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The 1983 Experimental Set-Net Fishery for Groundfish

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by

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INTRODUCTION

Experimental fishing permits were issued to the F/V Harvester and Zarana for set-netting groundfish during the period 1 May to 31 October 1983. These permits were issued to determine whether submerged gill nets are a suitable gear type for harvesting groundfish, and secondly, to determine the impact of such gear on other resources as well as other resource users. Observers were placed on both vessels to fulfill these objectives. To examine differences among areas, the Harvester was assigned to Westport, Washington, whereas the Zarana operated out of Neah Bay, Washington. The purpose of this report is to describe this fishery and to provide catch information for assessing the impact of set-net gear.

FISHERY DESCRIPTION

Description of Vessels, Gear, and Operation

The Harvester is a 42-foot vessel that carries a master and one or two crew members; a master and three crew members fished the 54-foot Zarana. Both vessels targetted on sablefish, although large quantities of lingcod and rockfish were often caught. According to the vessel captains, sablefish reside in deeper waters (>200 fathoms) from October to July. During the summer upwelling, the sablefish migrate towards the upper lip of the continental slope (90 to 150 fathoms). From July through September, the sablefish are vulnerable at the depths fished by the set-nets, and it is during these months that the captains expect to land the bulk of their sablefish catch. In October, the sablefish then migrate down into the deeper depths.

In general, the captains tried to avoid incidental catches of lingcod and rockfish, both because of the lower prices offered and the greater difficulty in

picking these species out of a gill net. Large catches of both species inflicted extensive damage to the nets. Generally, the mesh was either in need of extensive repair or was discarded after 3-8 uses on return to port.

Most fishing trips lasted two to three days, with the nets generally set in the evening and retrieved in the morning. The Zarana usually fished three nets per day, each net composed of three, four, or five 100-fathom shackles. On the Harvester, one to three nets were set per day, each net consisting of three or four 67-fm shackles. Thus, the Zarana fished 6,800 feet of 6-inch mesh daily, while the Harvester usually fished 3,200 feet of net (both 6 and 6 1/2-inch meshes).

Nearly all nets were set along the upper edge of the continental slope. The nets were set perpendicular to the slope, usually stretching from 90 to 130 fathoms (Fig. 1). The bottom was usually moderately sloped, hard, and sometimes rocky. Each net measured 20 meshes from the float-line to the lead-line with the lead-line resting on the bottom.

In addition to the commercial nets, both vessels were required to fish a shackle of 5 1/4" mesh (test net). The test net measured 25 meshes from the lead-line to the float-line, and was fished on both the deep and shallow ends of the commercial net. Generally, the test net was fished every day by both vessels except when it needed to be repaired.

Once on the fishing grounds, the fish finder was monitored as the vessel steamed along the 100-fathom contour searching for feed (e.g., krill). When suitable concentrations of feed were found, the nets were set off the stern--each end marked by a pole and buoy. The nets were anchored with approximately 100 pounds of heavy chain, and the nets were usually set a half mile apart from one another.

The nets were retrieved by the use of a hydraulic lifter on the port side. Because the webbing is made of light monofilament, the nets are subject to tearing upon retrieval, particularly in heavy swells; hence the nets are stacked on deck, before picking the fish, to minimize the time required for net retrieval. Once the entire net is aboard, the fish are removed from the net. All sablefish, lingcod, most *Sebastes* species, Pacific cod, and sole were retained. Some of the smaller species (e.g., greenstriped rockfish and rex sole) and all other species, primarily arrowtooth flounder and spiny dogfish, were discarded.

Areas Fished

Throughout the season, the *Zarana* fished all their gear within a 5 square mile area of the Nitinat Canyon, 35 nautical miles true west of Cape Alava (Fig. 2). The *Harvester* fished Gray's Canyon (30 miles west of Point Brown) during June and July, but moved northward the last week of July because of continually low catches. From 29 July to 18 August, the *Harvester* primarily fished the Juan de Fuca Canyon (30 miles west of La Push), and then moved to the Nitinat Canyon, 4 miles north of the *Zarana*'s fishing grounds. On the *Harvester*'s last trip, 6 nets were set on what is locally termed the "Prairie," at depths ranging from 66 to 80 fathoms.

Both vessels attempted to fish in areas where trawlers do not fish; hence gear conflicts were kept to a minimum. The vessels could have fished equally productive grounds closer to shore, but these areas were avoided due to the higher potential of gear conflicts. Only two minor gear conflicts occurred this summer--both on the *Zarana*. A dragger ran through one of the *Zarana*'s nets, and later a marker buoy was lost, presumably pulled away by a dragger.

SAMPLING METHODS AND ANALYTICAL TECHNIQUES

The Zarana fished from 18 May to 12 October, completing 24 trips totalling 41 days. An observer was on the vessel from 20 June to 4 September and sampled 20 of the 27 days fished during this period. A total of 118 nets were set by the Zarana, of which 60 were observed.

On the Harvester, the observer sampled 28 of the 37 days fished (14 out of 18 trips) during the period 28 June to 7 October. A four-day trip in August and a one-day trip in September were not sampled, as well as the last two trips after 21 September. Fifty-seven of the 71 nets set by the Harvester were observed; therefore, 80% of the Harvester's nets were sampled whereas only 51% of the Zarana's nets were observed.

Sampling Methods Aboard the Vessels

On both vessels, the total number of fish actually caught by the net was recorded for each species, except for box crabs on the Zarana. Thus, this total number includes the number of fish actually retained by the fishermen plus the fish lost by dogfish predation, sand flea infestation, fish observed falling out of the net, and discards. These losses were recorded by the Harvester's observer so that an estimate of wastage could be obtained.

Because all sablefish and most lingcod were dressed on the Harvester, the observer on this vessel had enough time to take average weights for all species from each net. One or two baskets of each species were sampled from each shackle to obtain weights for the most abundant species. When catches were low, the total weight of all individual species was obtained; usually total weights of all incidental species were acquired.

Aboard the Zarana, sablefish, lingcod, and rockfish were placed in the hold as soon as they were picked out of the net, so average weights were only occasionally taken, and only for the major species. The variation in average weights was much greater than the daily fluctuations observed aboard the Harvester.

Product recovery rates were measured for western-dressed sablefish and lingcod aboard the Harvester. The landings data for the Harvester were converted from dressed weights to round weights using product recovery rates of 0.70 and 0.75 for sablefish and lingcod, respectively.

Other biological data collected aboard the Harvester included halibut condition and sablefish length-frequencies. Before the halibut were returned to the sea, their condition was recorded as either excellent, poor, or dead. On 20 and 21 September, the sex was noted and length was measured on a total of 586 sablefish: 153 from the 5 1/4" test net and 433 from the commercial nets (6" mesh).

Analytical Techniques

Whereas the Zarana confined their fishing activities to the Nitinat Canyon, six distinct areas or sites were delineated for the Harvester (Table 1). Of the six sites fished by the Harvester, only the Prairie was not sampled. Although the Canadian border site actually lies in the Nitinat Canyon, this area was distinguished from the Nitinat Canyon for the following reasons: 1) average weights, species composition, and catch rates differed between the two sites, 2) the Zarana exclusively fished the Nitinat Canyon, and 3) a comparison between vessels fishing the same grounds could be made.

Due to the inconsistencies and incompleteness of the average weights taken aboard the Zarana, species' weights for the Zarana catches were

calculated by multiplying the daily numbers times the average weights obtained by the Harvester's observer for the two days the Harvester fished the same grounds (Nitinat Canyon area). The two dates were 22 July and 19 August.

The validity of the observer's samples was tested by comparing the sample estimates of sablefish, lingcod, and rockfish catches with the actual landings. Sample errors were computed for all observed trips, and the total error was calculated by this formula:

$$\frac{\sum_{i=1}^{n} \text{sample estimate} - \sum_{i=1}^{n} \text{vessel landing}}{\sum_{i=1}^{n} \text{vessel landing}}$$

where n equals the number of observed trips.

In addition, the observed landings were compared with the total landings (expected values) with a X^2 test under the null hypothesis that the observed landings are representative of the landings from the entire season. Similarly, observed and non-observed landings were tested for equal catch composition.

The six nets set on the Prairie were the only sets on the continental shelf. Since all other nets were set along the upper edge of the continental slope, a comparison of sets on the slope and shelf was the only depth effect considered. Daily fluctuations and the non-existence of distinct depth boundaries (i.e. nets overlapped) precluded any analysis of depth effects for the majority of nets which were set on the slope.

For observed trips, average weights, species composition, and catch rates were calculated by area, time, and mesh size. Because the vessels

used different net lengths, catch per unit effort (CPUE) was defined as kilograms caught per 100 fathoms of net fished (kg/100 fm net). The catch rate, CPUE, was not adjusted for the length of time that the nets were fished because the soak time was usually overnight and relatively constant between vessels and over the season. The CPUE over the entire season were simply calculated as the total weight caught divided by the total number of 100-fathom units of net sampled (138.67 and 242.0 100-fathom units for the Harvester and Zarana, respectively) for all species observed. Means and standard errors were calculated for the catch rates when stratified by area or mesh size. Mean catch rates were calculated for sablefish, lingcod, rockfish, and other species from the formula

$$\frac{\sum_{i=1}^{n} (\text{kg/100 fm net})}{n}$$

where n equals the number of nets observed for the Harvester and number of days sampled for the Zarana. The two methods of computing catch rates yielded similar results, but standard errors could only be calculated by the second method. Standard errors were not calculated for individual species over the entire season because most species sampled were merely incidental--75% of the species each comprised less than 1% of the catch.

