Reducing the Bycatch of Overfished and Rebuilding Rockfish Species in the U.S. Pacific Hake Fishery

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Abstract

This study examined a flexible sorting grid excluder designed to reduce rockfish (*Sebastes* spp.) bycatch in the U.S. Pacific hake (*Merluccius productus*) fishery. Tests occurred off Oregon during 2013 aboard a commercial trawler. A recapture net was used to quantify the retention of Pacific hake and rockfish bycatch. During this study, widow rockfish (*S. entomelas*) was the primary rockfish species caught. Their bycatch was reduced 26.2% by weight. The retention of Pacific hake was 92.7% by weight. Widow rockfish caught in the recapture net were statistically larger than widow rockfish retained in the trawl. Mean lengths of Pacific hake caught between the trawl and recapture net did not differ significantly. Estimated single haul catches of Pacific hake ranged from 40 to 100 mt. Catches producing over 90 mt of Pacific hake in haul durations less than 2.5 hours were made. However, under heavier fish volumes (over 90 mt of Pacific hake caught in less than 45 minutes of towing) the excluder tended to clog. While further refinement of the excluder is needed for the gear to function under heavy volumes of fish, this project has developed a bycatch reduction device that can assist Pacific hake fishermen in reducing rockfish bycatch when fishing conditions are moderate to high.

Introduction

The Pacific hake (*Merluccius productus*) fishery represents the largest groundfish fishery by volume off the U.S. west coast with landings exceeding 267,000 mt in some years (NMFS-NWR 2008, PacFIN 2011). Pacific hake are caught using midwater trawls fished from catcher boats delivering to shore-based processing plants and to at-sea mothership processors, and by large catcher-processor vessels. Spatially this fishery ranges from northern California to northern Washington and seaward to bottom depths exceeding 500 m. Although landed catches consist of mostly Pacific hake, bycatch is an issue affecting the fishery (PFMC and NMFS 2010, 2012).

In 2011, the U.S. Pacific hake fishery began management under a catch share program (PFMC and NMFS, 2010). This program establishes annual catch limits (ACLs) and individual fishing quotas (IFQs) along with individual bycatch quotas for prohibited species. For many Pacific hake fishermen participating in this program, bycatch of rockfishes (i.e. darkblotched rockfish [*S. crameri*], widow rockfish [*S. entomelas*], canary rockfish [*S. pinniger*]) is a major concern because limited quota is available due to low spawning stock biomass for these species relative to the more abundant and productive Pacific hake stock. Individual fishermen could reach their quota for one of these

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"lower-quota" species before reaching their catch share quota of Pacific hake, thereby ending their fishing season with allowable harvest still left in the ocean unless additional quota can be leased or purchased from another quota share/permit holder. Acquiring additional quota, however, can be costly and/or difficult to obtain given certain circumstances (i.e. species needing quota coverage, amount of extra quota needed, time of year). This scenario occurred in 2011, 2012, and 2013. Developing techniques that reduce rockfish bycatch while retaining a high proportion of the targeted species in the U.S. Pacific hake fishery are increasingly important.

The Pacific States Marine Fisheries Commission (PSMFC), NOAA Fisheries Northwest Fisheries Science Center-Marine Habitat and Ecology group, and fishing industry conducted a collaborative workshop to develop a rockfish excluder for testing in the Pacific hake fishery during 2012. After an exchange of information and considerable discussion, the group came to a consensus that a flexible sorting grid excluder showed merit for reducing rockfish bycatch. Implementing recommendations made at the workshop, a pilot study was conducted that examined two (design-A and B) flexible sorting grid rockfish excluders. Results were relatively successful with one design (design-B) retaining a relatively high proportion of Pacific hake (>93% by weight) while reducing rockfish bycatch by 70% (Lomeli and Wakefield, 2013). Design-B, however, was only effective under low to moderate fish volumes. Under moderate to high fish volumes this design tended to clog. Although design-B was ineffective under increased fish volumes, gear researchers and fishermen believed that the gear could be modified to improve its performance under higher catch levels and be effective at reducing rockfish bycatch while limiting Pacific hake loss.

Objective

The objective of this study was to build on recent findings and examine a flexible sorting grid excluder designed to reduce rockfish bycatch and evaluate its efficacy in the U.S. Pacific hake fishery.

