pots and/or longlining gear readily available? If not, what would need to be done in order to anticipate and meet the need?

b. Would there be enough skill manpower to assist fishermen/women in the conversion? If not, what would need to be done in order to anticipate and meet the need?

Managers:

1. How is the sablefish fishery currently managed in your state?
2. How many trawlers, longliners, and pot fishers operate out of your state?
3. How much sablefish does each group land respectively?
4. How would the management of the sablefish fishery change under a gear switching scenario?
5. What types of incentives would encourage gear switching?
6. What types of programs do you anticipate needing to ease the transition?
    a. Apparently in pot fishing the ability to minimize damage to the sea bottom by picking up rather than dragging the pots is a learned skill. How will you work to impart this knowledge to newly converted pot fishers?

Follow-up Interview Questions:

1. *Would increasing the sablefish allocation by the difference in discard allowances between trawls and fixed gear be a good incentive to switch gear? Why or why not?*
2. *Would giving a portion of the discard allowance to established fixed gear fishermen/women as compensation for what they might lose from additional competition be a good idea? Why or why not?*
3. *Would the opportunity to process fish on-board their vessels be a good compensation for established fixed gear fishermen/women to offset the costs of additional competition?*
4. *Would increasing the RCA for trawls, but allowing access by fixed gear be a good incentive to switch gears? Why or why not?*
5. *How much personnel, time, and financial resources would be needed to support the infrastructure (observers, enforcement, management) of a gear switching program?*

Ice houses, Fuel stations, other portside infrastructure:

1. Tell me about your business.
    a. What types of services do you provide?
    b. How many and what types of vessels do you routinely supply?
    c. Do you believe that your business is representative of other businesses in your industry? If not, how does it differ?
2. If whole sale gear switching were to occur, what would be the implications for your business?
    a. What would be the positive effects?
    b. What would be the negative effects? How could these be mitigated?

APPENDIX THREE:
GEAR MODIFICATIONS TO REDUCE BYCATCH AND HABITAT IMPACTS

Trawl Groundgear Modification:

The most promising technology was the modification of trawl groundgear used by Bering Sea flatfish trawlers (Rose 2007). In this fishery long "sweeps" connect the net to the trawl doors and are responsible for herding fish into the net (Fig. 25). These sweeps, which can be up to 1500 feet long, account for 90% of the trawl bottom contact. Dr. Rose found that by clustering rubber disks together at 30 foot intervals along the sweeps they could be lifted 3 inches off the seafloor, thus reducing bottom contact by 90% as compared to conventional trawls (Fig. 26).

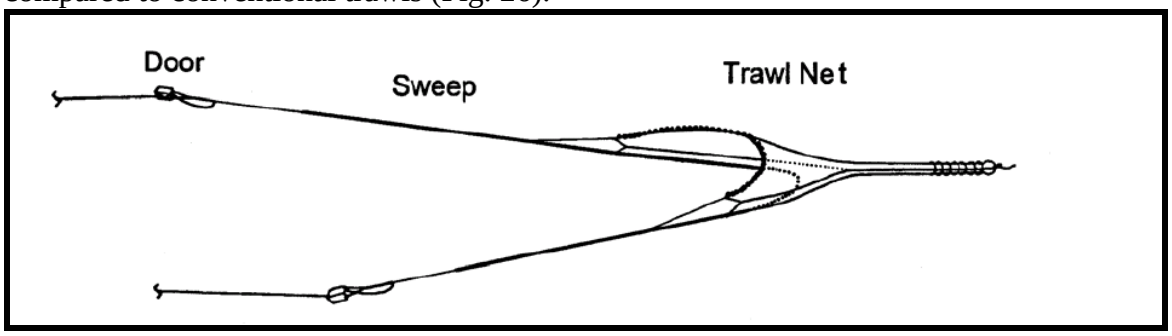

Figure 25: Relative Position of doors, sweeps, and trawl net in an otter trawl system from (from Rose 2007).