Catch rates were not calculated for non-observed trips for the following reasons:

1) catch rate per trip would have been obtained, not daily catch rates
2) net lengths often varied, but were not recorded by vessel captains
3) discarded individuals (e.g., sablefish that fell out of the net upon retrieval) would not have been included
4) catch rates of other species (e.g., arrowtooth flounder) could not have been assessed

5) no observer verification.

Most disturbing is the second reason: assuming a four-shackle net was used when a three-shackle net was actually fished introduces an error of 33% in the catch rate.

Even though catch rates were standardized for the different net lengths used aboard each vessel, weight caught per 100 fathoms of net is not entirely accurate due to the varying condition of nets. A new net certainly has a higher catch rate than a net that has been fished five times previously. However, this bias could not be quantified and was therefore neglected.

The 5 1/4" and 6" mesh sizes were compared by calculating average weights, species composition, and catch rates for each mesh size. One to three shackles of 6" mesh served as the control for one shackle of experimental net (5 1/4" mesh). Length-frequencies of sablefish were compared for the two different mesh sizes, and a X^2-test was used to determine if the sex ratio differed by mesh size.

SUMMARY OF 1983 CATCHES

A total of 360.6 metric tons (MT) was landed by the two vessels in 1983--178.9 MT of sablefish, 127.3 MT of lingcod, and 54.4 MT of rockfish. Over 80% of the combined landings were caught by the Zarana. The Zarana landed 142.7 MT of sablefish, 108.9 MT of lingcod, and 39.1 MT of rockfish, whereas the Harvester landed 36.2, 18.4, and 15.3 MT of sablefish, lingcod, and rockfish, respectively. Although the Harvester caught less than 20% of the combined landings, catches would have been greater if the sablefish and lingcod weren't dressed, and instead more nets fished. Alternatively, the Zarana's landings would have been greatly reduced had they dressed their fish.

Thirty-eight different species were observed on the vessels: sablefish, lingcod, 17 species of rockfish, and 19 other species (Tables 2 and 3). More species were observed aboard the Harvester probably as a result of the greater number of areas fished. All major species harvested by the vessels were mature adults: sablefish averaged over 4.5 kg, lingcod over 5.5 kg, and rockfish 2-5 kg, depending on species.

The largest sablefish weighed 13.2 kg (102 cm fork length). Small individuals were only rarely encountered in the nets. The smallest species observed were either entangled in the mesh (e.g., box crabs) or held in the nets by their spines (e.g., shortspine thornyheads, greenstriped rockfish, ratfish).

Sablefish comprised nearly half of the catch sampled (50.6% aboard the Harvester and 45.7% on the Zarana). Nearly one-fourth of the catch sampled on the Zarana was lingcod, but only 16.5% of the Harvester's catch contained lingcod. Conversely, rockfish composition was higher aboard the Harvester: 18.9% versus 10.7%. Other species made up 14% of the Harvester's catch (6% arrowtooth flounder, 5% spiny dogfish) and 19% of the Zarana's catch (15% arrowtooth flounder).

The most common rockfish species weighed over 2 kg. Major Sebastes spp. harvested by the set nets included silvergray, bocaccio, and canary rockfish. Silvergray rockfish was most common on the Zarana, whereas canary rockfish dominated the Harvester's rockfish landings. Red banded and yellowmouth rockfish were occasionally abundant on the Harvester.

Smaller Sebastes species were harvested by the set nets, but never in large quantities. Pacific Ocean perch was the most abundant smaller species--0.92 MT occurred in the observer's samples. But the Pacific Ocean perch averaged over 1.2 kg, which is quite high for this species, indicating that the set nets are selective for larger individuals. Furthermore, juveniles of the most common Sebastes spp. (e.g., canary rockfish) were scarce.

Major discard species included arrowtooth flounder, spiny dogfish, and ratfish--over 34 MT of turbots and 7 MT of dogfish were discarded by the two vessels on observed trips. Petrale and dover sole were the major sole species, but only 0.5 MT of sole were observed during the season.

The Zarana's catch rates exceeded those of the Harvester for all major species except canary rockfish. On the Harvester, though, the total catch rate of all Sebastes spp. combined averaged 99 kg/100 fm net, slightly greater than the Zarana's catch rate of 73 kg/100 fm net. The catch rate of the other species group (see Tables 2 and 3 for species lists) was two times greater on the Zarana, primarily due to the much lower incidence of arrowtooth flounder aboard the Harvester.

COMPARISON OF VESSEL LANDINGS WITH SAMPLE ESTIMATES

Eleven landings were estimated by each observer. The sample error exceeded ± 10% for only 3 of the 33 estimates made by the Harvester's observer (Table 4). Overall, sablefish landings were overestimated by 4.8%, lingcod was overestimated by 2.0%, and the sample error for rockfish was only -0.3%.

The total error in estimating the Zarana's landings was also fairly small, but the sample error exceeded ± 10% for 10 of the 33 comparisons (Table 5). Overall sampling errors were 4.1, -2.9, and 10.6% for sablefish, lingcod, and rockfish, respectively. The use of constant average weights obtained from only two days of sampling certainly accounts for some of this error, but inaccurate logging or counting errors are also a likely cause. Of the four rockfish landings having an error greater than ± 10%, three were overestimated by more than 35%, implying that counting errors were the primary source of error.

The differences in species composition between observed and non-observed trips summarized in Table 6 can be attributed to the non-observed trips made at the beginning and end of the season when catch rates were low for sablefish but high for lingcod.

Observed landings did not differ significantly from the total landings: $X^2 = 1.834$ and 1.903 (2 degrees of freedom) for the Zarana and Harvester, respectively. Thus the observer's samples were representative of the entire season.

Although the observed and non-observed landings were not significantly different for the Zarana ($X^2 = 4.071$, 2 d.f.), a highly significant result was obtained from the Harvester's landings ($X^2 = 24.965$, 2 d.f.). On the Harvester's last trip, the highest lingcod tonnage was caught (7,260 lbs), but only 109 pounds of sablefish were landed. Since the last trip was not sampled and only four trips were missed by the observer, the catch composition from non-observed trips differed significantly from both the observed landings and total landings.

ANALYSIS OF CATCHES BY AREA

Tremendous differences in catches existed between the different grounds. For example, on 18 August the Harvester retrieved one net set from the previous evening that yielded 79, 10, and 76 kg/100 fm net for sablefish, lingcod, and rockfish, respectively. This net was set in the North Juan de Fuca Canyon. The following day, 19 August, the Harvester retrieved two nets from the Nitinat Canyon: sablefish catch rates averaged over 900 kg/100 fm net, the lingcod catch rate was 95 kg/100 fm net, and 41 kg Sebastes spp. were caught per 100 fm net. Thus, sablefish and lingcod catch rates were approximately ten times greater in the Nitinat Canyon, one day later.

Catch Rates by the Harvester

Of the five areas sampled aboard the Harvester, the lowest CPUE occurred in the North Juan de Fuca Canyon and Grays Canyon (Table 7). Although only two nets were set in the North Juan de Fuca Canyon, the much lower catch rates observed in this area might be due to the closer proximity to land.

Large quantities of lingcod were never encountered in Grays Canyon. Comparing Grays Canyon with the combined totals of the four northern areas, CPUE of sablefish, lingcod and other species were 4, 11, and 25 times greater in the northern areas. Rockfish catch rates did not differ significantly between any of the five areas.

The much lower catch rates in Grays Canyon forced the Harvester to leave their assigned port--the vessel moved northward and sablefish catch rates soared. Whether CPUE in Grays Canyon would have improved later in the season remains unanswered.

One net was set in Grays Canyon on 12 August, but this net only soaked for 4 1/2 hours during the early afternoon. Since this net was not observed and daytime sets never yielded large quantities of sablefish, no conclusion can be made about August catch rates within Grays Canyon based upon this single net.

Catch Rates by Vessel

Catch rates of both sablefish and lingcod were greatest in the Nitinat Canyon. However, the Harvester only fished three nets in this area (note the high standard errors in Table 7). The Zarana's CPUE probably gives a more accurate portrayal of catch rates within the Nitinat Canyon area (Table 8). For the Nitinat Canyon site, the Harvester's CPUE

differed significantly from the Zarana's catch rate for only the other species group.

The catch rates of the Harvester for all areas combined were considerably lower than the Zarana's catch rates for all major species groups except rockfish. But when the Zarana's CPUE for the entire season is compared with the CPUE obtained from the northern areas fished by the Harvester, excluding the Grays Canyon area, no significant differences were found. In fact, sablefish catch rates were nearly equal. Since the Harvester fished Grays Canyon during June and July and the northern areas from August through October, the large differences in CPUE between these two areas may not be due to the area fished, but rather, time.

Average Weight

The average weights of sablefish and lingcod were fairly constant between the five areas with observer coverage, except for the South Juan de Fuca Canyon, where average weights were higher. This result is partially due to the use of the 5 1/4" test net on only 2 of the 5 days fished within the south Juan de Fuca Canyon. By mesh size though, sablefish averaged 5.31 kg in the commercial nets and 4.71 kg in the test net--considerably higher than all other areas.

