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Slinky Pot and Hook-and-Line Comparison Project During the Experimental Leg of the 2021 AFSC Sablefish Longline Survey

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Slinky Pot and Hook-and-Line Comparison Project During the Experimental Leg of the 2021 AFSC Sablefish Longline Survey

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ABSTRACT

Pot fishing gear was legalized in the Gulf of Alaska commercial sablefish (*Anoplopoma fimbria*) fishery in 2017. Since then, lightweight, collapsible "slinky" pots have been introduced into the fishery and usage is widespread and increasing. In an effort to collect baseline data on catch rates and catch compositions of slinky pots relative to hook-and-line longline gear, the Alaska Fisheries Science Center (AFSC) fished three paired slinky pot and hook-and-line sets during the July 2021 experimental leg of the annual AFSC sablefish longline survey in the West Yakutat region of the Gulf of Alaska. Paired sets were fished in similar locations and along comparable depth profiles. Pots were configured with four escape rings. Key results from the pilot study suggest that slinky pots catch a higher proportion of sablefish by number relative to other species when compared to hook-and-line gear, but that relative catch rates between slinky pots and hook-and-line gear were consistent across the three paired sets and by depth. Additionally, length frequency distributions were similar between the two gear types, which suggests that size-selectivity of survey hook-and-line gear is similar to slinky pots outfitted with 8.9 cm (3.5-inch) escape rings. While this pilot study was limited in scope, it will be useful in identifying strategies to improve future experimental designs and new avenues of research. Future studies should emphasize consistency in gear and methodology and investigations should focus on catch dynamics related to pot size, escape ring size, bait quantity, soak time, and pot spacing.

CONTENTS

INTRODUCTION

In July 2021, NOAA scientists on the annual AFSC longline survey conducted a 3-day pilot project comparing standard survey hook-and-line gear with slinky pots in the West Yakutat region of the Gulf of Alaska (Siwicke et al. 2022). Named for their helical spring-steel frames that allow the traps to fully collapse for storage or deployment (Fig. 1), slinky pots have rapidly increased in the commercial sablefish fishery since pot fishing became legal in the Gulf of Alaska in 2017 (Goethel et al. 2022, NPFMC 2021). Interest in pot gear has intensified in recent years due to increases in sperm whale (*Physeter macrocephalus*) and killer whale (*Orcinus orca*) depredation on hook-and-line gear in the Gulf of Alaska and Bering Sea (Hanselman et al. 2018, Peterson et al. 2013, Peterson and Hanselman 2017, Schakner et al. 2014). Slinky pots are lightweight and have made pot fishing accessible to smaller vessels that are unable to fish larger rigid pots due to limited deck space or hydraulic power.

Despite their rising popularity in the fishery, little is known about the fishing performance of slinky pots relative to hook-and-line gear. Interpreting commercial fishery data from slinky pot catches is thus problematic for the sablefish stock assessment, which uses fishery-dependent length, age, and catch-per-unit-effort (CPUE) as inputs to the population model (Goethel et al. 2022). The objectives of this pilot project were to compare catch composition, catch rates, and size-selectivity of the two gear types. Ultimately, the results of the pilot project will be used to inform future gear experiments and analysis of pot and hook-and-line fishery CPUE data.

METHODS

Three paired sets of standard survey hook-and-line gear and slinky pots were deployed over 3 days during the July 2021 experimental leg of the AFSC longline survey (Table 1; Siwicke et al. 2022). On each day, sets of both gear types were fished across similar depths and habitats approximately one nautical mile (nmi) apart at their closest points. Hook-and-line sets were composed of 90–92 skates of standard survey gear and

covered a linear distance of approximately 9,000–9,200 m (Siwicke et al. 2022, Sigler and Zenger 1989, Rutecki et al. 2016). Each skate was 100 m (55 fm) long and contained 45 size 13/0 Mustad circle hooks baited with squid heads and mantles, which were attached to 38 cm (15 in) gangions that were secured to beckets placed along the groundline at 2-m (6.5 ft) intervals (Siwicke et al. 2022). Pot sets were comprised of 87–91 pots spaced 73 m (40 fm) apart with a 3.2 kg weight fixed between each pot. The number of pots fished per set was primarily determined by the number readily available on the vessel. The length of the pot sets (approximately 6,570 m) was also determined by the length of groundline that was available. The pot sets were not as long as the hook-and-line sets and thus did not sample an equal distance. Pot spacing options were limited by the pre-rigged groundline that had built-in attachment points. Thus, spacing was set so as to distribute the pots maximally along the length of the existing groundline with equal spacing between pots. Each pot was baited with one mesh bait bag filled with 1–1.5 kg of chopped squid mantles, heads, and tentacles. The bait bag was left unattached inside the pot. Although the amount of bait was inconsistent between pots at the time of deployment, some quantity of bait remained in each pot at the time of retrieval.

