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I. Reducing the Incidental Catch of Prohibited Species in the Bering Sea Groundfish Fishery Through Gear Restrictions

by

Vidar G. Wespestad, Stephen H. Hoag, and Renold Narita

II. A Comparison of Pacific Halibut and Tanner Crab Catches in (1) Side-Entry and Top-Entry Crab Pots and (2) Side-Entry Crab Pots With and Without Tanner Boards

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ABSTRACT

The retention of several fully-utilized species (salmon, halibut, and crab) is prohibited in the Bering Sea groundfish fisheries. These prohibited species, however, are caught incidentally to groundfish, and the incidental catch reduces the yield available to the directed fisheries. The incidental catch of prohibited species is generally less with longlines or off-bottom trawls than with on-bottom trawls. Thus, one possible solution is to restrict the type of gear used in the groundfish fishery. This report examines the effect of restricting on-bottom trawls with respect to the production of groundfish as well as the catch of prohibited species. The results suggest that most of the available groundfish could be harvested with longlines and off-bottom trawls with a substantial reduction (over 80%) in the incidental catch of prohibited species. Allowing limited on-bottom trawling for flounders could minimize the loss of groundfish production and still provide for a reduction (over 60%) in the catch of prohibited species. Economic considerations were not examined, although the report recognizes that gear restrictions would likely increase the harvesting cost of some groundfish species.

I. Reducing the Incidental Catch of Prohibited Species in the Bering Sea Groundfish Fishery Through Gear Restrictions

by

Vidar G. Wespestad[1], Stephen H. Hoag[2], and Renold Narita[1]

INTRODUCTION

In the Bering Sea groundfish fisheries, the retention of salmon *(Onchorhynchus* spp.*)*, halibut *(Hippoglossus stenolepis),* king crab *(Paralithodes* spp.*),* and Tanner crab *(Chionoecetes* spp.*)* is prohibited. These species are essentially fully utilized in directed fisheries, and trawls (the primary gear used in the groundfish fisheries) tend to catch individuals of sub-optimal size. Also, most groundfish are harvested by foreign nationals whereas the directed fisheries are by United States nationals. Prohibiting retention is intended to eliminate any incentive to direct fishing effort on these species, all of which are of higher unit economic value than groundfish. Nevertheless, these species are caught incidentally and many die from injuries received during capture. This incidental catch not only reduces the yield available to the directed fisheries, but constitutes a conservation and management problem in that the catch is unspecified and difficult to estimate precisely. Hence, the incidental catch combined with the directed catch may result in excessive exploitation. This was apparently the case with halibut stocks in the 1960's and 1970's (Bell 1970, Skud 1973, Hoag 1976).

Hoag and Skud (1975) examined general management approaches to the problem of incidental catches in a multi-species fishery, and the North Pacific Fishery Management Council (unpublished)[3] has examined specific management options for the Bering Sea groundfish fishery. One of the options that could reduce incidental catches, while permitting harvesting of most groundfish species, is some form of gear restriction.

This report examines two possible management alternatives involving gear restrictions: (1) prohibit on-bottom trawls in all areas, i.e., groundfish will be harvested only with longlines and off-bottom trawls (trawls where the footrope of the net is not in contact with the bottom); (2) on-bottom gear will be allowed only in areas defined as yellowfin sole *(Limanda aspera)* or turbot *(Atheresthes stomias, Reinhardtius hippoglossoides)* grounds. These grounds would include the area of Bristol Bay shallower than 100 meters (yellowfin sole grounds) and the edge of the shelf deeper than 300 meters (turbot grounds). Off-bottom trawls or longline gear would be allowed in all areas.

Other management alternatives obviously could be examined. We chose Alternative (1) because it appeared to provide maximum protection for prohibited species and requires the greatest adjustment for the groundfish fisheries. Thus, Alternative (1) provides an upper limit to the potential benefits and costs of using off-bottom trawls and longlines to harvest groundfish. Alternative (2) is less restrictive and allows for harvesting fish which cannot be caught efficiently with off-bottom trawls.

[1]/U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, 2725 Montlake Blvd. East, Seattle, WA 98112.

[2]/International Pacific Halibut Commission.

[3]/Reducing the incidental catch of prohibited species by foreign groundfish fisheries in the Bering Sea, unpublished report. Working Group on Prohibited Species, North Pacific Fishery Management Council, January 1980.

In evaluating these alternatives, the effect of gear restrictions on the groundfish harvest was evaluated as well as the potential reductions in the catch of prohibited species. Data collected by U.S. observers aboard foreign fishing vessels during 1977-1979 were used in the evaluation. Catch rates for prohibited species (kg per mt of groundfish) were estimated for various gear types and target species, and these rates were projected to the estimated groundfish catch that would occur under the two alternatives. The economic implications of gear restrictions were not examined in this study.

TREATMENT OF DATA

To examine the question of the effectiveness of gear restrictions as a means of reducing the incidental catch of prohibited species, the 1977-1979 observer data files on catches of groundfish and prohibited species collected and maintained by the U.S. National Marine Fisheries Services were utilized. The organization and contents of these files have been presented by French et al. (1981).

Data in the observer files are recorded by individual hauls. Haul records were aggregated into five gear-target fishery categories:

(1) off-bottom trawl, pollock and other available species
(2) on-bottom trawl, yellowfin sole
(3) on-bottom trawl, turbot
(4) longline, Pacific cod *(Gadus macrocephalus)*
(5) longline, sablefish *(Anoplopoma fimbria)* and turbot

The average rate of incidence of halibut, salmon, Tanner crab and king crab in each category was estimated during 1977-1979 (Table 1). In reality, factors such as time, area, and depth also affect rates of incidence, and to some degree complicate the results. However, as discussed below, the five gear-target categories are generally distinct, and we consider the incidence rates in Table 1 to be indicative of the differences associated with each category. In any event, it is not possible to predict what changes might occur within each category if gear restrictions were instituted.

Table 1. Estimated catch rates (kg per m.t. of groundfish catch) for prohibited species by gear and target species in the Bering Sea.

	Prohibited Species Catch Rates			
Gear/Target Species	Halibut	Tanner Crab	King Crab	Salmon
Off-bottom trawl				
All available species	0.010	0.016	0.006	0.033
On-bottom trawl				
Yellowfin sole	0.499	6.861	0.517	0.020
Turbot	9.166	11.169	5.704	0.051
Longline				
Pacific cod	4.019*	0.000*	0.000*	0.010
Sablefish-turbot	1.503*	0.000*	0.000*	0.000

*Adjusted for an estimated survival of 75% for halibut and 100% for Tanner and king crab.