Differences in the average weights of rockfish were due to changes in rockfish composition between areas. For example, the highest average weight of rockfish occurred in the Canadian border area where bocaccio comprised 60% of the rockfish catch. Canary rockfish dominated the rockfish catches of all other areas fished by the Harvester, except for the North Juan de Fuca Canyon. In this area, 51% of the rockfish observed were red banded and 37% were shortraker rockfish.

The canary-bocaccio-silvergray complex exceeded 90% of the rockfish composition in all other areas except Grays Canyon. In Grays Canyon, this complex only comprised 68% of the rockfish landings. Yellowmouth and red banded rockfish comprised 14% and 10% of the rockfish in Grays Canyon, resulting in the lowest *Sebastes* average weight of all areas. Of the 333 yellowmouth rockfish observed on both vessels, 331 were caught in Grays Canyon.

Other Species

The incidence of arrowtooth flounder and spiny dogfish differed greatly between areas. Only four dogfish were observed in the 25 nets sampled from Grays Canyon (catch rate of 0.2 kg/100 fm net). In other areas, the *Harvester*'s CPUE varied from 3.4 to 67.4 kg dogfish per 100 fm net. On the two days the *Harvester* fished the Nitinat Canyon area, 14 kg of arrowtooth flounder were caught per 100 fathoms of net fished. But the *Zarana* averaged 123 kg/100 fm net on the same grounds.

Species Composition

Although species composition varied greatly between areas, most of this variation is due to higher catch rates of sablefish from July through September, which will be further discussed in the next section. However, the significantly lower composition of lingcod within Grays Canyon can not be explained by the effect of time. Either lingcod are much less abundant in Grays Canyon, or the *Harvester*'s captain was highly successful in avoiding areas of lingcod abundance (a market limit of 5,000 pounds per trip was imposed by the *Harvester*'s buyer).

ANALYSIS OF CATCHES BY TIME

Since the *Zarana* remained in one area throughout the season, the effect of time can be analyzed best from the *Zarana*'s catches. Sablefish

CPUE was low initially, but increased dramatically after 1 July (Fig. 3). The highest lingcod catch rate calculated from observer samples occurred on the Zarana's first trip; afterward catch rates were almost constant, but decreased somewhat from 15 July to 15 August when sablefish catches were highest. The Zarana's CPUE of rockfish remained constant for all observed trips.

Although catch rates were not calculated for non-observed trips, the effect of time over the entire season can be assessed by analyzing the monthly changes in species composition from vessel landings. The landings were predominantly sablefish from July through September on both vessels (Table 9). During May, June, and October though, most of the landings were comprised of lingcod and rockfish.

Sablefish Catch Rates

Although the Harvester's catches are confounded by shifts in fishing grounds, some interesting features about this fishery are revealed by analyzing this vessel's catch rates over time. Similar to the Zarana's CPUE, sablefish catch rates were low initially but increased substantially later in the season (Fig. 4). Sablefish CPUE was never over 500 kg/100 fm net until 19 August for the Harvester, even though the vessel was on the northern grounds from 29 July onward. Since the Zarana first exceeded 500 kg sablefish/100 fm net on 29 July, this demonstrates a time lag of approximately three weeks for a vessel to explore new grounds and find concentrations of sablefish.

Assuming it takes three weeks for a new permit-holder to find productive grounds, we would conclude that high concentrations of sablefish never occurred in Grays Canyon during June or July for the depths fished. But two additional considerations deserve attention: 1) sablefish

CPUE was not that much greater aboard the Zarana prior to mid-July, and 2) the Harvester's captain explored a broader area while in the northern areas than when he was in Grays Canyon (Fig. 2). Astoria Canyon and the Quinault Canyon, for example, were never fished.

Lingcod and Rockfish Catch Rates

Whereas the Zarana experienced relatively stable catch rates of lingcod and rockfish, the Harvester's catch rates of these species appear erratic. Most of this variation, however, can be explained. After 26 July, lingcod CPUE was nearly constant except for 14 September. On this day, only one net was set--a net in which the middle two shackles became tangled when launched; hence the catch rates of all three species groups were greatly reduced from the previous day.

The variation in lingcod CPUE prior to, and including, 26 July was caused by the much lower abundance of lingcod within Grays Canyon, and secondly, the fishing of a daytime set on 22 July. The July 22 set was fished in the Nitinat Canyon from 0420 to 1145 hours. Nearly 1 MT of lingcod was caught in this day set--considerably more than any other net.

The daytime sets yielded greater amounts of lingcod and rockfish and reduced quantities of sablefish compared to nighttime sets. Catch rates of over 250 kg rockfish/100 fm net were observed only twice, both times on the Harvester. The first occasion was on 5 July, and this resulted from a daytime set.

The highest catch rate of rockfish occurred on 6 August. Nearly 2.5 MT of rockfish were caught from the two nets set on this evening. Both nets were set shallow where the color fathometer showed "red"--a dense school of fish hugging the bottom. The nets were fished at depths

from 95 to 115 fathoms and 93 to 97 fathoms, which indicates that rockfish may be more vulnerable to set nets in shallower waters. This large by-catch of rockfish was scorned by the fishermen, and such areas, although sighted again, were later avoided.

ANALYSIS OF CATCHES BY DEPTH

On 5-7 October, six nets were fished on the Prairie at depths ranging from 66 to 80 fathoms, which yielded over 3 MT of lingcod and 1 MT of *Sebastes* spp., but only 0.05 MT of sablefish. Only 1% of the landings were sablefish. The *Harvester* was targeting on lingcod during this trip, and one of the nets yielded approximately 600 kg lingcod/100 fm net during a 2-hour soak.

Three separate grounds were fished on the Prairie during this trip, indicating that large quantities of lingcod and rockfish can be caught by set net gear in shallow areas. However, because these were day sets fished during October, such results might be expected. Whether the low CPUE of sablefish and high catch rates of lingcod and rockfish were due to depth, time, or area effects can not be ascertained.

COMPARISON OF MESH SIZES

Significant differences were not found for the species composition and catch rates of the two mesh sizes (Table 10). Mean catch rates of sablefish and lingcod were nearly equal between the test (5 1/4" mesh) and control (6" mesh). CPUE of rockfish and other species averaged slightly more in the 6" mesh.

Only eight species comprised greater than 1% of the catch in each mesh size: sablefish; lingcod; silvergray, bocaccio, canary, and red banded rockfish; arrowtooth flounder and spiny dogfish. Catch rates were

remarkably similar for the first six species, but CPUE of arrowtooth flounder was twice as much in the 6" mesh (39 versus 17 kg/100 fm net), whereas dogfish catch rates in the 5 1/4" mesh exceeded the catch rate in the 6" mesh by a factor of 2 (31 versus 14 kg/100 fm net). Flatfish appear to be much less vulnerable to the smaller mesh size than dogfish.

For the eight major species, average weights ranged from 6 to 36% greater in the 6" mesh. The average weight of sablefish was 24% greater in the 6" mesh. So even though the two mesh sizes catch equal quantities in terms of weight, 24% more sablefish by number were harvested by the 5 1/4" mesh.

Pacific Ocean perch CPUE averaged 3.5 and 2.0 kg/100 fm net in the 5 1/4 and 6"-mesh nets, respectively. Thus, the 5 1/4" mesh was 75% more selective for this species, which was one of the smaller rockfish species caught by the nets. Surprisingly, the average weight of Pacific Ocean perch was slightly greater in the 5 1/4" mesh.

More than two observations of the test net occurred only in Grays Canyon and the Canadian border area. Differences between the two areas outweighed any differences between the test and control. For example, catch rates of sablefish were four times greater at the Canadian border site, but the test and control catch rates were nearly equal within each area: 114 (test) versus 99 kg/100 fm net (control) in Grays Canyon, and 485 (test) versus 429 kg/100 fm net (control) for the Canadian border area. Likewise, significant differences between the test and control were not found for the three other species groups.

Catch Rates in Relation to Relative Depth of Test Net

CPUE differed according to whether the test net shackle was tied to the shallow or deep end of the control (three shackles of 6" mesh). When

the test net was tied to the shallow end of the net, the test net outfished the control for all four species groups (Table 11). Conversely, the control CPUE was considerably higher when the test net was tied to the deep end, again for all four species groups.

Since the shallowest shackle(s) caught the most fish, regardless of mesh size, these results indicate that more fish are caught in the shallower shackles. These results confirm observations made on board the vessels this summer: the shallowest section generally contained the most fish and the deepest shackle the fewest.

Sablefish Sex Ratio

From the two test nets sampled on 20 and 21 September, the sex ratios were 53.5 and 69.2% female. A X^2 test revealed that the sex ratios of the two nets were not significantly different at the 5% level (X^2 = 3.5222, 1 d.f.). The pooled estimate of the sex ratio thus became 58.8% female from 153 sablefish sexed.