Two sizes of pots were fished during the experiment: smaller-sized pots with an approximate length of 127 cm (50 in), diameter of 69 cm (27 in), and volume of 0.47 m^3; and larger pots with an approximate length of 140 cm (55 in), diameter of 84 cm (33 in), and volume of 0.78 m^3. All pots had two 22.9 cm (9 in) tunnel entrances and a 45.7 cm (18 in) panel of biodegradable cotton twine sewn in parallel to the pot length near its midsection. Each pot was fitted with four escape rings placed 6.4 cm (2.5 in) and 11.4 cm (4.5 in) from the ends of the pots on both sides of the large and small pots, respectively. The escape rings were 8.9 cm (3.5 in) in diameter for the small pots and 10.2 cm (4 in) on the large pots. However, the larger rings were modified to approximate the smaller rings by closing a portion of the rings with cable ties. Given the uneven number of small and large pots available for use and to record catch and length data associated with pot size, the planned order of pots along the groundline was 5 large pots, 80 small pots, and 5 large pots. There were a few slight deviations in sample size from this design (Table 1), but nevertheless, catch and length data were accurately discriminated by pot size.

Pot sets were deployed at approximately 05:00, followed by hook-and-line sets at approximately 06:30. Soak times were defined by the time between the first buoy set and the first buoy hauled. Pot sets received a minimum soak time of 8.9 hours while the hook-and-line sets received a minimum soak time of 3 hours. The 8.9 hour soak time for the pot sets maximized fishing time for that gear while still allowing for continuation of normal survey operations, including the standard minimum soak time for hook-and-line sets and adherence to the survey schedule, which requires substantial daily transit time between stations.

A full census of catch was recorded for each hook and pot. Catch rates were defined as the number of sablefish per hook-and-line skate or pot, and were calculated by gear type. Data from skates or pots deemed ineffective (i.e., snarled, broken or missing hooks, open trap doors, or otherwise fouled) were not included in catch rate calculations. Only organisms captured on hooks or inside pots were enumerated. Depth was recorded during haulback at every fifth skate or pot and whenever the depth crossed a depth stratum (301–400 m, 401–600 m, and 601–800 m). Length and sex data were collected according to standard survey protocols (Siwicke et al. 2022).

RESULTS

A total of 272 hook-and-line skates (12,240 hooks) and 268 slinky pots (32 large and 236 small) were fished over the 3 days of sampling (Table 1). Paired sets were generally fished at comparable depth profiles ranging from 396 to 689 m. On hook-and-line gear, a total of 4,291 sablefish were caught and of these 3,665 were sampled for sex and length (Table 2). A total of 2,249 sablefish were caught in pots (277 in large pots and 1,972 in small pots) and 2,229 lengths and sexes were collected (271 from large pots, and 1,958 in small pots). No hook-and-line or pot gear was lost during the experiment. However, over the course of the study, the twine securing trap doors on six pots was found broken at the time of retrieval, including four large pots and one small pot on the first set, and one small pot on the third set. These six pots were empty, deemed ineffective, and excluded from

further catch rate analysis. No significant snarls occurred during the hook-and-line sets; therefore, all data from hook-and-line sets were retained for analysis.

A sperm whale was observed during haulback of the second hook-and-line set and three hooks returned with lips or jaws, which was recorded as evidence of whale depredation on the gear (Table 2). However, the whale was not seen in the survey area after retrieval of the 36th skate. There was also evidence of depredation (i.e., one hook with lips or jaws) on both the first and third hook-and-line sets, though no sperm whales were observed during haulback on either set. Besides whale depredation, other species such as sleeper sharks are known to depredate on longline gear. No sperm whales were observed during setting or haulback of any pot sets.