Materials and Methods

The concept to the flexible sorting grid excluder tested is that fish smaller than the grid openings (i.e. Pacific hake) will pass through and move aft towards the codend, whereas fish larger than the grid openings (i.e. rockfishes) will be excluded. The excluder was constructed within a four-seam tube of netting that was 200 meshes deep (fore to aft) and 168 meshes in circumference, excluding meshes in each selvedge. The device was designed to be inserted between the intermediate section of the trawl and the packer/stuffing tube forward of the codend. The design utilizes two vertical panels (grids) of 7.62 x 8.89 cm (H x L) rectangular slot openings to crowd fish and direct large fish towards an upward-angled exit ramp. The vertical panels were built of 0.95 cm Spectra® line (running vertically) and 0.79 cm (7 x 19 strand core) galvanized steel cable (running horizontally) placed through 1.27 cm (inside diameter) AQUAPEX® tubing to create a semi-rigid grid. The exit ramp was constructed of

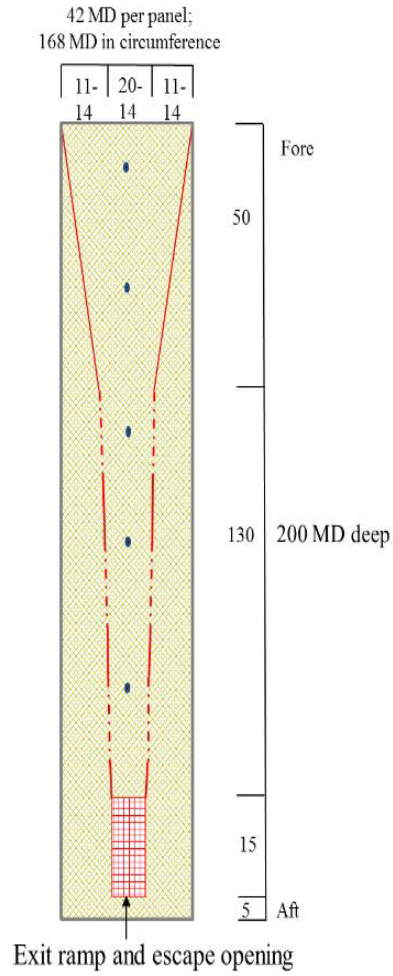

Figure 1. *Top view diagram depicting the flexible sorting grid excluder tested. Solid red lines represent the vertical sorting panels; red dashed-dot-dash lines represent the "flex panels; the red grids represent the exit ramp and escape opening; the blue oval shapes represent the ropes with chaffing gear wedged through them; MD = diamond mesh. Note: this diagram is not drawn to scale.*

Spectra® line placed through AQUAPEX® tubing. The vertical panels stand approximately 1.2 m in height and extend longitudinally down the tube of netting 175 meshes deep before connecting to the exit ramp. Over this distance the two panels gradually angle inward then straighten to create a narrow "hallway" that extends aft (Fig. 1). Within the "hallway" section of the excluder ropes with chaffing material wedged through them were installed to stimulate fish to interact with the vertical panels by creating a partial obstruction to fish moving aft. These ropes were positioned vertically (attached to the bottom and top panel of the tube of netting) and placed approximately every 15 meshes deep within the "hallway" section of the excluder. To reduce the potential of clogging under high fish volumes, three large rectangular sections 0.91 x 1.52 (H x L), referred to as "flex panels", along each vertical sorting panel were created that were designed to swing open (such as a door would) to allow fish to move directly aft towards the codend if clogging was occurring. Strands of shock cord were placed vertically over the outside of the rectangular sections to keep them closed under low to moderate fish volumes. These rectangular sections occurred every 1.52 m apart within the "hallway" section of the excluder. Escapement of Pacific hake and bycatch was quantified using a recapture net. The excluder and recapture net used in this study was manufactured by Foulweather Trawl, LLC.

Sea Trials:

Tests were conducted off Oregon between 44°152 and 45°082N and between 124°202 and 124°392W during August 2013 aboard the chartered *F/V Perseverance*; a 26.5 m long, 1,000 horsepower midwater trawler (Fig. 2). Tow speeds ranged from 3.0 to 3.4 knots. Headrope fishing depths occurred between 139 and 225 m. Tow durations ranged from 1.3 to 8.3 hrs (avg. = 3.9 hrs).