A total of 433 sablefish were sexed from four 6"-mesh nets, where sex ratios of 61.7, 76.8, 77.3, and 78.7% females were obtained. Because three of the nets only differed by 2% and the fourth was much lower, pooling was not justified (X^2 = 11.777, 3 d.f.). If the lowest sex ratio is omitted, the three other nets can be pooled (X^2 = 0.118, 2 d.f.) and the sex ratio becomes 77.7% female. All four nets combined averaged 73.0% female.

Regardless of whether the lowest sex ratio obtained from the commercial nets is discarded, the sex ratio of the test net differed significantly from the control (X^2 = 10.645 when all four commercial nets are pooled;

X^2 = 17.787 when only three were pooled; 1 d.f.). Accordingly, the 5 1/4" mesh nets averaged 58.8% female, which differed significantly from the commercial net average of 77.7% (outlier removed, $p < .001$). The 6"-mesh consequently harvests 32% more females than the 5 1/4" mesh.

Sablefish Length-Frequency Analysis

The 6" mesh was more selective for larger fish (Fig. 5). Although the sample size was small, the relative length-frequency distributions of both sexes are shifted to the right for the commercial nets. Only 6.4% of the males and 16.7% of the females sampled from the test net were greater than 70 cm. However, the 6" mesh contained 47.0% males and 62.7% females over 70 cm in length.

Mean length differed both by mesh size and sex. Males averaged 62.92 cm and 69.66 cm in the 5 1/4 and 6" mesh, respectively. Corresponding mean lengths of females were 66.63 and 72.42 cm. Males caught by the test net averaged nearly 7 cm less than those in the commercial nets, and females in the test net averaged 6 cm less than those in the 6" commercial net.

INCIDENCE OF PROHIBITED SPECIES

Sixty net lifts were observed for prohibited species on the *Zarana* and 57 on the *Harvester*. One chinook and one coho salmon were observed on each vessel during the entire season and all four salmon were caught before 7 July. Both salmon caught by the *Harvester* were captured in the 5 1/4" mesh. The king salmon caught by the *Zarana* was from the 6" mesh; no mesh size was recorded for the coho salmon.

A total of 165 Pacific halibut were observed from the 20 days sampled on the *Zarana*, for an average of 8.25 halibut per day (the range was 3-21/day). On the *Harvester*, 72 halibut averaging 8 kg were observed

from the 28 days sampled. An average of 2.57 halibut were caught per day (range = 0-8/day). The Harvester's catch rate was somewhat lower than the Zarana's CPUE: 4.1 versus 6.1 kg/100 fm net fished.

The incidence of halibut was random with respect to area and time, but a five-fold difference existed between the two mesh sizes. Only 2 of the 72 halibut observed on the Harvester were caught in the 5 1/4" mesh (0.9 kg/100 fm net). In the 6" mesh, 5.0 kg of halibut were caught per 100 fathoms of net.

The condition of halibut was almost equally divided between the three categories: 22 were judged excellent, 24 poor, and 26 were dead. Possible halibut survival, therefore, ranged from 31 to 64%, depending upon the survival of the halibut classified as poor; the actual survival rate was probably near the lower range.

WASTAGE

Waste losses included dogfish predation, sandflea infestation, fish falling out as the net cleared the water, and discards. For the commercially important species, fish falling out of the net was usually the major loss.

Sablefish and lingcod were the only species suffering any significant losses. A total of 276 out of 6,813 observed sablefish were lost (4%) whereas only 57 lingcod were lost. Sand flea infestation was more prevalent in Gray Canyon compared to the northern areas; dogfish predation only occurred in the northern areas (only 4 dogfish were observed in Grays Canyon).

Dogfish predation can cause significant losses. On 24 August, one net soaked for 16 hours until 1430 hours. Eighty sablefish (34% of the sablefish catch) and 33 lingcod (39% of lingcod catch) were discarded due

to dogfish predation. Subsequent nets set in the same area, but with a shorter soaking time, did not encounter this problem.

DISCUSSION

The two vessels operated under experimental fishing permits for set netting groundfish in 1983 to determine the suitability of set-net gear in harvesting bottomfish and to estimate the impacts of the widespread usage of such gear. With regards to the first objective, set nets not only proved to be effective in harvesting groundfish, but the success of the Harvester reveals that first-time permit-holders can conduct a profitable operation with such gear.

Over 360 metric tons of sablefish, lingcod, and rockfish were landed by the two vessels this summer--an average of nearly 5 metric tons per vessel-day. The set-nets are selective for large, mature fish, yielding a prime-quality product for consumers.

With just two vessels fishing set-net gear in 1983, no adverse impacts on other resources or resource users were witnessed. Many questions have been answered from the data collected this year, but I would recommend the collection of data from one more fishing season before making a decision on the general usage of set nets to catch groundfish for the following reasons:

1) Tremendous fluctuations existed in the catches, by both area and time; therefore impacts of set-net gear may not have been fully realized this summer.
2) Only a few net sets were fished in depths shallower than 90 fathoms.
3) Additional biological data (e.g., length frequencies and sex ratio) on the catch of the important species is needed to evaluate selectivity of the gear and assess the impact on the stocks.

4) 1983 was characterized by much higher water temperatures and little upwelling. Thus, this year's results may not be indicative of the norm.

For the above reasons, one should be cautious in extending this year's results to the widespread use of set-net gear in the ocean. But several conclusions, perhaps tentative, can be drawn from the 1983 fishery. First, the effectiveness of set-net gear in targetting on sablefish is dependent on an up-slope migration by this species. This year's results indicate that a season from July through September is optimal in maximizing sablefish landings and minimizing the incidental catch of lingcod and rockfish: 93% of the total sablefish landings occurred during these months. Perhaps more significant, though, is that a July-September season would reduce lingcod landings by over 50% and rockfish landings by 30%.

Secondly, it doesn't appear that profitable catch rates can be obtained off the southern Washington coast (e.g., Grays Canyon) during June and July. However, I am still not convinced that large quantities of sablefish cannot be caught in Grays Canyon during August, September, and perhaps even October. If high concentrations of sablefish do in fact occur during these months, this is certainly desirable in terms of spreading out the set-netting vessels over a larger area to more fully understand the impacts of a set-net fishery (experimental phase) and minimizing potential gear conflicts.

A third conclusion is that nets set in shallower waters on the continental shelf yield reduced catches of sablefish, but potentially large catches of lingcod and rockfish. This might be expected since mature

sablefish are not commonly found on the shelf proper. More observations of nets set in shallower depths (50-100 fathoms) are needed to determine whether the use of submerged gill nets should be permitted at these depths.

Fourthly, we can conclude that a 6" mesh is preferable to a 5 1/4" mesh if large fish are desirable. Species composition and catch rates were nearly equivalent for the two mesh sizes, but the 5 1/4" mesh harvested smaller individuals and a higher percentage of male sablefish. If an equal sex ratio is desired for the sablefish harvests, the 5 1/4" mesh would be preferred. Since sablefish were only sexed from two days of sampling, more sex-length data is required for this species and perhaps others (e.g., lingcod) by mesh size.

A fifth conclusion we can make is that the incidence of salmon and halibut in the gear is low for the two vessels fishing in 1983. This conclusion is supported by Leo Cramer, captain of the Zarana, who claims that salmon are simply not vulnerable to the gear at the depths fished.

An important concern of an expanded ocean set-net fishery is the potential for some vessels (e.g., smaller boats) to target on rockfish and lingcod. The magnitude of the bycatch of halibut and salmon of such a fishery operating in areas and seasons other than those fished in 1983 cannot be forcasted from the current data. Such a fishery would also compete with trawlers and jig boats fishing groundfish. If the Zarana can land 10,000 pounds of rockfish and 30,000 pounds of lingcod as incidental catch, smaller vessels might enjoy lucrative profits by targetting on these species if markets are available. However, the data collected in 1983 indicates that season and area (depth) restrictions could minimize this adverse impact on other species and user groups. Furthermore, the damage inflicted on set-net gear by targetting on lingcod and rockfish might be cost-prohibitive--the time and money required to rehang nets could render such an operation unprofitable.

Another consideration that must be addressed is the potential for gear conflicts. Only two minor gear conflicts occurred this summer; but as more vessels enter this fishery, gear conflicts might become a nuisance. Modifications in marking the gear (e.g., the use of strobe lights instead of light bulbs on the poles) may decrease this impact, but the principal means of minimizing gear conflicts would be for the vessels to voluntarily fish as far apart from one another as possible. Again, the question of whether profitable catch rates can be sustained in southern Washington (and Oregon) remains unanswered.

Ghost fishing is another legitimate concern for this fishery. No nets were lost in the summer of 1983. If the requirement of the use of cotton twine to secure the floats to the float-line is enforced, ghost fishing by lost nets should be temporary. The vessel owners have substantial investments in their gear, and every effort possible was made to insure that their gear wasn't lost.

Finally, the proper disposal of old mesh should be encouraged. During one season, up to 20 nets may be rehung by each vessel. This old net was discarded on land in 1983, but improper disposal of old mesh at sea by a much larger fleet could lead to harmful environmental consequences.

In summary, observations of the 1983 set net fishery have shown that set nets are a very effective and efficient gear type for harvesting groundfish. Although no significantly adverse impacts were witnessed this summer, I don't believe the widespread usage of set nets can be fully assessed from just this data set.