The most common species caught by both gear types was sablefish, followed by giant grenadier (*Albatrossia pectoralis*; Table 2). Shortspine thornyhead (*Sebastolobus alascanus*), shortraker rockfish (*Sebastes borealis*), rougheye/blackspotted rockfish (*Sebastes aleutianus/melanostictus*), and arrowtooth flounder (*Atheresthes stomas*) were also caught by both gear types in varied numbers (Table 2). Although the two gear types caught a similar number of species overall, the slinky pots caught a lower proportion of non-sablefish species. Across all sets, 95–98% of all fish caught in pots were sablefish, whereas 79–87% of fish caught on hook-and-line sets were sablefish. The biggest species composition discrepancies between the two gear types were for giant grenadier and shortspine thornyhead. Hook-and-line catches of giant grenadier ranged from 8 to 13% of total catch while pot catches were 1–2%. Similarly, shortspine thornyhead made up 3–7% of the hook-and-line catches and 0–0.2% of pot catches.

The smaller pots caught fewer sablefish per pot on average (mean ± standard deviation: 8.3 ± 5.4 fish/pot) than the large pots (9.9 ± 6.2 fish/pot), though this difference was not statistically significant (t = -1.3, df = 32.1, p-value = 0.22). Across the three paired sets, catch rates for the hook-and-line skates averaged 14.1 to 17.7 sablefish per skate, while pot catch rates combined by set averaged 5.8 to 10.5 sablefish per pot (Fig. 2). In addition to higher average catch rates, sablefish catches on the hook-and-line skates were less variable (coefficient of variation, CV = 0.4) than pot catches (CV = 0.7). Despite these

differences, trends in catch rates were consistent across sets, with an increase in hook-and-line catch rates corresponding to an increase in pot catch rates (Fig. 2). Additionally, standardized catch rates (i.e., mean of 0, standard deviation of 1) for the two gear types were positively correlated by depth (Pearson's rho = 0.85), and maximum catch rates in both gears were observed between 600 and 650 m (Fig. 3).

Length compositions of sablefish captured by hook-and-line and pot gear were similar across sets and by sex and showed no consistent pattern in size-selectivity (i.e., one gear did not consistently catch larger fish; Fig. 4). When the length data were aggregated across the three paired sets, the pots and hook-and-line gear had the same overall mean length, though the hook-and-line gear caught a slightly broader range of lengths (61.4 ± 7.8 cm) than pots (61.4 ± 7.0 cm). In addition to having the same means, the hook-and-line and pot length data exhibited similar underlying distributions (non-parametric two-sample Kolmogorov-Smirnov test: D = 0.036, p-value = 0.06). Despite the consistencies in length data, there were small but consistent differences in sablefish sex ratios between gear types, with the proportions of females caught on hook-and-line gear (0.46, 0.40, and 0.36) consistently lower than in the paired pot sets (0.58, 0.57, and 0.52).

When comparing sablefish length compositions between pot types, fish from the small pots were significantly larger on average (61.7 ± 7.0 cm) than fish from large pots (59.0 ± 6.8 cm; Welch two sample t-test: t = -6.3, df = 354.5, p-value < 0.001). Although the order of pots was not randomized, this finding was consistent in the two depth strata sampled (401–600 m and 601–800 m). In both depth strata, sablefish from small pots were consistently larger on average than fish from large pots, and fish from the deeper 601–800 m stratum were larger than fish from the 401–600 m stratum in both pot sizes (401–600 m: 60.8 ± 6.9 cm from small pots and 57.8 ± 6.4 cm from large pots; 601-800 m: 62.2 ± 7.0 cm from small pots and 60.1 ± 6.9 cm from large pots).