The pollock fishery is the largest in the Bering Sea, accounting for over 74% of the total groundfish catch (Bakkala et al. unpublished)[1]. The fishery is concentrated along the continental slope and most catches are made in depths between 100-200 m. Pollock are semi-demersal, occurring on- and off-bottom. Observers do not record whether individual hauls are on- or off-bottom hauls; however, observer reports note that Polish vessels exclusively utilize pelagic trawls and U.S.S.R. vessels generally fish off-bottom, while Japanese and Korean vessels trawl on-bottom. Observer reports also note that off-bottom hauls are almost entirely pollock. Therefore, to estimate the incidental catch rates of prohibited species in off-bottom trawls, data from Soviet and Polish hauls containing at least 98% pollock were utilized.

The yellowfin sole fishery occurs on the Bering Sea shelf in waters less than 100 m. Catch rates were based on hauls containing at least 50% yellowfin sole observed on Japanese motherships and U.S.S.R. large trawlers, the two vessel classes which account for most of the yellowfin sole catch.

A distinct deep water fishery occurs along the outer continental slope for turbot, which are fished primarily by Japanese small trawlers. Turbot are the major portion of the catch at depths over 300 m whereas pollock and Pacific cod are the primary species caught in shallower water.

Data from Japanese longlines were available separately for depths less than 500 m and depths greater than 500 m. Observer reports show that at depths less than 500 m the target species is Pacific cod, while at depths greater than 500 m sablefish is the target species.

All prohibited species captured in trawls were assumed to be dead, based on reports of observers aboard foreign vessels (U.S. National Marine Fisheries Service unpublished) and studies conducted by Hoag (1975). Observers on trawl vessels subjectively examine the condition of prohibited species in the catch. They report that nearly all of the salmon are dead when returned to the sea, that halibut viability ranges from 0-10%, and that many of those released alive are eaten by sea lions following the vessels. The survival rate of king and Tanner crab is uncertain, but a high percentage is noted to have crushed carapaces or severe appendage loss which indicates a very low probability of survival.

Catch rates for longline gear were adjusted for the following survival rates: 75% for halibut, 100% for Tanner and king crab, and 0% for salmon. These rates are approximations based on unpublished reports from U.S. observers on foreign vessels, joint U.S.-Japan longline surveys, and the International Pacific Halibut Commission.

ESTIMATED CATCH OF GROUNDFISH

In 1976, Canada, Japan, and the United States cooperated in a joint study to test a Japanese off-bottom trawl, designed to reduce the incidental catch of halibut (Pereyra et al. unpublished)[2]. The study involved four Japanese stern trawlers in the southeastern Bering Sea during January 1 through May 15. The vessels fished in pairs with one vessel

[1]/ Bakkala, R., V. Wespestad, L. Low, and J. Traynor. 1980. Condition of groundfish resources of the eastern Bering Sea and Aleutian Islands Region in 1980. (Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Anchorage, Alaska, October 1980.) National Marine Fisheries Service, Northwest and Alaska Fisheries Center. 98 p.

[2]/ Pereyra, W., I. Ellis, S. Hoag, and S. J. Westrheim. 1976. Results of comparative testing of the Japanese off-bottom trawl designed to reduce the incidental catch of halibut. (Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Tokyo, Japan, October 1976.) National Marine Fisheries Service, Northwest and Alaska Fisheries Center. 24 p.

using the experimental off-bottom trawl and the other acting as a control, using a standard on-bottom trawl. The experimental off-bottom trawl differed from the on-bottom trawl in the following manner: (1) the footrope was attached to a groundrope by 90 cm lengths of chain; (2) the groundrope was adjusted to position it directly under the footrope; and (3) floats were placed in two rows along the upper body of the net for greater buoyancy. Testing results indicated that the footrope would be about 70 cm above the bottom at a trawling speed of 3 knots.

The results from the comparative tests (Table 2) showed that groundfish catches in off-bottom trawls are equal to or greater than those in on-bottom trawls. The detailed species composition of the groundfish catch was not available, but the catch consisted primarily of pollock. The incidence rates of halibut observed were substantially lower in the off-bottom trawls, although the rates were greater than those shown in Table 1 because the experiment was conducted in an area which contains high densities of halibut and is not open to foreign trawl fisheries. Based on these findings and on the fact that Soviet and Polish vessels traditionally fish pollock with off-bottom trawls, we concluded that pollock can be fully harvested with off-bottom trawls.

Table 2. Results from comparative testing of a Japanese off-bottom trawl (from Pereyra et al. unpublished).

Trawl Type	January	February	March	April	May	Average[1]
			Number of Hauls			
On-Bottom	74	59	45	55	2	
Off-Bottom	98	81	56	75	11	
			Mean Weight of Halibut (kg)			
On-Bottom	2.26	1.40	1.98	1.93	1.56	1.89
Off-Bottom	3.33	1.75	1.74	1.91	2.09	2.18
			Incidence of Halibut (kg/mt Halibut)			
On-Bottom	1.40	3.43	7.35	1.77	0.97	3.64
Off-Bottom	0.74	0.78	2.29	1.52	1.19	1.48
			All-Species Catch Rate (mt per hour)[2]			
On-Bottom	10.2	8.6	7.6	8.6	1.7	8.8
Off-Bottom	12.8	9.0	7.7	8.3	7.0	9.5

[1]/ Unweighted average over months of January-April.
[2]/ Primarily pollock.

Comparative catch data are not available for other species, but squid *(Loligo* spp.*),* Atka mackerel *(Pleurogrammus monopterygius),* and rockfish *(Sebastes* spp.*)* probably can be at least partially harvested with off-bottom trawls because these species are often found off-bottom. Pacific cod tend to be close to the bottom, and probably cannot be fully harvested with off-bottom trawls. However, Pacific cod can be effectively taken with longline gear. Similarly, longlines could harvest sablefish and large flounders (primarily turbot).

Yellowfin sole and other flounders could not be harvested with either off-bottom trawls or longlines. To harvest these species would require allowing on-bottom trawls in at least limited areas or time periods such as suggested under Alternative (2).

The impact of gear restrictions on the groundfish harvest is difficult to predict because the catch rates and costs of fishing for some species with off-bottom trawls and longlines are unknown. Using 1977-1979 actual catches as a basis for comparison and assuming that off-bottom trawls and longlines are economically viable, we estimate that 12% of the total groundfish production, or 157,615 mt, would be lost under Alternative (1) (Table 3). Although some additional loss in production is likely because off-bottom trawls and

Table 3. Average catch (mt) of groundfish during 1977-1979 and the projected catch that might have occurred under the proposed management alternatives if off-bottom trawls and longlines are an economically viable method of harvesting.