I recommend the issuance of up to five experimental fishing permits for a 1984 set-net fishery. The sole objective in issuing these permits should be to provide the Council with enough information so that a reasonable

decision can be made concerning the legalization of ocean set-nets at the conclusion of the 1984 season.

The following plan is suggested:

1. Criteria should be established to evaluate the fishery in order for the Council to make a decision. Conditions that would prevent the legalization of a set-net fishery must be clarified.
2. A sufficiently detailed experimental design must be established to generate the necessary information.
3. Experimental fishing permits should be issued from 1 May to 31 October to collect the data.

The most important information to be collected is data from shallower regions (e.g., 50-100 fathoms) and observations from the southern Washington (and Oregon) during August through October. If a set-net fishery were to become legal, such information would be useful in establishing appropriate regulations. A 1984 set-net fishery should also either validate or invalidate conclusions drawn from the 1983 fishery.

One constraint that must be realized is that permit holders must make a profit wherever and whenever they fish. Thus, confining a vessel to an unprofitable area will not work, as confirmed by the Harvester's fishing activities this summer. However, if all permit holders fish just one area (e.g., Nitinat Canyon), insufficient data will be obtained to make a decision on the widespread usage of set-net gear. These two trade-offs must be fairly balanced so that all permit holders make a profit, and secondly, as much data as possible is generated from different areas with respect to time.

Table 1.--Areas fished, fishing effort, and sampling effort for the ZARANA and HARVESTER during the 1983 season.

Vessel/Areas Fished	Dates Fished	Days on Grounds	No. Nets Set	No. Nets Sampled	Total Net Length Sampled (100's of fathoms)
ZARANA					
Nitinat Canyon	5/18 - 10/12	41	118	60	242.00
HARVESTER					
Grays Canyon	6/28-7/26, 8/12	11	26	25	56.67
Nitinat Canyon	7/22, 8/19	2	3	3	7.33
South Juan de Fuca Canyon	7/29 - 8/11	8	13	10	24.67
North Juan de Fuca Canyon	8/18	1	2	2	4.67
Canadian Border	8/24 - 9/29	12	21	17	45.33
Praire	10/5 - 10/7	3	6	0	0.00
		37	71	57	138.67

TABLE 2: Season totals for all species sampled aboard the HARVESTER.

	TOTAL NUMBER	TOTAL WEIGHT (KG)	AVERAGE WEIGHT (KG)	SPECIES COMP. (%)	CATCH RATE (KG/100 FM NET)
SABLEFISH	7952	36825.4	4.63	50.640	265.574
LINGCOD	2021	11971.3	5.92	16.462	86.334
ROCKFISH					
SILVERGRAY	870	2162.3	2.49	2.973	15.594
BOCACCIO	813	3766.9	4.63	5.180	27.166
CANARY	2438	5725.6	2.35	7.873	41.291
PAC OCEAN PERCH	201	241.1	1.20	0.332	1.739
RED BANDED	381	840.0	2.20	1.155	6.058
GREENSTRIPED	59	28.9	0.49	0.040	0.208
WIDOW	28	46.8	1.67	0.064	0.338
YELLOWEYE	8	27.6	3.45	0.038	0.199
YELLOWTAIL	48	95.0	1.98	0.131	0.685
YELLOWMOUTH	333	712.7	2.14	0.980	5.140
BLACK	4	7.6	1.90	0.010	0.055
SHARPCHIN	17	11.1	0.65	0.015	0.080
SPLITNOSE	3	3.0	1.00	0.004	0.022
REDSTRIPE	5	3.5	0.70	0.005	0.025
SHORTRAKER	14	77.7	5.55	0.107	0.560
ROUGHEYE	1	1.4	1.40	0.002	0.010
OTHER SPECIES					
SHORTSP THNYHD	67	91.9	1.37	0.126	0.663
ARROW. FLOUNDER	2063	4503.9	2.18	6.194	32.481
SPINY DOGFISH	1568	3544.6	2.26	4.874	25.563
RATFISH	726	484.2	0.67	0.666	3.492
PACIFIC HALIBUT	72	569.9	7.92	0.784	4.110
PACIFIC COD	46	125.3	2.72	0.172	0.904
PACIFIC WHITING	23	31.9	1.39	0.044	0.230
SILVER SALMON	1	2.5	2.45	0.003	0.018
KING SALMON	1	1.8	1.82	0.003	0.013
SOUPFIN SHARK	2	44.8	22.40	0.062	0.323
BOX CRAB	288	191.9	0.67	0.264	1.384
LONGNOSE SKATE	57	500.0	8.77	0.688	3.606
POLLOCK	1	2.1	2.10	0.003	0.015
BLACK SKATE	1	0.5	0.50	0.001	0.004
PETRALE SOLE	16	45.7	2.86	0.063	0.330
REX SOLE	8	2.5	0.31	0.003	0.018
DOVER SOLE	29	24.1	0.83	0.033	0.174
ENGLISH SOLE	2	1.8	0.90	0.002	0.013
FLATHEAD SOLE	4	2.6	0.65	0.004	0.019
TOTAL	20171	72719.9	3.61	100.000	524.438

TABLE 3: Season totals for all species sampled aboard the ZARANA.

	TOTAL NUMBER	TOTAL WEIGHT (KG)	AVERAGE WEIGHT (KG)	SPECIES COMP. (%)	CATCH RATE (KG 100 FM NET)
SABLEFISH	18751	88628.0	4.73	45.744	366.231
LINGCOD	8676	47347.6	5.46	24.438	195.651
ROCKFISH					
SILVERGRAY	3456	9073.2	2.63	4.683	37.493
BOCACCIO	1318	6875.6	5.22	3.549	28.411
CANARY	1207	3142.8	2.60	1.622	12.987
PAC OCEAN PERCH	516	676.0	1.31	0.349	2.793
RED BANDED	325	541.7	1.67	0.280	2.238
GREENSTRIPED	239	126.3	0.53	0.065	0.522
WIDOW	26	49.4	1.90	0.025	0.204
YELLOWEYE	10	51.0	5.10	0.026	0.211
ROSETHORN	1	1.0	1.00	0.001	0.004
YELLOWTAIL	61	120.7	1.98	0.062	0.499
OTHER SPECIES					
SOLE, UNIDENT.	305	450.2	1.48	0.232	1.860
SHORTSP THNYHD	51	30.6	0.60	0.016	0.126
ARROW. FLOUNDER	13890	29863.5	2.15	15.414	123.403
SPINY DOGFISH	2121	3681.7	1.74	1.900	15.214
RATFISH	1168	807.0	0.69	0.417	3.335
PACIFIC HALIBUT	165	1479.5	8.97	0.764	6.114
SKATE, UNIDENT.	66	442.2	6.70	0.228	1.827
PACIFIC COD	59	148.6	2.52	0.077	0.614
PACIFIC WHITING	45	69.8	1.55	0.036	0.288
SILVER SALMON	1	2.3	2.27	0.001	0.009
KING SALMON	1	4.1	4.08	0.002	0.017
SOUPFIN SHARK	6	134.4	22.40	0.069	0.555
TOTAL	52464	193747.2	3.69	100.000	800.606

Table 4.--Delivered weights, observer estimates, and sampling error for major species landed by the HARVESTER.

Date Landed	Days at Sea	Sablefish Pounds Landed	Sablefish Sample Estimate	Sablefish % Error	Lingcod Pounds Landed	Lingcod Sample Estimate	Lingcod % Error	Rockfish Pounds Landed	Rockfish Sample Estimate	Rockfish % Error
6/28	1	836	940	12.44	39	42	7.69	434	506	16.59
6/30	1	1,464	1,489	1.71	640	591	-7.66	1,525	1,632	7.02
7/6	2	1,291	1,286	0.39	92	93	1.09	3,148	3,110	1.21
7/8[a]	2		2,249			248			1,119	
7/19	3	3,463	3,671	6.01	407	399	-1.97	3,955	4,032	1.95
7/26	2	2,049	1,960	-4.34	2,285	2,344	2.58	1,360	1,404	3.24
7/30	2	6,710	7,070	5.37	1,945	1,979	1.75	1,580	1,542	-2.41
8/6	3	4,034	4,004	-0.74	5,025	4,725	-5.97	6,820	6,569	-3.68
8/12	4	880			4,897			1,070		
8/19	2	10,080	10,120	0.40	1,075	1,193	10.98	860	875	1.74
8/26	3	14,237	15,369	7.95	4,304	4,440	3.16	2,740	2,711	-1.06
9/3	3	13,117	14,070	7.27	3,872	4,035	4.21	2,375	2,358	-0.72
9/16	3	11,511			3,464			1,634		
9/21	2	7,259	7,660	5.52	4,324	4,641	7.33	2,645	2,623	-0.83
9/29	1	464			693			300		
10/7	3	109			7,260			2,072		
Total	37	79,753			40,570			33,637		

[a] Fish ticket lost

Table 5.--Delivered weights, observer estimates, and sampling error for major species landed by the ZARANA.