DISCUSSION AND CONSIDERATIONS FOR FUTURE INVESTIGATIONS

Results from this pilot project provide preliminary data for comparing catch composition, catch rates, and size-selectivity of sablefish between hook-and-line and slinky

pot gear. Species compositions caught by the two gear types differed, with pot and hook-and-line gear catching 97% and 83% sablefish by number, respectively, on average across all sets (Table 2). This finding is consistent with several years of data collected by human observers and electronic monitoring in the commercial sablefish fishery (e.g., Figs. 5-7 in NPFMC 2021). Little is known about the characteristics of sablefish pot gear that contribute to these low bycatch rates. One hypothesis is that the pot tunnel entrance, which is currently limited to 20.32 cm (8 inches) in diameter in the Gulf of Alaska, may contribute to the relatively low catch rates of rockfish, flatfish, sharks, and grenadier species that are caught in high numbers on hook-and-line gear (e.g., Siwicke et al. 2022). Experimental research comparing catch composition and catch rates of different pot entrance tunnel diameters, shapes (e.g., circular vs. oval), or material (e.g., rigid vs. flexible entrance tunnel material) may provide insight into the configurations that affect bycatch. This type of data would be helpful for guiding proposed regulatory changes aimed at increasing operational flexibility for fishery participants wanting to target both Pacific halibut and sablefish with pots.

Although species catch composition differed between hook-and-line and pot gear, relative catch rates of sablefish between the two gear types were positively correlated across the paired sets and by depth (Figs. 2 and 3). Paired hook-and-line and pot sets were intentionally fished in close proximity and along similar depth profiles and habitats in order to control for spatial and bathymetric variability in the availability of sablefish and other species. These results provide preliminary data on the comparability and standardization of hook-and-line and slinky pot catch rates; however, they should be interpreted with caution due to the small scale of the pilot study and inconsistencies in methodology (e.g., see units of gear in Table 1). The collection of more data will aid in the interpretation of pot and hook-and-line fishery CPUE data and the potential development of a pot or mixed gear index of abundance for sablefish.

In addition to catch rates, hook-and-line and combined pot gear length compositions of sablefish were also similar across sets (Fig. 4). The mean length of sablefish caught in both hook-and-line and pot gear was the same (61.4 cm), and there was evidence that the underlying length distributions were statistically similar. However, these results were

confounded by small, but statistically significant differences in the mean length of sablefish caught in the small and large pots. The small pots, which had four 3.5-inch escape rings, caught larger fish on average than the large pots, which had four 4-inch escape rings that were modified to resemble 3.5-inch escape rings. The resulting difference in size distributions between the two pot types highlights the importance of controlling pot and escape ring size in future investigations, as well the value of collecting data on pot characteristics in the sablefish pot fishery in order to standardize length frequency data used in stock assessments. Escape rings in particular are known to affect catch rates and size-selectivity of sablefish pot gear, with larger escape rings generally resulting in lower catch rates but larger fish on average (Haist et al. 2004, Haist and Hilborn 2000). However, no studies exist quantifying the size-selectivity differences between longline and pot gear. Given our results and those in the literature, further research examining pot gear configuration and escape ring size effects on size-selectivity for sablefish and other groundfish is warranted.

Other factors that were likely influential to the study results include the bait used, soak times, and spacing of the pot and hook-and-line gear. *Illex* squid was used to bait pots during this pilot project, which has been the standard bait used on the AFSC longline survey since its inception. The amount of squid used per pot was not standardized, although some bait remained in each pot at haulback. Although evidence from hook-and-line studies suggest that bait type and bait condition is less influential on sablefish catch rates than other factors like soak time or hook spacing (Sigler 2000), future studies should control for bait volume and potentially bait placement, which could affect bait plume dispersal (Løkkeborg et al. 1995). The type of bait used is also an avenue for exploration given the fact that pots are generally soaked for longer periods than hook-and-line sets and some baits may be more persistent and/or more attractive. Along those lines, pot soak time in this project was determined primarily by the daily operations of the survey and its requirement to stay on a regimented schedule. For this reason, the maximum soak time that could be allowed for pots was approximately 9 hours. Soak time may have a significant effect on catch rates of pot gear, and research into this variable is warranted to understand the catch dynamics of sablefish in pots over time. Finally, a key consideration when

designing this pilot project was determining the spacing to use between pots. The pot spacing used in this study (73 m) was limited by the available gear on the vessel. Hook spacing is known to influence the catch rates of sablefish (Sigler 2000, Sigler and Lunsford 2001), and there is much to learn with respect to slinky pot spacing and the influence of this variable on sablefish catch rates. Therefore, whether the goal is to compare pot catches with hook-and-line catches or to determine the catching efficiency of pots, pot spacing must be a consideration in future investigations.