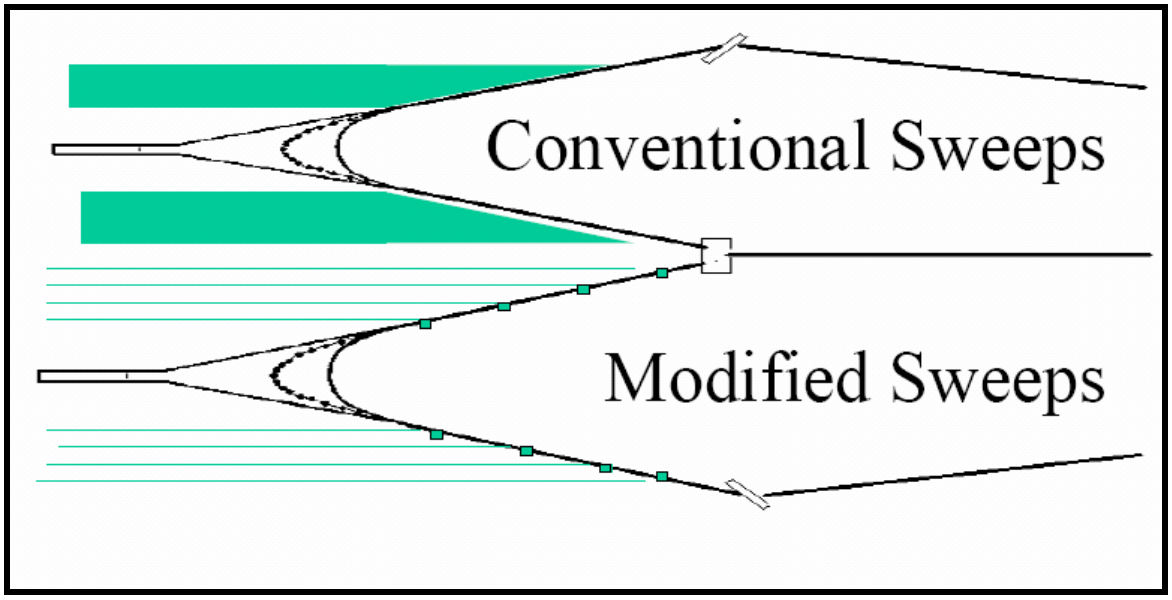

Figure 26: Schematic showing the concept of reducing bottom contact area of sweeps by limiting contact to disk clusters (from Rose 2007)

On soft bottoms, such as sand and mud, this gear significantly reduced the impacts on sessile invertebrates, such as anemones, ascidians, sponge, and basketstars (Fig. 27). These are all low-profile organisms, but flexible organisms, such as sea whips benefited as well (Fig. 28). Although organisms living under the surface of the seafloor

were not considered in this study, Dr. Rose conjectured that impacts to these organisms may be reduced by as much as 100%.