Date Landed	Days at Sea	Sablefish Pounds Landed	Sablefish Sample Estimate	Sablefish % Error	Lingcod Pounds Landed	Lingcod Sample Estimate	Lingcod % Error	Rockfish Pounds Landed	Rockfish Sample Estimate	Rockfish % Error
5/18	1	1,060			6,804			662		
5/29	3	940			26,876			9,768		
6/6	2	3,904			28,292			9,053		
6/20	1	1,878	1,375	-26.78	15,178	14,546	-4.16	2,404	2,325	-3.29
6/24	1	948			8,925			3,777		
6/30	1	3,665	3,407	-7.04	7,961	7,195	-9.62	2,535	2,702	6.59
7/7	2	14,145	13,515	-4.45	15,316	13,968	-8.80	5,800	5,992	3.31
7/11	2	17,712			6,655			5,399		
7/17	1	7,421			2,777			2,606		
7/19	1	6,219	6,700	7.73	2,052	1,444	-29.63	2,824	2,414	-14.52
7/24	3	18,197	20,278	11.44	10,234	10,166	-0.66	9,589	10,467	9.16
7/30	2	32,129	35,971	11.96	6,983	7,135	2.18	2,514	2,754	9.55
8/6	3	23,721	22,206	-6.39	13,816	13,331	-3.51	7,070	7,471	5.67
8/10	2	37,841	35,700	-5.66	9,074	10,347	14.03	2,242	3,055	36.26
8/13	1	5,155	4,950	-3.98	1,027	1,011	-1.56	1,682	1,736	3.21
8/19	1	13,555			4,602			2,070		
8/22	2	34,490			4,937			5,069		
8/26	2	17,095	18,788	9.90	14,338	13,619	-5.01	2,900	4,297	48.17
9/4	2	27,577	32,501	17.86	11,505	11,622	1.02	1,606	2,331	45.14
9/13	2	27,394			14,664			1,465		
9/16	1	6,806			530			275		
9/24	1	1,428			9,917			1,428		
10/1	2	6,277			5,968			1,614		
10/12	2	4,957			11,625			1,845		
Total	41	314,514			240,056			86,197		

Table 6. Species composition of observed, non-observed, and total landings of sablefish, lingcod, and rockfish for each vessel.

	Species Composition (%)		
	Sablefish	Lingcod	Rockfish
Zarana Landings			
Observed	55.8	32.0	12.2
Non-observed	41.7	43.5	14.8
Total	49.1	37.5	13.4
Harvester Landings			
Observed	55.8	20.3	23.9
Non-observed	37.7	47.5	14.8
Total	51.8	26.4	21.8

TABLE 7: Catch statistics for the HARVESTER, by area.

	TOTAL NUMBER	TOTAL WEIGHT (KG)	AVERAGE WEIGHT (KG)	SPECIES COMP. (%)	CATCH RATE (KG/100 FM NET) MEAN	SE OF MEAN
			GRAYS CANYON			
SABLEFISH	1188	5330.2	4.49	40.6	91.387	12.208
LINGCOD	131	692.7	5.29	5.3	12.801	3.168
ROCKFISH	2168	4903.0	2.26	37.3	88.662	20.812
OTHER SP	1193	2210.0	1.85	16.8	38.584	4.955
			NITINAT CANYON			
SABLEFISH	937	4428.8	4.73	63.6	626.629	275.375
LINGCOD	260	1418.9	5.46	20.4	187.611	90.153
ROCKFISH	247	671.2	2.72	9.6	85.724	48.436
OTHER SP	294	440.7	1.50	6.3	59.200	20.434
			SOUTH JUAN DE FUCA CANYON			
SABLEFISH	958	5046.4	5.27	38.5	198.883	37.886
LINGCOD	448	3048.2	6.80	23.2	125.902	14.581
ROCKFISH	1438	3709.4	2.58	28.3	152.638	64.686
OTHER SP	813	1314.4	1.62	10.0	53.302	6.698
			NORTH JUAN DE FUCA CANYON			
SABLEFISH	80	373.8	4.67	39.8	80.287	1.313
LINGCOD	17	97.3	5.72	10.4	22.619	12.381
ROCKFISH	84	210.4	2.51	22.4	39.843	36.693
OTHER SP	139	258.3	1.86	27.5	55.175	1.225
			CANADIAN BORDER			
SABLEFISH	4789	21646.2	4.52	56.1	477.484	52.855
LINGCOD	1165	6714.2	5.76	17.4	148.106	25.139
ROCKFISH	1286	4257.2	3.31	11.0	93.908	20.593
OTHER SP	2536	5948.6	2.35	15.4	131.218	21.195
			NORTHERN AREAS			
SABLEFISH	6764	31495.2	4.66	52.9	379.583	47.048
LINGCOD	1890	11278.6	5.97	18.9	137.029	16.719
ROCKFISH	3055	8848.2	2.90	14.9	108.116	23.392
OTHER SP	3782	7962.0	2.11	13.4	95.366	13.299

TABLE 8: Catch statistics for each vessel, compiled over the entire season.

	TOTAL NUMBER	TOTAL WEIGHT (KG)	AVERAGE WEIGHT (KG)	SPECIES COMP. (%)	CATCH RATE (KG/100 FM NET) MEAN	SE OF MEAN
			HARVESTER			
SABLEFISH	7952	36825.4	4.63	50.6	253.179	32.880
LINGCOD	2021	11971.3	5.92	16.5	82.542	12.514
ROCKFISH	5223	13751.2	2.63	18.9	99.583	15.910
OTHER SP	4975	10172.0	2.04	14.0	70.461	8.588
			ZARANA			
SABLEFISH	18751	88628.0	4.73	45.7	371.825	52.012
LINGCOD	8676	47347.6	5.46	24.4	197.413	25.610
ROCKFISH	7159	20657.7	2.89	10.7	84.385	7.303
OTHER SP	17878	37113.9	2.08	19.2	151.623	19.852

Table 9. Monthly species composition of vessel landings for sablefish, lingcod, and rockfish.

		Species Composition (%)		
	Month	Sablefish	Lingcod	Rockfish
ZARANA	May	4.4	73.0	22.6
	June	11.7	68.2	20.1
	July	56.9	26.1	17.0
	August	65.7	23.8	10.5
	September	60.4	35.0	4.6
	October	34.8	54.5	10.7
HARVESTER	June	46.6	13.7	39.7
	July	49.4	15.6	35.0
	August	52.2	27.3	20.5
	September	77.6	17.4	5.0
	October	1.2	76.9	21.9

TABLE 10: Catch statistics for test (5 1/4" mesh) and control (6" mesh) nets for 21 observations made aboard the HARVESTER.

	TOTAL NUMBER	TOTAL WEIGHT (KG)	AVERAGE WEIGHT (KG)	SPECIES COMP. (%)	CATCH RATE (KG/100 FM NET) MEAN	SE OF MEAN
			5 1/4" MESH			
SABLEFISH	1061	3955.3	3.73	57.5	282.521	46.748
LINGCOD	247	1263.0	5.11	18.3	90.214	23.322
ROCKFISH	381	863.8	2.27	12.5	61.700	10.389
OTHER SP	479	802.5	1.68	11.7	57.319	11.817
			6" MESH			
SABLEFISH	2511	11573.2	4.61	57.4	281.826	61.530
LINGCOD	536	3216.7	6.00	16.0	89.367	24.659
ROCKFISH	995	2714.3	2.73	13.5	87.106	23.697
OTHER SP	1236	2659.6	2.15	13.2	67.614	9.992

Table 11. Comparison of the catch rates of test net (5-1/4" mesh) and commercial nets (6" mesh), stratified by the relative depth of the test net.

		Catch Rate (kg/100 fm Net)			
Depth of Test Net Shackle	Species	Test Net		Commercial Net	
		Mean	SE of Mean	Mean	SE of Mean
Shallow	Sablefish	338.5	69.67	271.9	73.82
	Lingcod	130.7	36.35	95.0	34.41
	Rockfish	78.9	15.74	66.7	14.70
	Other Sp	78.5	15.21	76.6	15.71
Deep	Sablefish	207.9	51.31	294.9	109.80
	Lingcod	36.2	10.59	81.9	36.93
	Rockfish	38.8	7.80	114.3	52.15
	Other Sp.	29.0	5.60	55.6	9.92