In summary, we found pots caught a higher proportion of sablefish by number than hook-and-line gear, but that relative catch rates of sablefish were consistent between the two gear types across the three paired sets and by depth. We also found that sablefish length distributions were similar between the two gear types; however, this result was confounded by disparities between the two pot sizes fished. While this pilot study was limited in scope, it was useful in identifying strategies to improve future experimental designs and new avenues of research. Future studies should emphasize consistency in gear and methodology, including pot size, escape ring size, bait quantity, soak time, and pot spacing. In particular, further research into the comparability of hook-and-line and pot catch efficiency and size-selectivity of sablefish would benefit fishery CPUE analyses and aid in the interpretation of fishery-dependent catch and length frequency data used in stock assessment.

ACKNOWLEDGMENTS

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TABLES

Table 1. -- Experimental station information by gear (HAL = hook-and-line and POT = slinky pot), locations (in decimal degrees), approximate soak time (in hours), units of gear set, and the minimum and maximum depth fished (in meters). For HAL, a unit of gear is one skate of gear, which is 45 hooks; for pot gear, it is a single pot. For pot gear, the values in parentheses under 'units of gear' are the number of each size of pot fished from shallow to deep. For example, 90 (5, 80, 5) represents 90 total pots (5 large, 80 small, 5 large) in order along the groundline from the shallow end of the set to the deepest.

Station	Date	Gear	Start latitude	Start longitude	End latitude	End longitude	Soak time	Units of gear	Min. depth	Max. depth
E1	7/24/2021	HAL	58.98	-141.30	59.01	-141.17	3.0	90	433	646
E1	7/24/2021	POT	59.02	-141.26	59.00	-141.35	9.1	87 (5, 77, 5)	396	648
E2	7/28/2021	HAL	59.55	-142.98	59.51	-143.12	3.1	90	585	648
E2	7/28/2021	POT	59.58	-142.88	59.54	-142.96	9.6	90 (5, 79, 6)	585	651
E3	7/29/2021	HAL	59.53	-143.27	59.50	-143.40	3.0	92	531	670
E3	7/29/2021	POT	59.54	-143.17	59.51	-143.26	8.9	91 (5, 80, 6)	564	689

Table 2. -- A summary of catch and length data collected by experimental station for hook-and-line (HAL) and slinky pots (POT).

Station	Common name	HAL catch	HAL lengths	POT catch	POT lengths
E1	Sablefish	1,267	1,174	496	490
	Giant grenadier	129	105	6	6
	Shortspine thornyhead	78	71	-	-
	Shortraker rockfish	52	52	3	3
	Rougheye/blackspotted rockfish	8	8	11	11
	Arrowtooth flounder	3	3	7	7
	Brittle star	3	-	-	-
	Lips/jaws - depredation	1	-	-	-
	Sea cucumber	-	-	2	-
E2	Sablefish	1,396	1,185	811	802
	Giant grenadier	226	119	18	18
	Shortspine thornyhead	124	116	2	1
	Rougheye/blackspotted rockfish	5	5	-	-
	Arrowtooth flounder	-	-	2	2
	Brittle star	2	-	-	-
	Lips/jaws - depredation	3	-	-	-
	Sea whip	5	-	-	-
	Tanner crab	-	-	1	-
E3	Sablefish	1,628	1,306	942	937
	Giant grenadier	184	107	17	17
	Shortspine thornyhead	57	48	2	2
	Arrowtooth flounder	2	2	2	2
	Rougheye/blackspotted rockfish	2	2	-	-
	Brittle star	7	-	-	-
	Lips/jaws - depredation	1	-	-	-
	Sea whip	1	-	-	-
	Dover sole	-	-	1	-