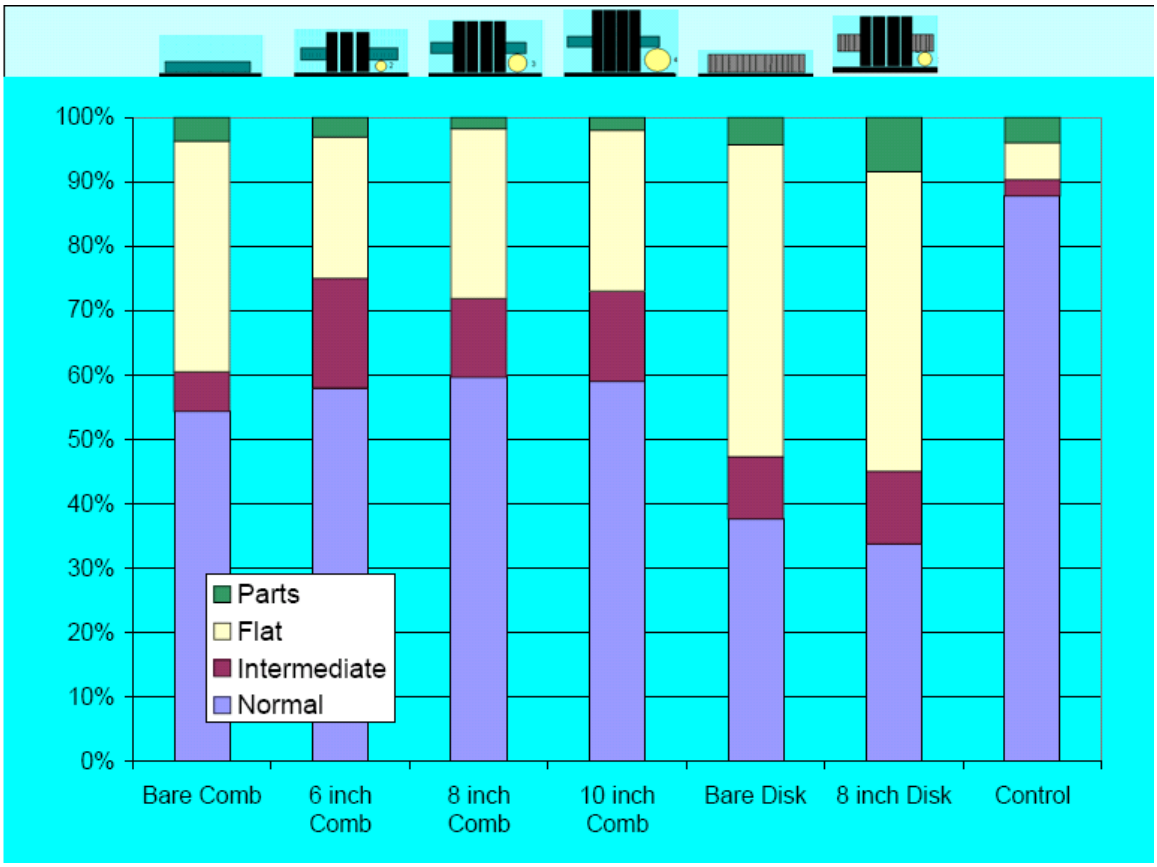

Figure 27: Percent of basketstars in different condition categories after exposure to trawl sweep modifications (from Rose 2007).