Species	Average Catch 1977-1979	Gear	Projected Catch Alternative (1)	Projected Catch Alternative (2)
Pollock	966,692	Off-bottom trawl	966,692	966,692
Squid	8,262	Off-bottom trawl	8,262	8,262
Atka mackerel	23,745	Off-bottom trawl	23,745	23,745
Pacific ocean perch	8,350	Off-bottom trawl	8,350	8,350
Pacific cod - Trawl	37,733	Off-bottom trawl	20,682	20,682
- Longline	3,631	Longline	20,682	20,682
Sablefish	3,323	Longline	3,323	3,323
Yellowfin sole and other flounder	132,657	On-bottom trawl	0	132,657
Turbot - Trawl	47,901	On-bottom trawl	0	47,901
- Longline	2,014	Longline	24,958	2,014
Other	76,985	Off-bottom trawl	38,492	38,492
		Longline	38,492	38,492
Total	1,311,293		1,153,678	1,311,293

longlines probably are not efficient for some species, all available evidence suggests that pollock can be essentially fully harvested with off-bottom trawls. Therefore, an upper bound on the loss can be calculated by assuming that only pollock would be harvested under Alternative (1). Again using 1977-1979 catch data, the harvest would be 966,692 mt, and the loss would be 26%, 344,600 mt. The loss in groundfish production under Alternative (2) should be minimal because on-bottom trawling is allowed. A reduction in the catch of species such as Pacific ocean perch *(Sebastes alutus)* and Atka mackerel is possible but these species represent a relatively minor part of the total groundfish complex.

ESTIMATED SAVINGS OF PROHIBITED SPECIES

The catches of prohibited species that would occur under Alternatives (1) and (2) were estimated by extrapolating the catch rates from Table 1 to the projected groundfish catch in Table 3. The results by gear and target species are given in Table 4. The estimated catch was then compared to the observed catch (1977-1979 average), and the savings (difference) was calculated (Table 5).

Alternative (1) greatly reduced the catch of all prohibited species: halibut catches were reduced by about 92%, Tanner crab catches and king crab catches by 99%, and salmon catches by over 80%. Alternative (2) also reduced catches of prohibited species but the reductions were less than for Alternative (1). High incidental catches of halibut and crab were estimated for the on-bottom trawl fishery for turbot, and large catches of Tanner crab occurred in the yellowfin sole fishery.

A reduction in the allowable catch of yellowfin sole, other flounder, and turbot would, in turn, reduce the catch of prohibited species. For example, if the optimum yield of all flounder species were reduced by 50% under Alternative (2), the estimated catch (mt) of prohibited species would be:

Halibut	Tanner crab	King crab	Salmon
460	751	182	38

Table 4. The estimated catches of prohibited species by gear and target species under Alternatives (1) and (2).

Gear/Target Species	Prohibited Species Catch (m.t.)* Halibut	Tanner Crab	King Crab	Salmon
		Alternative (1)		
Off-bottom trawl				
All available species	10.6	16.9	6.3	34.8
Longline				
Pacific cod	124.7	0.0	0.0	0.3
Sablefish-turbot-other species	100.4	0.0	0.0	0.0
Total	235.7	16.9	6.3	35.1
		Alternative (2)		
Off-bottom trawl				
All available species	10.6	16.9	6.3	34.8
On-bottom trawl				
Yellowfin sole and other flounders	66.2	910.2	68.6	2.7
Turbot	457.5	557.5	284.7	2.5
Longline				
Pacific cod	124.7	0.0	0.0	0.3
Sablefish and other species	62.9	0.0	0.0	0.0
Total	721.9	1,484.6	359.6	40.3

*Estimates are based on catch rates in Table 1 and projected groundfish catches in Table 3.

Table 5. Estimated savings of prohibited species under Alternatives (1) and (2), based on 1977-1979 data.

	Prohibited Species Catch (m.t.) Halibut	Tanner Crab	King Crab	Salmon
Observed catch (m.t.) (1977-1979 average)	2,830	4,572	920	227
Alternative (1)				
Estimated catch	236	17	6	35
Estimated savings[1]	2,594	4,555	914	192
Alternative (2)				
Estimated catch	722	1,485	360	40
Estimated savings[1]	2,108	3,087	560	187

[1]/Observed catch minus estimated catch.

CONCLUSIONS

An examination of catch data from 1977-1979 indicates that it is technically possible to substantially reduce the incidental catch of prohibited species in the Bering Sea while harvesting most of the available groundfish by restricting the type of gear used in the groundfish fishery. We recognize that precise rates of incidental catch will vary with the area and time of year fished and that the institution of restrictions could alter the manner in which the fishery is conducted and therefore the incidental catch that would occur. However, we doubt that these deviations would change the basic conclusions. A more serious concern is that gear restrictions would increase the cost of harvesting and could affect the economic viability of the fishery. Data are not currently available to fully address these aspects of gear restrictions, and further research is needed to assess the economics of the fishery and, in particular, the catchability of different groundfish species with longline and off-bottom trawls.

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II. A Comparison of Pacific Halibut and Tanner Crab Catches in (1) Side-Entry and Top-Entry Crab Pots and (2) Side-Entry Crab Pots With and Without Tanner Boards

by
Gregg H. Williams, Donald A. McCaughran,
Stephen H. Hoag, and Timothy M. Koeneman

ABSTRACT

Catch rates of Pacific halibut *(Hippoglossus stenolepis)* and Tanner crab *(Chionoecetes bairdi)* by several types of crab pot were compared. Top-entry crab pots had substantially lower catch rates of halibut than side-entry pots. Catch rates of legal Tanner crab in top-entry pots were only slightly lower than in side-entry pots, but the sample sizes were considered too small to clearly demonstrate this difference. "Tanner boards", which are placed horizontally across the upper half of the tunnel opening, reduced the catch rate of halibut by side-entry pots by 63%. In addition, the catch of halibut over 90 cm long was almost eliminated. Tanner boards also reduced the catch rate of Tanner crab by side-entry pots, but overall crab catches were not large enough to provide meaningful results. Further research is recommended on crab pot modifications, and an observer program is recommended to establish halibut incidence rates in the commercial crab fisheries.

II. A Comparison of Pacific Halibut and Tanner Crab Catches in (1) Side-Entry and Top-Entry Crab Pots and (2) Side-Entry Crab Pots With and Without Tanner Boards

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INTRODUCTION

Although Pacific halibut *(Hippoglossus stenolepis)* are fished commercially with setline gear, they are subject to incidental capture by several types of gear. Pacific halibut fishery regulations prohibit the retention of halibut caught by nets and pots (International Pacific Halibut Commission 1981), but mortality of the incidentally-caught fish can be high, resulting in a substantial loss to the commercial fishery. Incidental catches have contributed to the decline of the halibut stocks in the north Pacific Ocean and eastern Bering Sea (Hoag 1976), but previous research has centered on the foreign groundfish fisheries (Hoag and French 1976).