FIGURES

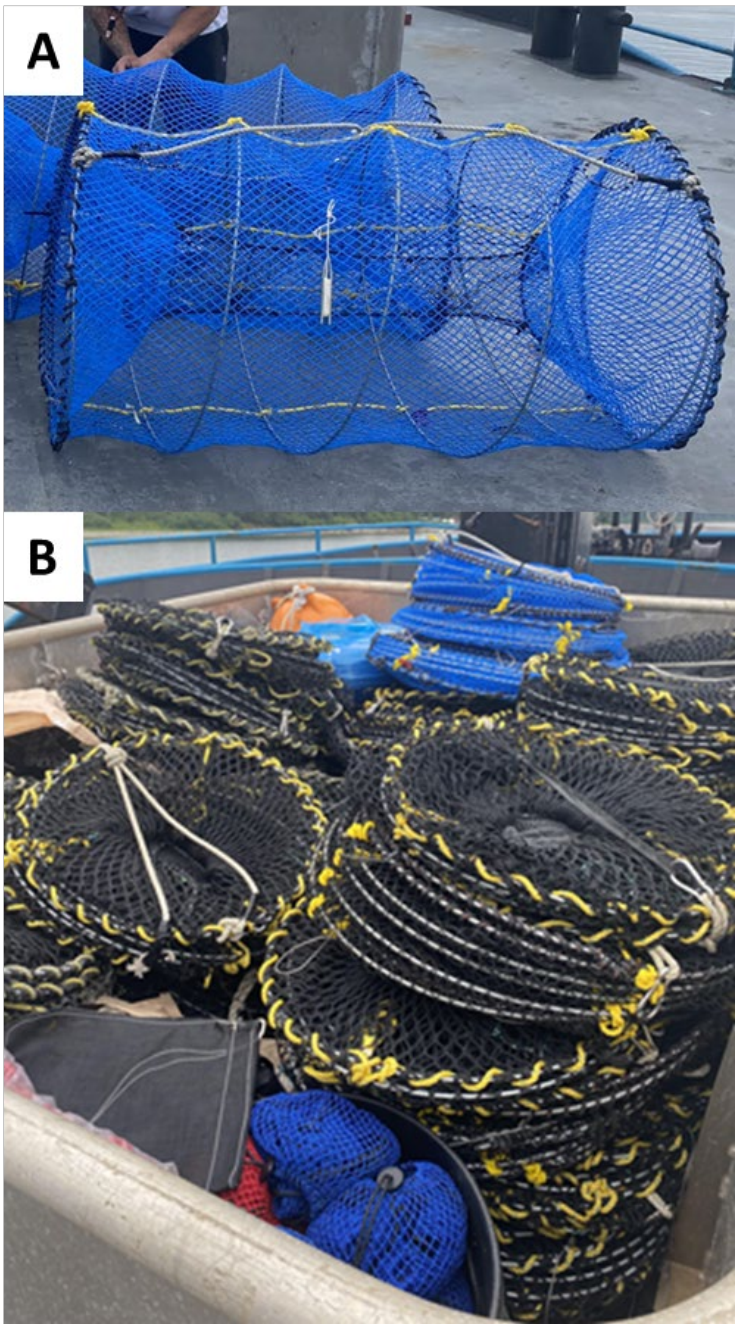

Figure 1. -- (A) Slinky pots in the open position. (B) Stacks of collapsed slinky pots with mesh bait bags in the foreground.