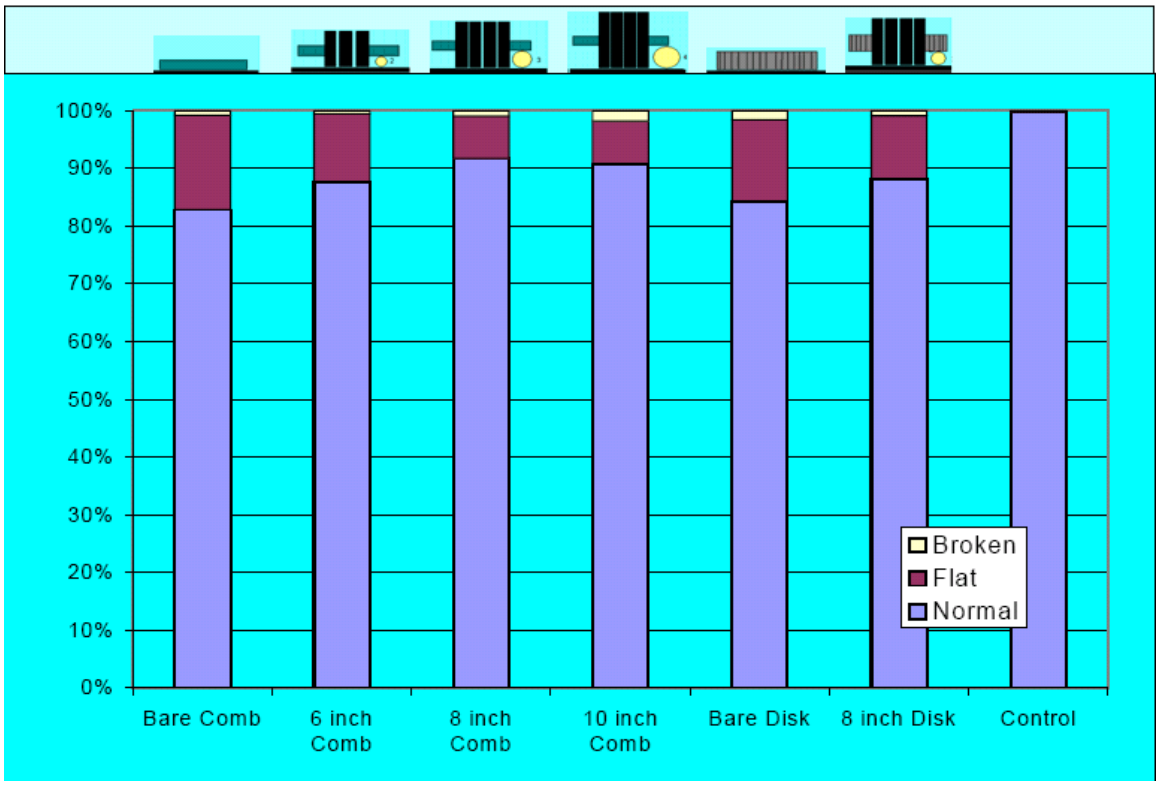

Figure 28: Percent of sea whips in different condition categories after exposure to trawl sweep modifications (from Rose 2007).

The best configuration of this gear involves clusters of 8-inch diameter disks on combination rope (i.e., interwoven cable of steel and fiber). This configuration had no significant change in catch rates for flathead sole, yellowfin sole, rock sole, and arrowtooth flounder in comparison to conventional trawls (Fig. 29) There was also some data suggesting the same may hold true for rex sole and Dover sole, which are species that are also targeted by the west coast groundfish fishery (Rose 2005). The 8-inch disk configuration also had slight increases in the catch rates of roundfish, such as Pacific cod and pollock, in comparison to conventional trawls. In addition, this gear substantially reduced the sediment cloud produced by the trawl, indicating that the cloud may not be necessary to herd fish into the net.

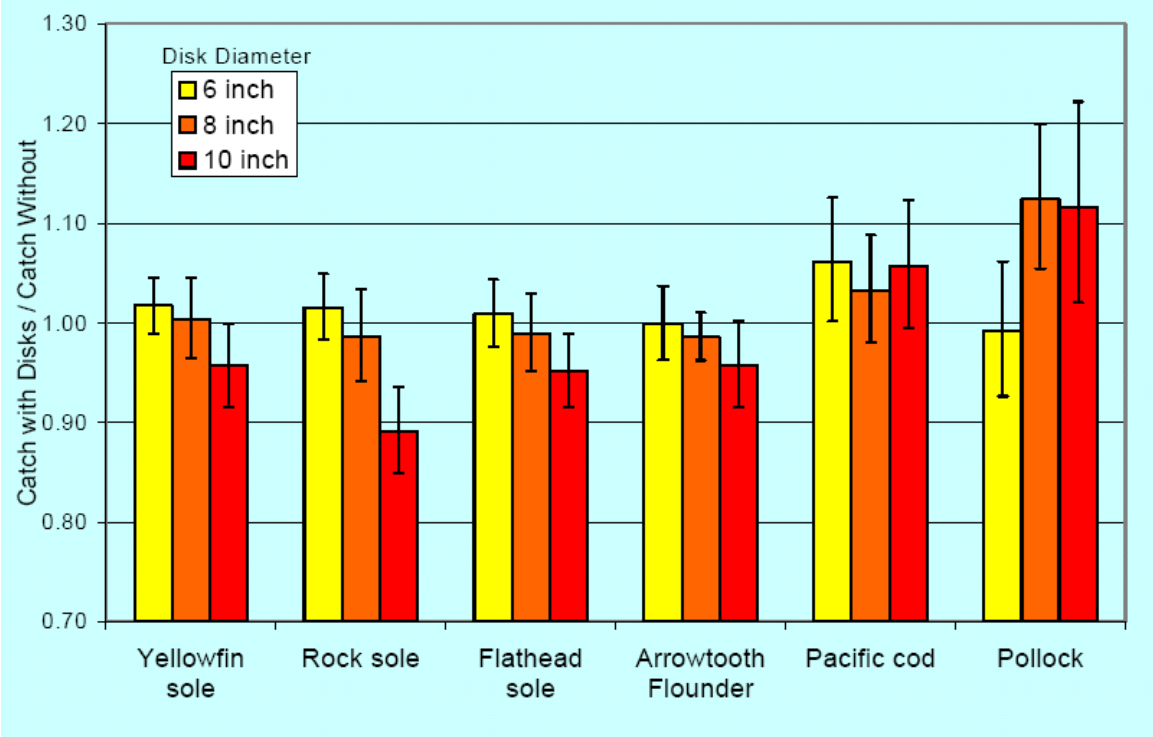

Figure 29: Proportional change in catch rates when trawl sweeps had disk clusters (6, 8 and 10 inch diameters) installed at 30 foot intervals (from Rose 2007)

Dr. Rose is continuing to explore improvements to the groundgear modification. Preliminary tests have shown that the spacing between disk clusters can be increased to 45 feet without causing the sweeps to sag. It may be possible to increase the intervals to 60 feet or even 90 feet, thus further decreasing bottom contact.