Although quantitative information on the incidental catch of halibut in the crab fisheries is limited, reports from fishermen and research surveys by the Alaska Department of Fish and Game (ADF&G) suggest that the incidental catch is substantial. Using incidence rates collected on ADF&G crab research surveys, Williams (unpublished)[3] estimates that 3.9 million pounds of halibut were caught in the king *(Paralithodes* spp.*)* and Tanner *(Chionoecetes* spp.*)* crab fisheries in the north Pacific Ocean during the 1979-1980 season.

Crab fishermen have indicated that halibut incidence varies with crab pot type. Fishermen from Yakutat, Alaska, reported large incidental catches during the 1979-1980 Tanner crab season and that the incidental catch was much higher in side-entry pots (rectangular in shape) than in top-entry pots (pyramid or conical in shape). They requested ADF&G to prohibit the use of side-entry pots to reduce incidental halibut catches, but data were not available to document these reports.

It has also been reported that "Tanner boards" reduce the catch of halibut by side-entry crab pots. A Tanner board is a wooden board that is placed across the upper half of the tunnel opening, reducing the height of the opening to no more than five inches, usually three to four inches. Its primary purpose is to keep king crab from entering the pot. It also keeps Tanner crab in the pot and, reportedly, reduces the incidental catch of halibut. However, quantitative data on the effects of Tanner boards on halibut incidental catch are lacking.

Consequently, ADF&G and the International Pacific Halibut Commission (IPHC) proposed that the North Pacific Fishery Management Council fund a study comparing the incidence of halibut and catch rates of Tanner crab in top-entry and side-entry crab pots. Funding by the Council was approved in July, 1980 and the study was conducted in August. In addition to testing the two pot types for crab catches, the effect of Tanner boards on the catch of halibut was also compared. The results from these studies are provided in this report.

[1]/International Pacific Halibut Commission.
[2]/Alaska Department of Fish and Game, P.O. Box 667, Petersburg, Alaska 99833.
[3]/Williams, Gregg H. 1981. Estimates of the incidental catch of halibut by the king and Tanner crab fisheries. International Pacific Halibut Commission, Seattle, Washington. 10 p.

METHOD

Materials

The side-entry pots used in the study belonged to ADF&G, whereas the top-entry pots were leased from a commercial Tanner crab fisherman (Figures 1 and 2). The ADF&G pots, which are used in annual crab index surveys, are 80 inches (203 cm) square on the top and bottom and are 30 inches (76 cm) in height. These pots weigh approximately 750 pounds (340 kg) each. The top-entry pots are 68 inches (173 cm) square at the base, 34 inches (86 cm) square at the top and have a height of 30 inches (76 cm). They weigh approximately 200 pounds (91 kg) each. Tunnel opening dimensions are 8 inches by 36 inches (20 cm by 91 cm) on the side-entry pots; the top-entry pots have round tunnels, 23.5 inches (60 cm) in diameter at the top and 15 inches (38 cm) in diameter at the bottom, and a vertical depth of 9 inches (23 cm). Webbing is 3.5-inch (9 cm) stretch mesh on the side-entry pots and 7-inch (18 cm) stretch mesh on the top-entry pots. The Tanner boards used in this study were made of spruce and were 4 inches by 38 inches (10 cm by 97 cm) in size.

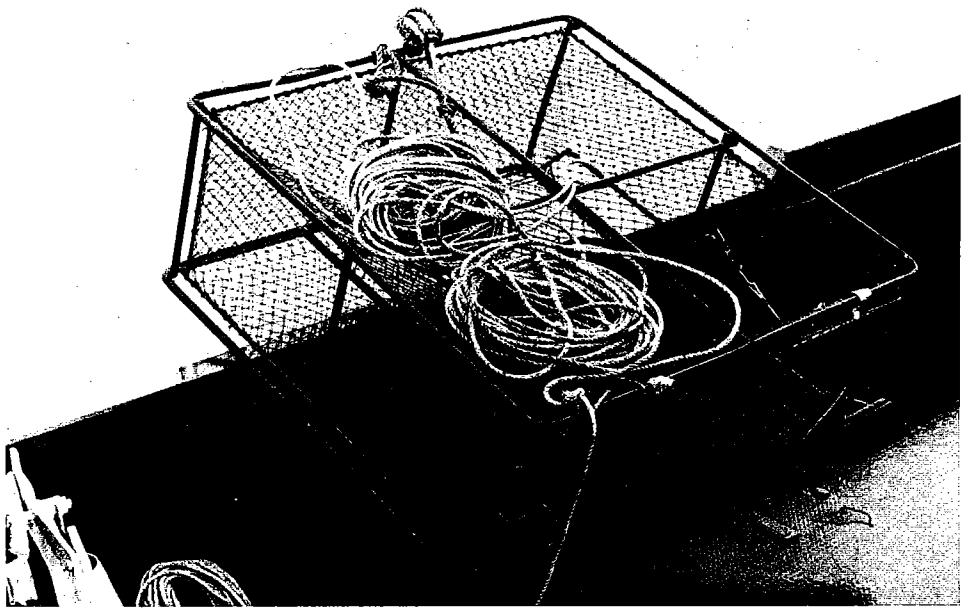

Figure 1. Side-entry crab pot as used in Experiments I and II. This pot has no "Tanner boards" over the tunnel openings.

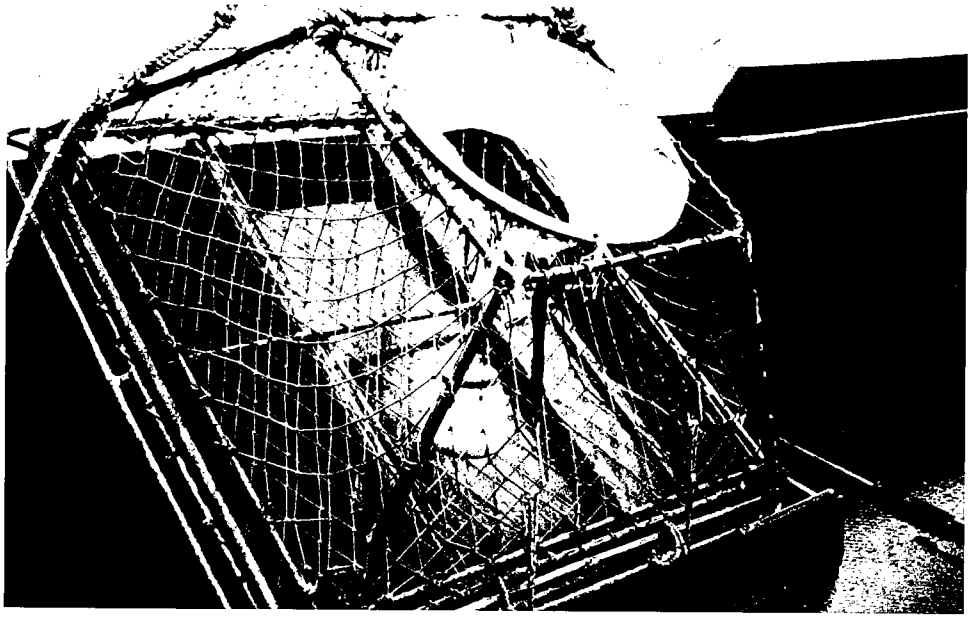

Figure 2. Top-entry crab pot as used in Experiment I.