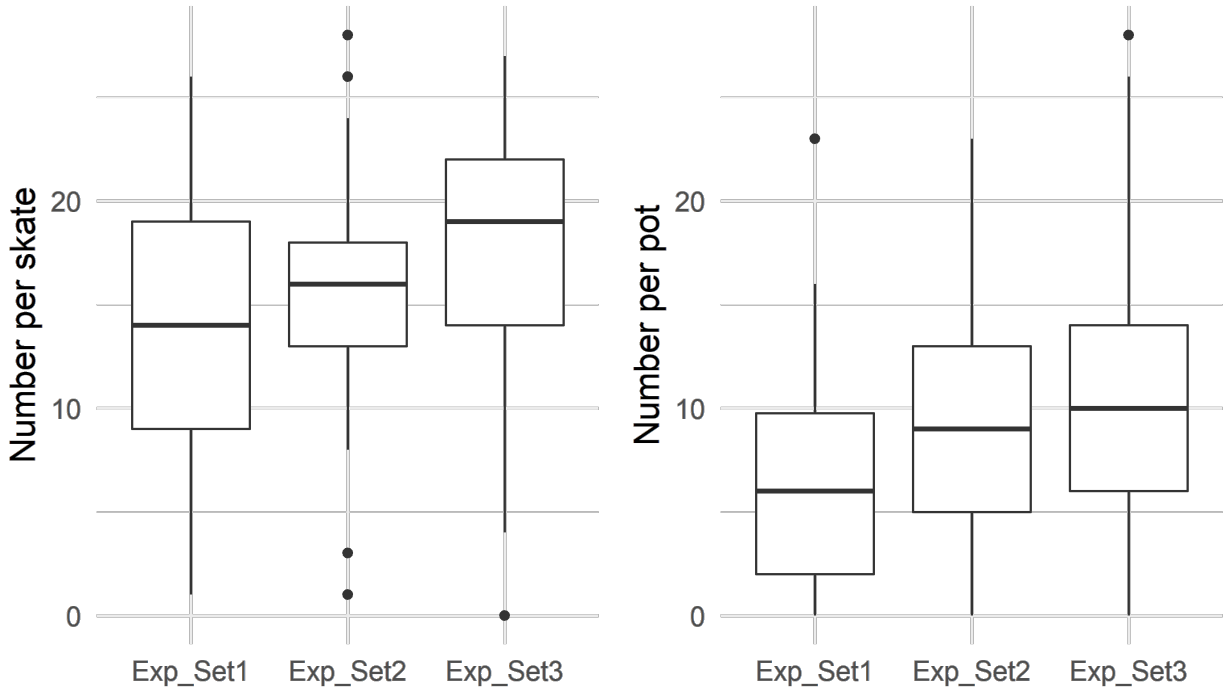

Figure 2. -- Box plots of number of sablefish caught per hook-and-line skate (left) and slinky pot (right) on three paired experimental sets.