Several issues still need to be addressed for the gear to be commercially viable. Most importantly, a means must be found to attach the disks to the net so that they can withstand the rigors of commercial fishing. Also the modified gear works best with boats that are rigged to haul the net onboard using the net reel. The towing blocks that are used on other boats damage the disk clusters. The gear has not been studied at deep depths, where light conditions are low, but day/night studies showed no difference in fish catch. Also the gear has not been studied on extremely soft bottoms. Even with the issues that still need to be addressed, the Alaska Fisheries Management Council is seriously considering the groundgear modification for use by the Bering Sea flatfish fishery.

Dr. Rose tentatively reasoned that the gear may be of value to the west coast groundfish fishery. Because the sweeps are smaller in this fishery, Dr. Rose guessed off-the-cuff that bottom contact may only be decreased by 60%. Also this gear was designed only for used in soft bottom areas, so it could not be used in the rocky areas of the fishery. The groundgear modification should be compatible with any trawl net configuration including the selective flatfish trawl currently being used by a portion of the west coast groundfish fishery.

Halibut Bycatch Reduction Device:

Dr. Rose is also working on a halibut bycatch reduction device for use in the Alaskan cod fishery. Because halibut and cod are well matched in swimming speed and strength, this device takes advantage of the differences in morphology. Halibut are flatfish and cod are round-bodied fish with large heads. The device consists of placing horizontal halibut sized slots in the trawl net. Halibut are able to escape though these slots, but Alaskan cod physically cannot, because of their large heads. This basic principle would hold true for excluding halibut from trawls targeting sablefish. However, because the heads of sablefish are smaller than those of Alaskan cod, additional and likely substantial research would be needed to modify this device for use in the sablefish fishery.

Salmon Bycatch Reduction Device:

Dr. Rose is also developing a device to reduce salmon bycatch in the pollock fishery. This device operates on behavioral differences between the two species. Salmon are stronger swimmers and have a tendency to swim into currents. The device consists of a funnel that directs both cod and pollock toward the codend of the net. Surrounding the funnel are square-meshed escape holes, through which the strong swimming salmon can exit. To increase Pollock retention Dr. Rose has developed a mesh-flap that covers the escape holes until the trawl slows down to a low speed. For this device to work optimally, trawlers would voluntarily have to periodically slow down while trawling. A major problem that needs to be solved with this device is the tendency for the trawl net to tear at the junction of the diamond-mesh of the net's main body and the square-mesh of the escape holes. The development of this device is worth monitoring; however its usefulness for the sablefish fishery can only be gauged after conducting behavioral studies of sablefish and other target species in the west coast groundfish fishery. Also, the adaptation of this device to the west coast groundfish fishery would likely require extensive gear development and testing.

Pot Modification:

Dr. Rose and Keith Matteson of the Oregon Department of Fish and Wildlife conducted a behavioral study of sablefish approaching baited pots (Rose, Stoner et al. 2005). The study showed pots are extremely inefficient at capturing sablefish. When two pots were left to soak for six hours there were more than 2000 and 5000 approaches of a sablefish in the area of the pots with only 9 and 10 captures, respectively. A single fish likely approached the pot multiple times, highlighting the difficulty of sablefish entering the pot once attracted. This evidence of inefficiency could be a motivating force for the fishing industry and other parties to invest in further developing sablefish pots. Three of the fishermen I interviewed recounted unsuccessful attempts to modify pots to make them more efficient or more able to capture other species, such as flatfish. Each of these interviewees believed that such a design was possible. If a flatfish pot were developed, it would offer an alternative to trawling as a means of capturing commercially important flatfish.