Design

The study was conducted in Yakutat Bay and south along the coast to Dry Bay (Figure 3) during August. This area was chosen because of reports of large incidental halibut catches in crab pots during the 1979-80 Tanner crab season.

The operation was divided into two experiments. Experiment I examined the differences in the halibut and Tanner crab *(Chionoecetes bairdi)* catches in top-entry and side-entry crab pots and consisted of five days of setting and hauling pots (setting preceded hauling by one day). The depths fished ranged from 16 to 171 meters (9 to 94 fathoms). Experiment II examined the differences in the halibut and Tanner crab catches in side-entry pots with and without Tanner boards and consisted of three days of setting and hauling pots. Depths ranged from 25 to 164 meters (14 to 90 fathoms).

The pots were usually set from 1300 to 1500 hours and hauled back the following morning from 0730 to 1200 hours. Soak time generally averaged 19 hours. Two one-quart plastic containers holding chopped herring were used for bait.

In Experiment I, the pots were laid out in a 4 x 10 Latin rectangle design. Each pot type occurred in each row and column an equal number of times, allowing the effects of depth and horizontal changes in habitat to be removed from the comparison of pot type. A total of 40 pots were fished each day, resulting in a total of 100 observations for each pot type (not adjusting for lost or unbaited pots). The schematic arrangement was:

X	O	X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X	O	X
X	O	X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X	O	X

where "X" designates a side-entry pot and "O" designates a top-entry pot.

In Experiment II, the pots were arranged in a 2 x 10 Latin rectangle design. Side-entry pots with Tanner boards and without Tanner boards were placed in equal number in each row and column to allow the analytical removal of the depth effect and the effect of any

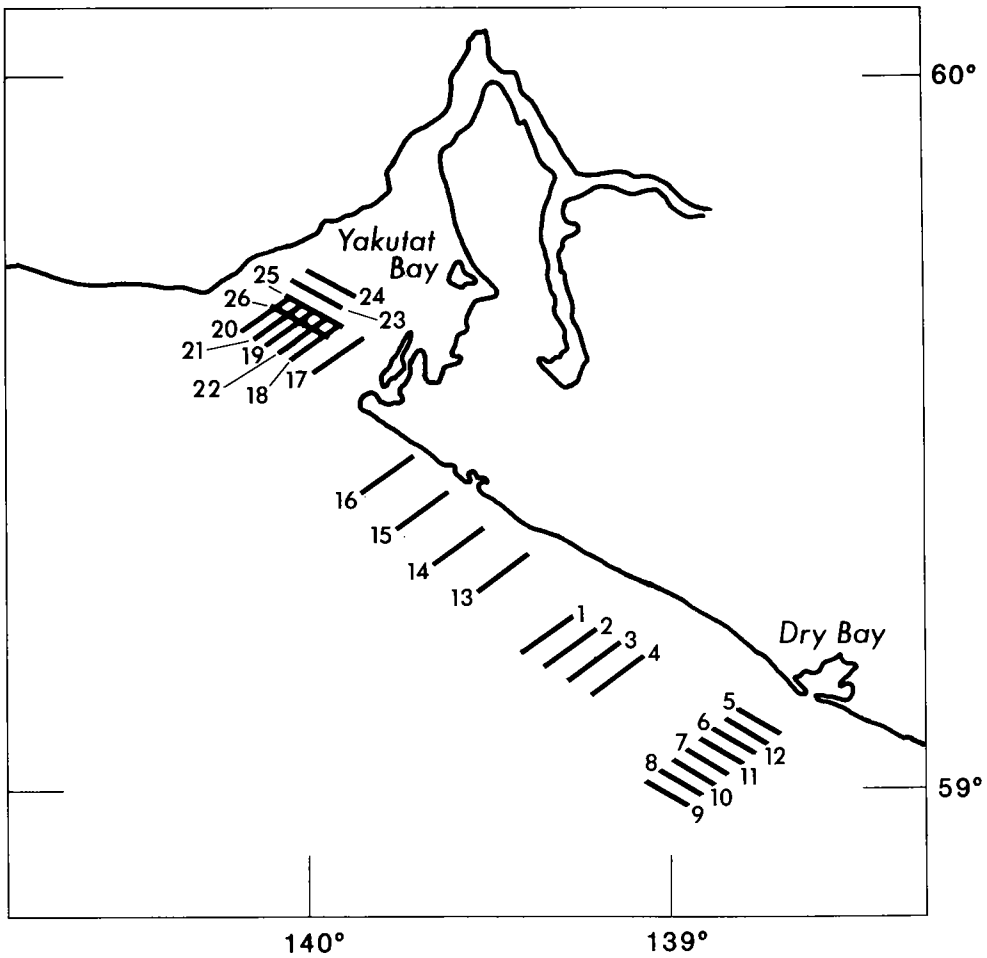

Figure 3. General area of operation and line locations during Experiments I and II.

horizontal change in habitat. Twenty pots were fished each day, resulting in a total of 60 observations. The schematic arrangement was:

X	O	X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X	O	X

where "X" designates a side-entry pot with Tanner boards and "O" designates a side-entry pot without Tanner boards.

The distance between lines and pots in both experiments was held constant within each day but varied slightly among days. The pots were set along C-Loran lines and the distance between lines varied from 4.2 to 9.3 kilometers (2.25 to 5 nautical miles). The distance between pots within a line varied from 0.5 to 0.93 kilometers (0.25 to 0.5 nautical miles).

All of the halibut and Tanner crab were counted and measured, and those halibut alive were tagged. The left otolith was removed from the dead halibut to determine age. Shell condition, carapace width, and sex were recorded for all Tanner crab. All other species caught in the pots were counted and economically-important species such as lingcod *(Ophiodon elongatus)* and Pacific cod *(Gadus macrocephalus)* were measured.