Autonomous, high-resolution, low-light, color video camera systems were used throughout the study to gather information on fish behavior and gear performance. However, several tows occurred without the use of cameras and artificial lights to observe gear performance under "normal" fishing conditions. After each tow, all fish caught in the recapture net were dumped on deck and identified to species, measured (nearest cm fork length), and weighed (kg) using a motion compensating platform scale. Fish retained in the codend were dumped into the vessel's fish holds then delivered to a shore-side processing plant where data on catch compositions, lengths, and weights were collected.

Percent retention by weight (trawl / (trawl + recapture net)) in kg was calculated for Pacific hake and widow rockfish. To determine if mean lengths differed significantly between fish caught in the recapture net and codend we used a Kolmogorov-Smirnov test.

Figure 2. F/V Perseverance *chartered for the research project. Photo courtesy* F/V Perseverance.

	Widow rockfish			Pacific hake		
	total weight (kg)			total weight (kg)		
Trip no.	codend	recapture net	% escapement	codend	recapture net	% retention
1	124	59	32.2	86,505	5,245	94.3
2	305	38	11.1	74,063	6,352	92.1
3	158	60	27.5	97,486	8,303	92.2
4	100	74	42.6	100,083	7,990	92.6
5	39	27	40.9	87,889	7,259	92.4
Total	727	258	26.2	446,026	35,149	92.7

Table 1. *Percent escapement for widow rockfish and percent retention for Pacific hake by total weight (kg).*

Results

During this work, widow rockfish was the primary rockfish species caught. At the trip level, percent escapement of widow rockfish ranged from 11.1% to 42.6% (Table 1). Overall, their bycatch was reduced by 26.2%. The retention of Pacific hake ranged from 92.1% to 94.3% at the trip level. Overall, the retention of Pacific hake was 92.7%. Estimated single haul catches of Pacific hake ranged from 40 to 100 mt. Catches producing over 90 mt of Pacific hake in haul durations less than 2.5 hours were made (Fig. 3). However, under heavier fish volumes (when over 90 mt of Pacific hake were being caught in less than 45 minutes of towing) the excluder tended to clog, resulting in the vessel having to haulback before completing its tow.

Widow rockfish caught in the recapture net were statistically larger than widow rockfish retained in the trawl ($P<0.01$, Table 2). Length frequency distributions of widow rockfish caught in the codend and recapture net are shown in Figure 4. This figure shows a higher frequency of larger-sized widow rockfish occurring in the recapture net. Widow rockfish larger than 40 cm in length accounted for 61.2% of the total proportion caught in the recapture net. In the trawl, 51.5% of the total proportion retained was larger than 40 cm. Mean lengths of Pacific hake caught between the recapture net and codend did not differ significantly ($P>0.05$). The mean length of Pacific hake encountered during this work was 40 cm, approximately a 328 gram fish (Table 2).

Segments of video footage obtained during this project can be viewed at the PSMFC Pacific Fisheries Bycatch Program website at: http://www.psmfc.org/bycatch/videos.html

Figure 3. *Crewman on the chartered* F/V Perseverance *preparing the recapture net (right) for bringing onboard the vessel after a successful tow. To the left is the vessels codend containing over 90 mt of Pacific hake (photo credit, Mark Lomeli, PSMFC).*

	Mean fork length (cm)				
Species	recapture net (SE)	*N*	codend (SE)	*N*	p-value
Widow rockfish	41 (0.31)	273*	40 (0.17)	722*	0.0029
Pacific hake	41 (0.20)	428**	40 (0.13)	399**	0.5852

Table 2. *Kolmogorov-Smirnov test comparison of mean fork lengths (cm) of widow rockfish and Pacific hake between fish caught in the recapture net and trawl. N = refers to the number of fish measured; * = expanded length data from subsample length measurements; ** = unscaled length data, subsample lengths only.*