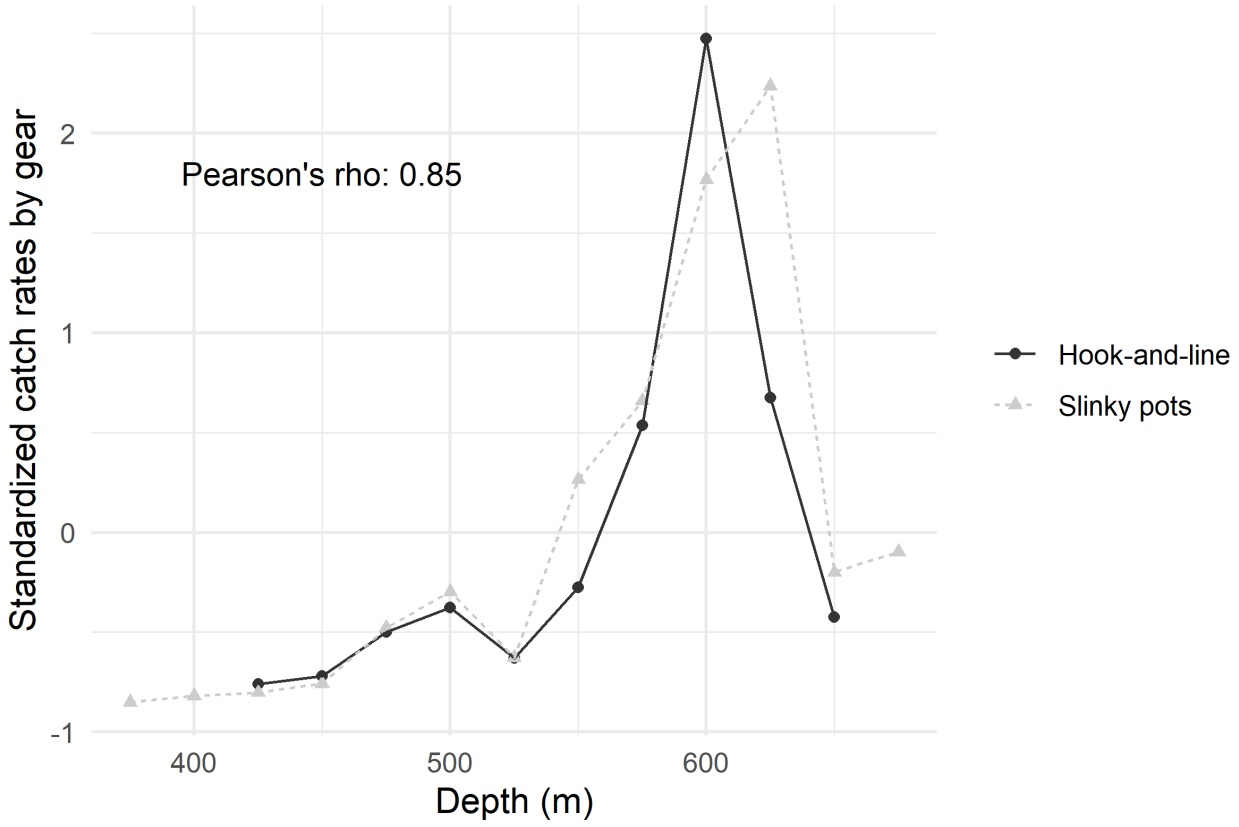

Figure 3. -- Standardized (mean of 0, standard deviation of 1) catch rates for hook-and-line (black points) and slinky pot (grey triangles) gear by depth (m), where data from all sets were combined.

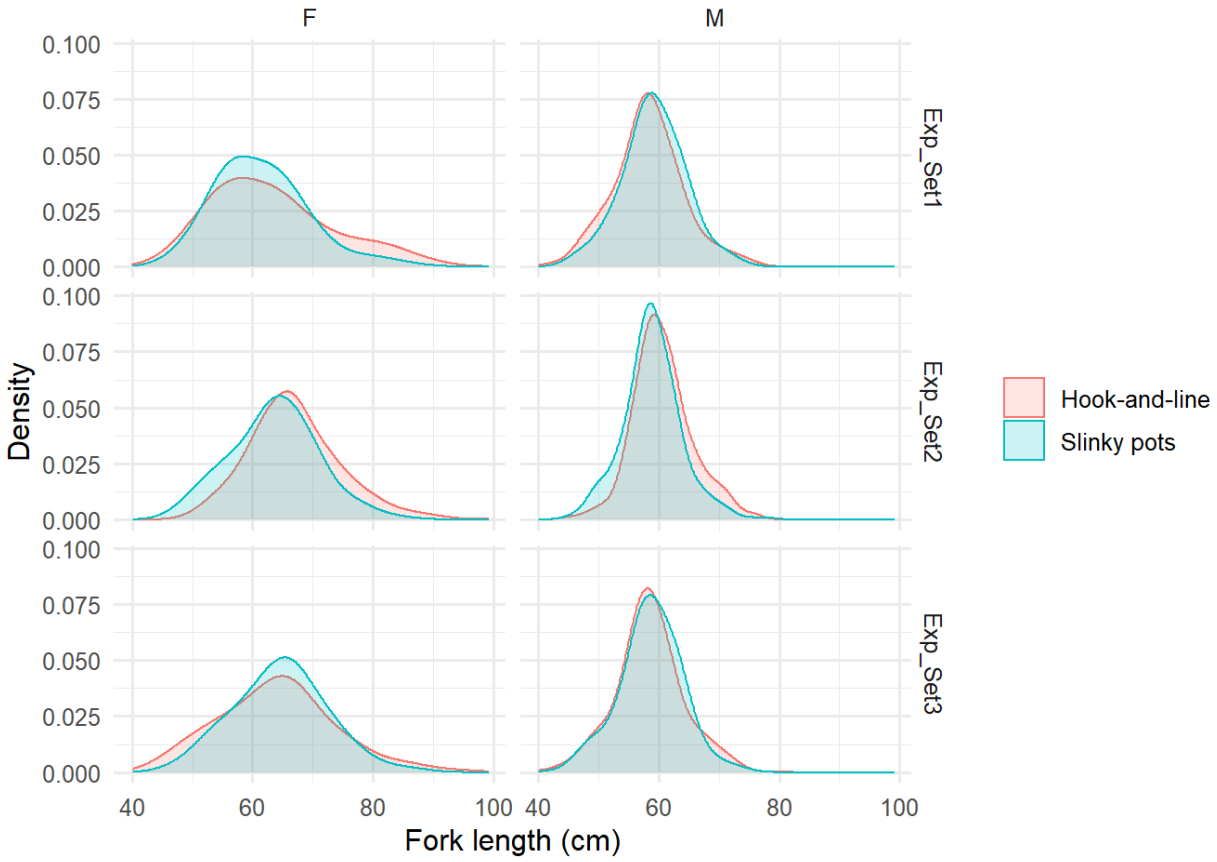

Figure 4. -- Sablefish fork length (cm) distributions by gear (hook-and-line in red, slinky pots in blue), by sex (columns where F = female and M = male), and experimental station (rows).

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