ANALYSIS

An analysis of variance was performed on each day's results. Since the location of the experiment was changed each day, each day's data cannot be considered as a replicate in a larger experiment. Replicates are identically distributed independent random variables and since the experiment was moved each day, the observations cannot be modeled as identically distributed. No suitable transformation of the data was obvious, so reliance was placed on the robust properties of the analysis of variance. Although the testing was performed on each day separately, an overall statement of significance was desired. An overall significance level of 0.05 was chosen; hence, the individual test level for the five tests is α that satisfies $0.05 = 1 - (1-\alpha)^5$, that is $\alpha = 0.01$.

In Experiment I, data for an unbaited pot and a lost pot were filled in by use of a missing plot formula. In Experiment II one pot was lost, and the column that contained the missing pot was deleted in the analysis.

RESULTS

Table 1 summarizes the overall results from Experiments I and II. Table 2 summarizes the daily results and indicates significant differences as shown by the analysis of variance tests. Detailed information on the halibut and Tanner crab catch in each pot is given in Appendix Tables 1 and 2. Summaries of the size composition of the Tanner crab catch for each experiment are in Appendix Tables 3 and 4. Appendix Table 5 shows the catch of species other than halibut and Tanner crab. Results of the analysis of variance tests are in Appendix Tables 6 and 7.

Experiment I: Side-Entry Pots versus Top-Entry Pots

The results from Experiment I clearly show a much higher incidence of halibut in side-entry pots than in top-entry pots: the overall number caught per pot-lift was 1.43 ± 0.11 ($\bar{X} \pm SE$) for side-entry pots, compared to 0.04 ± 0.02 for top-entry pots (Table 1). The average size of halibut was lower for top-entry pots (6.0 pounds versus 16.1 pounds), but the sample size (four fish) was small. The analysis of variance tests showed that top-entry pots caught significantly fewer halibut on each of the five days of the experiment (Table 2), a definite indication that the catch rate of halibut is much lower in top-entry pots than in side-entry pots.

Overall, side-entry pots caught more Tanner crab than top-entry pots. The average catch was 2.78 ± 0.57 crab per pot-lift for top-entry pots and 3.85 ± 0.39 crab per pot-lift for side-entry pots (Table 1). Review of the individual day's experiments shows a nonsignificant increase in crab catches by top-entry pots on Days 1 and 3 (Table 2). The other three days had higher crab catches in side-entry pots, but only two of the three were statistically significant. The five separate analyses were combined into one analysis by combining the sums of squares and computing an overall "F" ratio. The resulting F ratio of 2.22 indicates the overall results are not significantly different.

The results may be biased by the larger mesh on the top-entry pots, which would allow some female and smaller male crab to escape. Examining the overall catch of legal Tanner crab (those 140 mm and larger in carapace width) shows that side-entry pots caught an average of 0.76 crab per pot-lift and that top-entry pots caught an average of 0.68 crab per pot-lift. These results suggest that side-entry pots have a higher catch rate but much larger sample sizes than used here are needed to clearly demonstrate it.

Another method of comparison between the two pot types is made by examining the ratio of the number of halibut per legal Tanner crab. In this experiment, side-entry pots

Table. 1 Summary of data collected during pot comparison studies. Halibut weight is expressed in net pounds and length is fork length in centimeters.

	Experiment I		Experiment II	
	Side-Entry	Top-Entry	Side-Entry With Boards	Side-Entry Without Boards
Number of potlifts*	98	100	30	29
No. halibut per legal crab	1.89	0.06	0.26	0.72
		Halibut		
Number	140	4	18	47
Catch per potlift	1.43	0.04	0.60	1.62
Average weight	16.1	6.0	10.6	15.8
Average length	88.5	65.5	79.2	88.4
		Tanner Crab		
Number	377	278	466	300
Catch per potlift	3.85	2.78	15.53	10.34
No. of legal crab	74	68	69	65
Catch per potlift	0.76	0.68	2.30	2.24

*Excludes lost and unbaited pots.

Table 2. Mean number of halibut and Tanner crab per potlift for each day of Experiments I and II. An asterisk indicates a significant difference between the two means at the 0.01 significance level.

	Experiment I		Experiment II	
	Side-Entry	Top-Entry	Side-Entry With Boards	Side-Entry Without Boards
Day 1				
Halibut	1.70*	0.05*	1.09*	4.70*
Tanner Crab	1.25	1.45	41.70	26.30
Day 2				
Halibut	1.65*	0.05*	0.80	1.30
Tanner Crab	0.25*	0.00*	15.88	8.78
Day 3				
Halibut	1.60*	0.05*	0.50*	1.80*
Tanner Crab	0.25	0.30	24.40*	10.80*
Day 4				
Halibut	0.70*	0.00*		
Tanner Crab	11.80*	7.75*		
Day 5				
Halibut	1.35*	0.05*		
Tanner Crab	5.30	4.40		

caught 1.89 halibut per legal Tanner crab and top-entry pots caught 0.06 halibut per legal Tanner crab (Table 1).

Experiment II: Side-Entry Pots With and Without Tanner Boards

In Experiment II, the use of Tanner boards reduced the overall average halibut catch 63%. The overall average catch was 0.60 ± 0.12 per pot-lift for pots with Tanner boards and 1.62 ± 0.21 per pot-lift for pots without Tanner boards (Table 1). Halibut catches were reduced by using Tanner boards in all three individual experiments (Table 2) but in only two of the experiments was the reduced catch statistically significant. The nonsignificant difference on Day 2 was the result of high variability in the catch. The three individual analyses were combined and resulted in an overall F ratio of 8.97, which is highly significant. These results clearly indicate a reduced halibut catch when the tunnel opening on side-entry pots is reduced in size.

In addition, halibut caught in pots with Tanner boards averaged smaller in length than those caught in pots without Tanner boards (Table 1). A Student's t-test of the average length of fish caught by the two pot types indicated a significant difference ($P = 0.036$). A detailed examination of the length frequencies shows that Tanner boards reduced the catch of all sizes encountered in the study, but almost eliminated the catch of halibut over 90 cm in length. The catch per pot-lift by length group was as follows:

	Length group (cm)					
	<70	70-79	80-89	90-99	100-109	>109
Without boards	0.10	0.45	0.31	0.34	0.04	0.21
With boards	0.07	0.23	0.23	0.03	0.03	0.00

Side-entry pots with Tanner boards caught 33% more Tanner crab than pots without Tanner boards (Table 1). The overall average catch of all sizes of Tanner crab for the three experiments was 15.53 ± 2.43 crab per pot-lift for pots with Tanner boards and 10.34 ± 2.05 crab per pot-lift for pots without Tanner boards. Overall average catch rates of legal Tanner crab show little difference between the two pot types: pots with Tanner boards caught 2.30 per pot-lift, whereas pots without Tanner boards caught 2.24 crab per pot-lift. A review of the individual experiments shows that Tanner boards increased the catch of Tanner crab in each experiment, but on only one of the three days is the increased catch statistically significant. The combined analysis resulted in an overall F ratio of 2.50, indicating the overall catches are not significantly different. However, with the large variability observed in Tanner crab catches, larger sample sizes are required to obtain consistent statistical significance when the difference in the catch rate between the two pot types is of this magnitude.