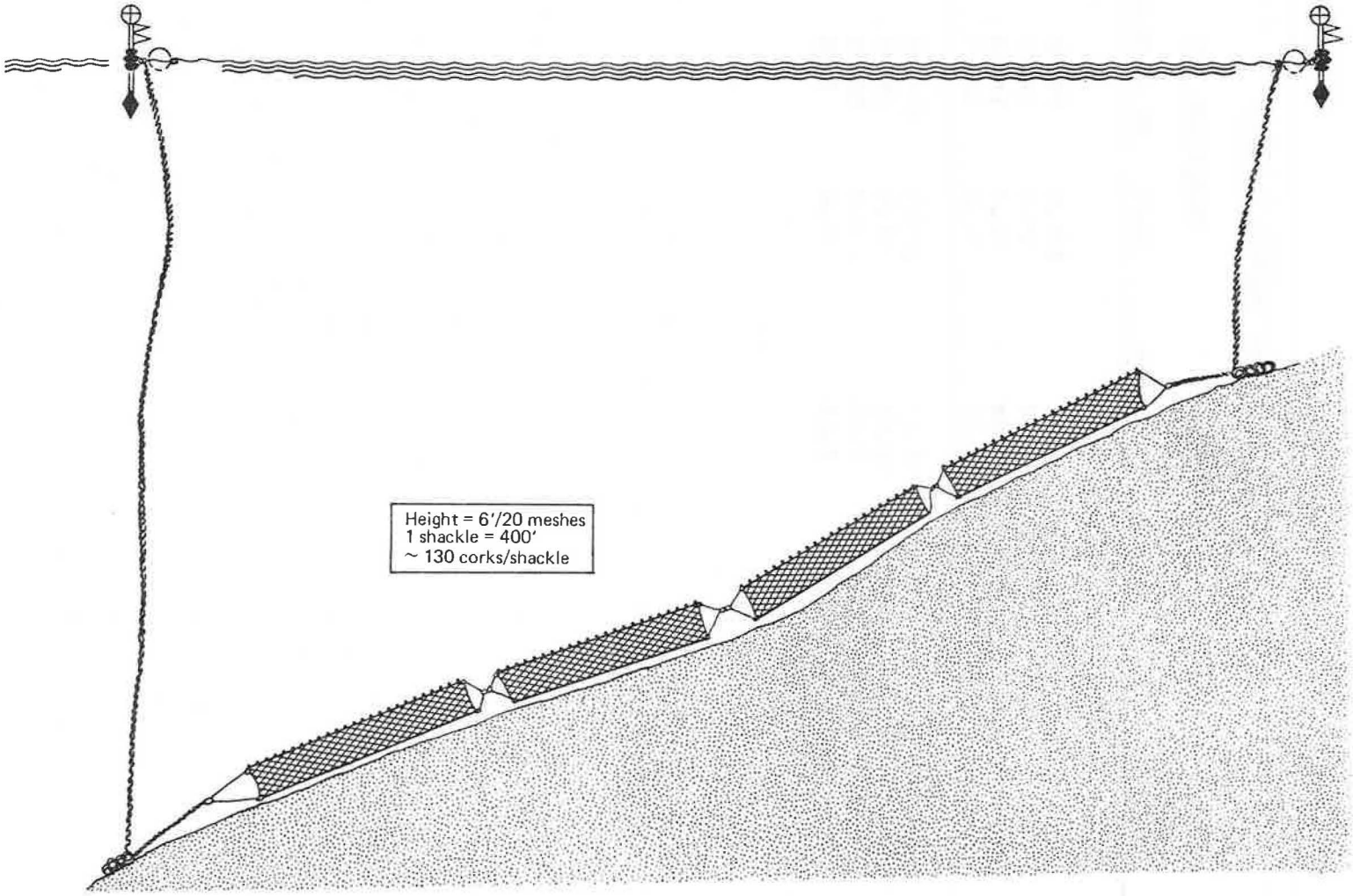

Figure 1. Typical set-net configuration used by the Harvester.

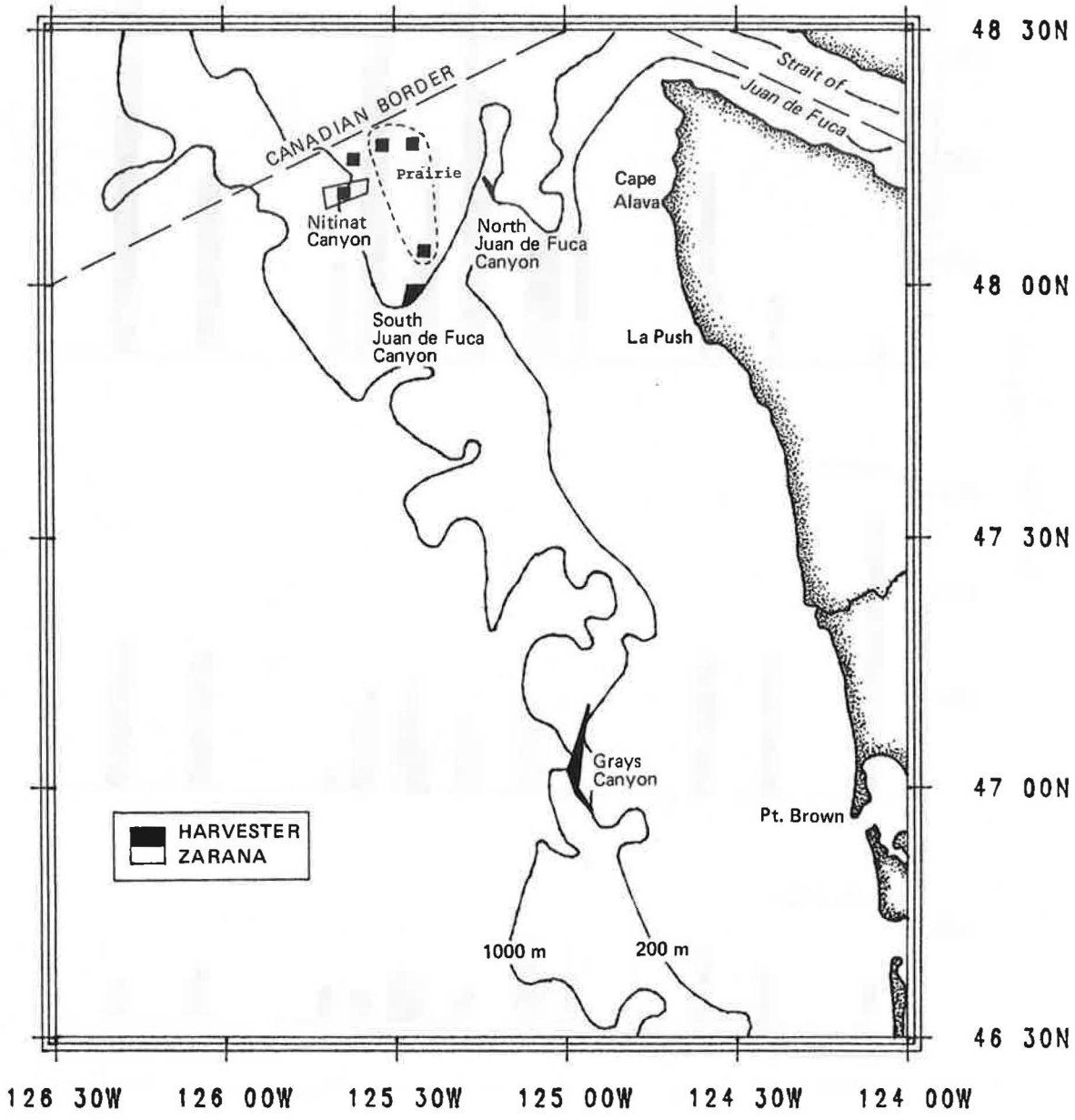

Figure 2. Areas fished by the Harvester and Zarana during the 1983 season.

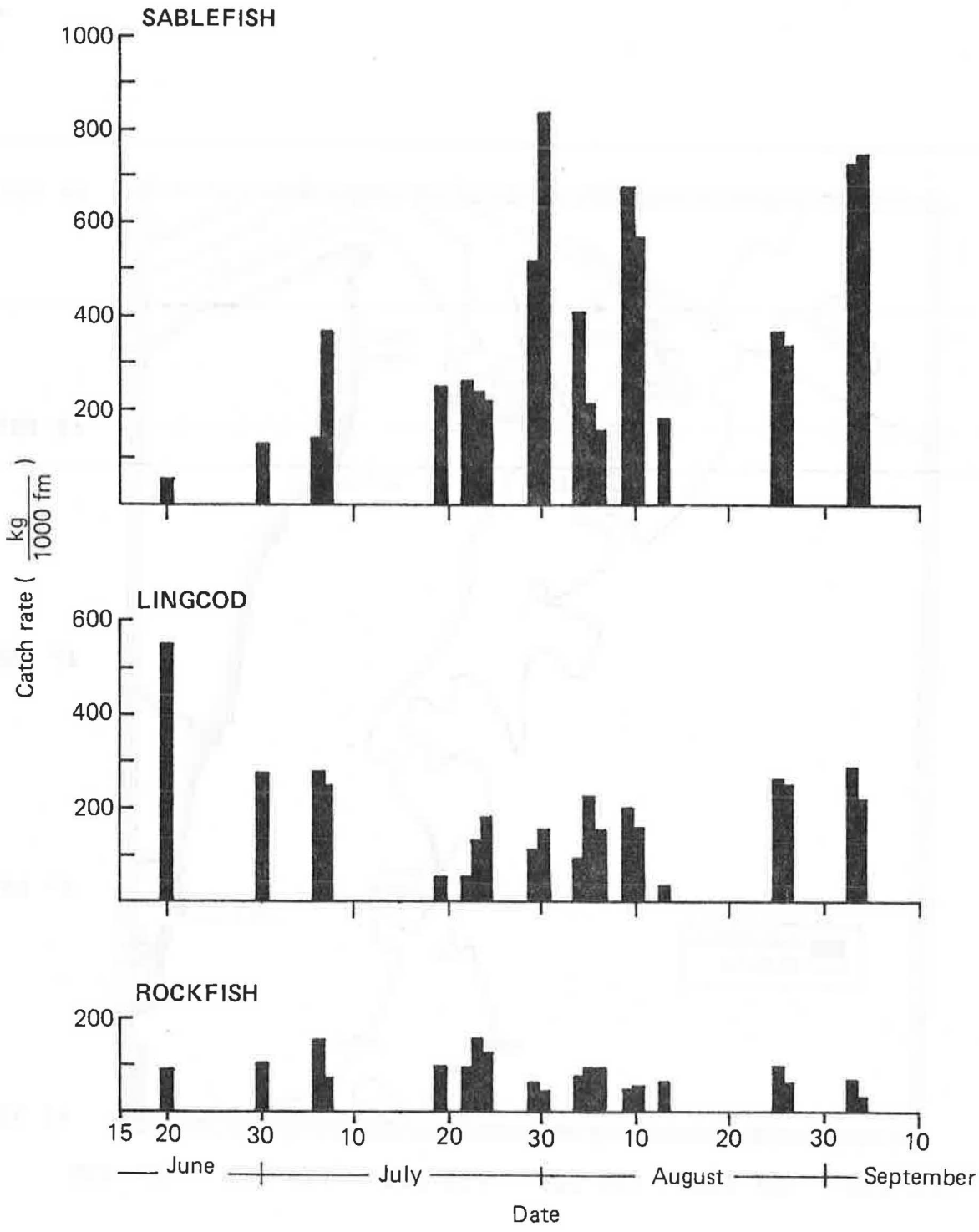

Figure 3. Daily catch rates of sablefish, lingcod, and rockfish on observed dates aboard the Zarana.