Discussion

Developing techniques that improve trawl selectivity and provide fishermen with more opportunities to fully utilize their catch share quota of Pacific hake and increase their net economic benefits are increasingly important to fishermen and management. Additional tools, such as improved selectivity, are also needed to reduce fishing mortality on overfished stocks to augment their recovery and on stocks that are experiencing overfishing under status quo management measures (i.e., some slope and shelf rockfish species). In this study, a flexible sorting grid excluder was examined that demonstrated the ability to reduce widow rockfish bycatch while limiting the loss of Pacific hake. Although further refinement of the excluder is needed for the gear to function under heavy fish volumes, this project has developed a bycatch reduction device (BRD) that can assist Pacific hake fishermen reduce rockfish bycatch when fishing conditions are moderate to high (i.e. over 90 mt of Pacific hake caught in haul durations less than 2.5 hours). As efforts to improve trawl selectivity in the Pacific hake fishery continue, findings from this study provid
to industry and management.

Relatively small widow rockfish were encountered during this study (mean length 40 cm, approximately a 1.01 kg fish). While only a 26.2% reduction in widow rockfish bycatch was noted, it is likely that exclusion rates would have been higher if larger rockfish species were encountered, such as rougheye rockfish (*S. aleutianus*), bocaccio (*S. paucispinis*), and canary rockfish which are typically much larger than widow rockfish.

Current management tools available to reduce catches of species with low ACLs relative to encounter rates include depth-area closures (i.e. rockfish conservation areas) along with the implementation of the IFQ program which requires 100% observer coverage and full accountability of catch (PFMC and NMFS, 2010). Landings exceeding acceptable biological catches and overfishing limits (OFLs) have recently been documented for some species and species groups caught by the trawl fishery (Hicks et al., 2014; NMFS, 2013). Unless more selective trawl gear is used, as described herein, management may be forced to restrict fishing over a broader range of depths/areas or

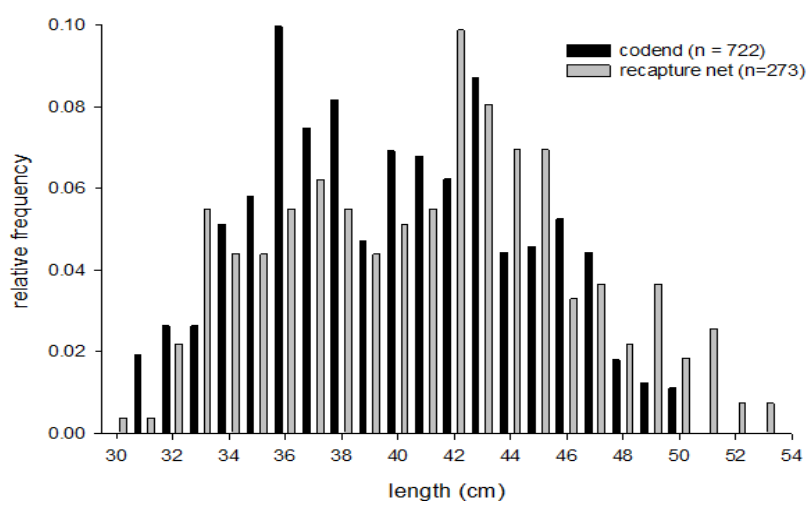

Figure 4. *Length frequency distributions of widow rockfish caught in the codend and recapture net.*

implement lower harvest guidelines and ACLs to ensure that commercial fisheries do not exceed the OFLs for certain species. Providing fishermen with an option of using a more selective trawl that will provide access to a productive Pacific hake stock while reducing the catch of those species with relatively low ACLs or harvest guidelines would be beneficial to the fishery, coastal communities, management, and the resource.

In summary, this research examined a flexible sorting grid excluder that demonstrated the ability to reduce widow rockfish bycatch while retaining a relatively high proportion of Pacific hake (92.7% by weight). Although further development of the excluder is needed for the gear to function under heavy fish volumes, this project has developed a BRD that can assist Pacific hake fishermen reduce rockfish bycatch when fishing conditions are moderate to high (i.e. over 90 mt of Pacific hake caught in haul durations less than 2.5 hours). Insights and lessons learned during this project are being exchanged between gear researchers, managers, and fishermen in a collaborative effort to reduce rockfish bycatch in the Pacific hake fishery.

Acknowledgements

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