The increased crab catches by pots using Tanner boards is likely the result of increased retention of crab by the pots. The tunnel openings face slightly upward in side-entry pots, and crab are able to drop through the opening and escape the pot. Placing the boards over the tunnel opening decreases the size of the opening and makes it difficult for crab to escape the pot in this manner. Hence, more crab are retained by the pot.

The number of halibut per legal Tanner crab was 64% lower when Tanner boards were used. Pots without Tanner boards caught 0.72 halibut per legal Tanner crab and pots with Tanner boards caught 0.26 halibut per legal Tanner crab (Table 1).

Condition of Halibut

Nearly all of the halibut caught suffered from minor abrasions caused by either struggling in the pot or by being in contact with crab. However, most (87%) of the halibut

were tagged and 79% of these were considered to have a high survival potential. The remainder were dead and these were partially eaten by sand fleas.

These results, however, should not be extended to the commercial fishery, where fishing conditions are considerably different. Soak times are generally much longer than in these experiments, resulting in higher mortality. Additionally, higher catch rates of over 100 legal crab per pot will probably reduce the viability of halibut considerably. Also, fishermen reportedly use incidentally-caught halibut for bait in their pots and as food for the crews of the crab vessels, further increasing the loss.

CONCLUSIONS

Halibut catches are substantially lower in top-entry crab pots (0.04 halibut per pot-lift) than in side-entry crab pots (1.43 halibut per pot-lift). Those halibut caught in top-entry crab pots may also average smaller in size, but data collected during this study are not conclusive.

The use of Tanner boards in side-entry pots reduced the catch of halibut by 63% in this study. The catch of halibut over 90 cm in length was almost eliminated.

Total Tanner crab catches were higher in side-entry crab pots than in top-entry crab pots. These results may be biased by a difference in pot mesh size, however. The catch rate of legal Tanner crab, less affected by this bias, was only slightly higher in side-entry pots, but much larger sample sizes are needed to clearly demonstrate a higher catch rate by side-entry pots.

Total Tanner crab catches were 33% higher in side-entry pots when Tanner boards were used. However, catch rates of legal Tanner crab showed little difference between side-entry pots with Tanner boards and side-entry pots without Tanner boards. Because of the large variability observed in the Tanner crab catches, larger sample sizes are necessary to show a higher catch rate when Tanner boards are used in side-entry pots.

RECOMMENDATIONS

In view of the results emerging from the two experiments, the following recommendations are made:

Further gear research should be conducted to determine if side-entry pots can be modified to significantly reduce halibut loss with little cost. Ideas include: (a) an escape opening under the door panel to allow small halibut to leave the pot; (b) a vertical bar half-way across the tunnel opening to prevent large halibut from entering the pot; (c) an escape opening in the top of the pot which would allow fish of all species to escape.

An observer program should be conducted to confirm the results of this study and establish rates of halibut incidence in the commercial fishery.

The commercial fishery should be monitored to determine if existing regulations on the use of Tanner boards are being followed.

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APPENDIX

Appendix Table 1. Detailed catch data from Experiment I: Comparison of Tanner crab and halibut catches in top-entry (TE) and side-entry (SE) crab pots.

Date	Location	Line	Pot Type	Depth (fathoms)	Soak (hh:mm)	Halibut No.	Halibut Lengths(cm)	No. of Crab
8/09	59:14N X 139:20W	1	SE	33	22:41	0		0
			TE	35	22:43	0		0
			SE	37	22:46	1	103	0
			TE	41	22:52	0		0
			SE	45	22:55	1	49	0
			TE	50	22:59	0		1
			SE	53	23:03	3	82, 120, 72	1
			TE	56	23:07	0		6
			SE	60	23:12	1	87	18
			TE	63	23:18	1	54	21
8/09	59:12N X 139:17W	2	TE	32	24:08	0		0
			SE	36	24:04	Not Baited		0
			TE	39	23:59	0		0
			SE	43	23:57	2	81, 83	0
			TE	45	23:52	0		0
			SE	47	23:49	2	87, 112	0
			TE	50	23:45	0		0
			SE	53	23:40	0		0
			TE	55	23:35	0		1
			SE	57	23:33	2	83, 107	5
8/09	59:11N X 139:13W	3	SE	30	24:06	6	76, 94, 81, 86, 68, 95	0
			TE	32	24:08	0		0
			SE	35	24:13	2	84, 107	0
			TE	38	24:16	0		0
			SE	40	24:17	1	60	0
			TE	42	24:21	0		0
			SE	45	24:24	2	99, 80	0
			TE	47	24:27	0		0
			SE	50	24:30	2	65, 87	0
			TE	52	24:33	0		0
8/09	59:10N X 139:10W	4	TE	30	24:55	0		0
			SE	33	24:51	2	94, 99	0
			TE	36	24:49	0		0
			SE	38	24:46	2	74, 84	0
			TE	40	24:43	0		0
			SE	42	24:41	2	122, 109	0
			TE	44	24:39	0		0
			SE	45	24:38	2	73, 73	0
			TE	47	24:37	0		0
			SE	50	24:31	1	93	1
8/10	59:06N X 138:46W	5	TE	32	16:51	0		0
			SE	32	16:54	1	58	0
			TE	32	16:55	0		0
			SE	33	16:58	2	83, 111	0
			TE	34	17:01	0		0
			SE	35	17:03	2	–, –	0
			TE	36	17:07	0		0
			SE	41	17:08	1	75	0
			TE	50	17:10	0		0
			SE	57	17:13	2	62, 78	0
8/10	59:04N X 138:51W	6	SE	41	18:06	2	92, 84	0
			TE	42	18:04	0		0
			SE	43	18:00	1	82	0
			TE	45	17:56	0		0
			SE	47	17:53	2	107, 106	0
			TE	50	17:49	0		0
			SE	52	17:46	0		0
			TE	56	17:41	1	85	0
			SE	62	17:37	3	77, 100, 91	0
			TE	75	17:34	0		0
8/10	59:03N X 138:55W	7	TE	47	18:10	0		0
			SE	48	18:13	2	94, 64	0
			TE	49	18:15	0		0
			SE	50	18:16	2	71, 84	1
			TE	52	18:17	0		0
			SE	53	18:19	2	81, 82	0
			TE	55	18:21	0		0
			SE	57	18:23	3	67, 89, 81	0
			TE	61	18:30	0		0
			SE	67	18:31	2	103, –	0

Appendix Table 1. Detailed catch data from Experiment I: Comparison of Tanner crab and halibut catches in top-entry (TE) and side-entry (SE) crab pots.