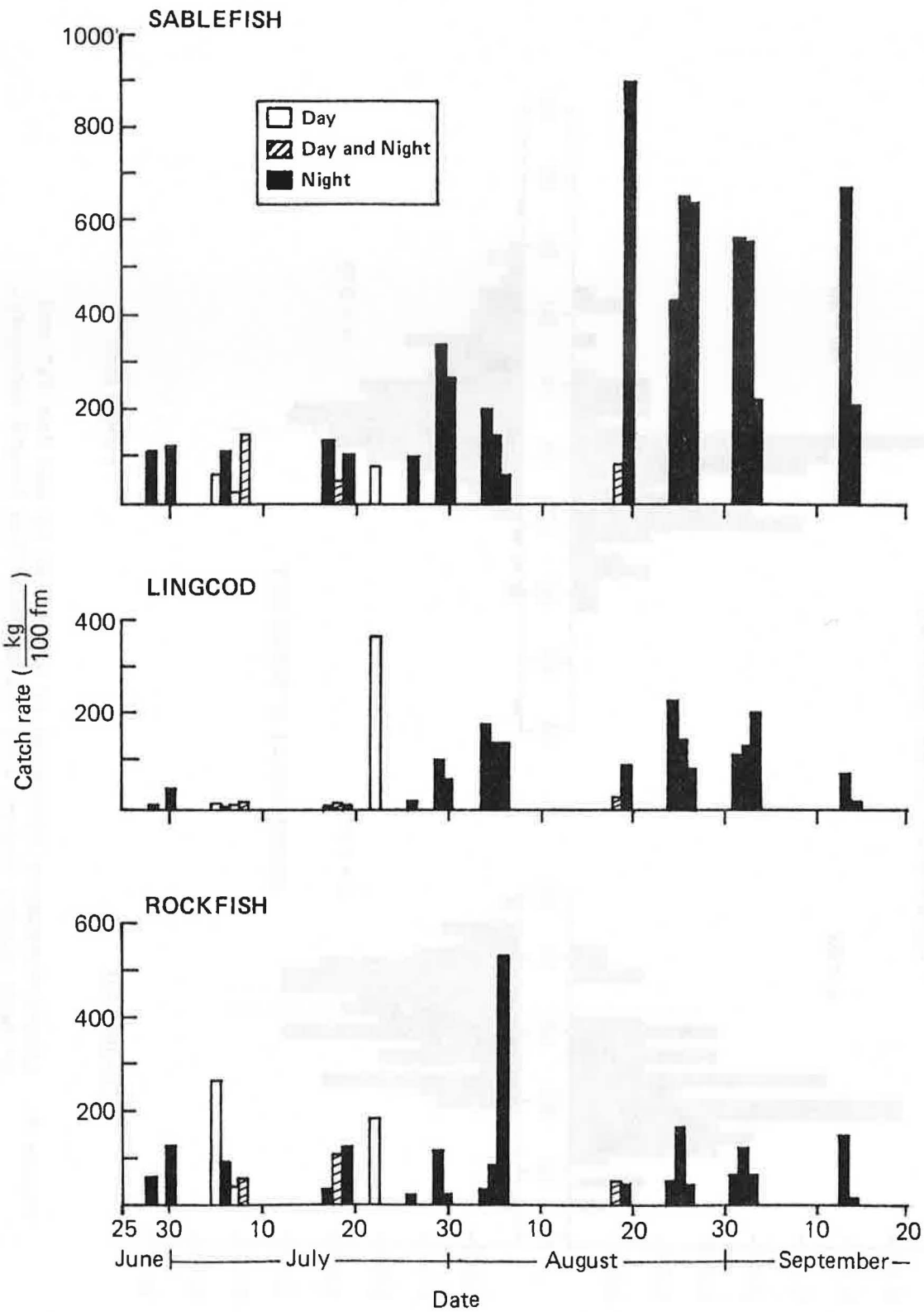

Figure 4. Daily catch rates of sablefish, lingcod, and rockfish on observed dates aboard the Harvester; daytime sets are denoted by open bars, nighttime by black bars, and the combination of day and night sets by cross-hatched bars.

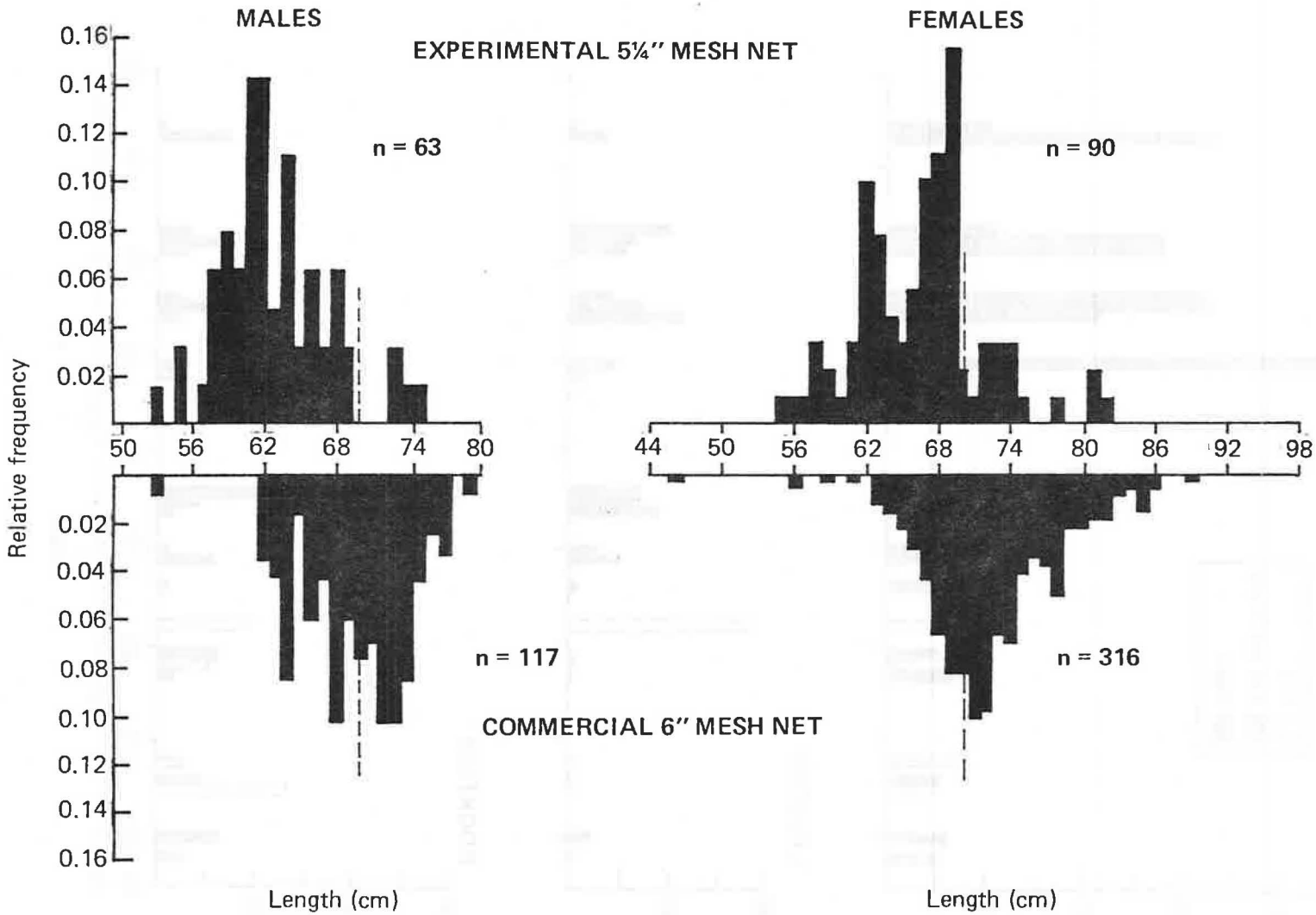

Figure 5. Length-frequency histogram of sablefish by sex for 5¼" and 6" mesh sizes, dashed line references 70cm length category.