Date	Location	Line	Pot Type	Depth (fathoms)	Soak (hh:mm)	Halibut No.	Halibut Lengths(cm)	No. of Crab
8/10	59:01N X 138:59W	8	SE	53	19:03	2	61,75	0
			TE	53	19:00	0		0
			SE	53	18:57	0		1
			TE	54	18:54	0		0
			SE	55	18:51	1	61	2
			TE	55	18:49	0		0
			SE	56	18:46	2	108,94	1
			TE	58	18:43	0		0
			SE	63	18:39	1	91	0
			TE	66	18:34	0		0
8/11	59:00N X 139:02W	9	SE	56	17:56	1	81	0
			TE	57	17:58	0		0
			SE	58	18:01	1	96	0
			TE	57	18:03	0		3
			SE	59	18:06	3	83,108,106	3
			TE	61	18:10	0		3
			SE	62	18:13	1	104	1
			TE	63	18:16	0		0
			SE	64	18:19	2	110,86	0
			TE	67	18:22	0		0
8/11	59:02N X 138:57W	10	TE	53	19:03	0		0
			SE	53	18:59	2	140,-	0
			TE	54	18:57	0		0
			SE	55	18:55	3	92,71,89	1
			TE	55	18:52	0		0
			SE	56	18:49	1	116	0
			TE	58	18:46	0		0
			SE	60	18:43	0		0
			TE	63	18:41	0		0
			SE	67	18:37	3	118,110,84	0
8/11	59:03N X 138:53W	11	SE	46	19:03	4	80,98,76,77	0
			TE	46	19:06	0		0
			SE	48	19:09	2	89,77	0
			TE	49	19:11	0		0
			SE	51	19:13	1	128	0
			TE	53	19:16	0		0
			SE	55	19:18	1	74	0
			TE	59	19:21	0		0
			SE	63	19:23	1	76	0
			TE	68	19:26	0		0
8/11	59:05N X 138:48W	12	TE	40	19:51	0		0
			SE	40	19:49	1	70	0
			TE	40	19:47	0		0
			SE	42	19:44	1	98	0
			TE	45	19:42	0		0
			SE	47	19:39	1	119	0
			TE	50	19:37	1	58	0
			SE	54	19:34	2	112,82	0
			TE	59	19:31	0		0
			SE	71	19:28	1	93	0
8/12	59:18N X 139:29W	13	TE	25	15:52	0		0
			SE	38	15:55	2	69,94	0
			TE	50	15:58	0		2
			SE	60	16:03	1	117	5
			TE	66	16:05	0		5
			SE	72	16:08	0		9
			TE	78	16:10	0		18
			SE	83	16:13	0		27
			TE	89	16:14	0		15
			SE	91	16:20	0		14
8/12	59:21N X 139:36W	14	SE	44	16:56	3	61,61,76	0
			TE	54	16:53	0		2
			SE	62	16:50	0		6
			TE	67	16:47	0		6
			SE	75	16:44	0		17
			TE	79	16:42	0		14
			SE	83	16:38	0		22
			TE	86	16:34	0		22
			SE	91	16:31	0		32
			TE	94	16:28	0		26

Appendix Table 1. Detailed catch data from Experiment I: Comparison of Tanner crab and halibut catches in top-entry (TE) and side-entry (SE) crab pots.

Date	Location	Line	Pot Type	Depth (fathoms)	Soak (hh:mm)	Halibut No.	Halibut Lengths(cm)	No. of Crab
8/12	59:24N X 139:42W	15	TE	24	17:00	0		0
			SE	38	17:01	2	92,77	2
			TE	46	17:06	0		1
			SE	52	17:09	0		3
			TE	61	17:11	0		2
			SE	69	17:14	Lost Pot		0
			TE	76	17:16	0		7
			SE	82	17:21	0		37
			TE	87	17:25	0		18
			SE	92	17:30	0		24
8/12	59:27N X 139:48W	16	SE	9	17:55	1	110	0
			TE	15	17:54	0		0
			SE	28	17:49	1	86	0
			TE	39	17:48	0		0
			SE	47	17:45	3	69,71,94	0
			TE	55	17:42	0		2
			SE	65	17:40	0		2
			TE	75	17:37	0		6
			SE	80	17:33	1	84	36
			TE	88	17:28	0		9
8/13	59:38N X 139:55W	17	SE	40	17:44	1	117	0
			TE	37	17:48	0		0
			SE	34	17:51	1	84	0
			TE	76	17:52	0		2
			SE	77	18:11	0		11
			TE	65	18:14	0		0
			SE	79	18:16	0		9
			TE	20	18:19	0		0
			SE	18	18:21	1	53	0
			TE	30	18:25	0		0
8/13	59:39N X 139:58W	18	TE	84	19:06	0		3
			SE	82	19:03	0		2
			TE	83	18:59	0		4
			SE	60	18:58	1	100	6
			TE	50	18:56	0		1
			SE	35	18:54	1	110	0
			TE	53	18:50	0		0
			SE	80	18:47	1	101	10
			TE	80	18:43	0		3
			SE	71	18:41	3	74,110,118	1
8/13	59:40N X 140:03W	19	SE	84	19:10	2	77,79	6
			TE	83	19:12	0		8
			SE	46	19:15	2	71,92	0
			TE	55	19:17	0		9
			SE	61	19:20	2	80,81	15
			TE	65	19:22	0		16
			SE	60	19:24	2	82,95	1
			TE	72	19:28	0		18
			SE	71	19:29	3	92,92,134	11
			TE	72	19:31	0		11
8/13	59:41N X 140:07W	20	TE	14	19:57	0		0
			SE	20	19:54	1	91	0
			TE	47	19:51	0		1
			SE	57	19:48	0		9
			TE	50	19:46	0		0
			SE	38	19:44	2	79,115	0
			TE	39	19:42	1	65	0
			SE	64	19:39	2	98,91	15
			TE	64	19:36	0		12
			SE	63	19:34	2	69,71	10

Appendix Table 2. Detailed catch data from Experiment II: Comparison of Tanner crab and halibut catches in side-entry crab pots with (WB) and without (WOB) tanner boards.

Date	Location	Line	Pot Type	Depth (fathoms)	Soak (hh:mm)	Halibut No.	Halibut Lengths(cm)	No. of Crab
8/14	59:40N X 140:05W	21	WB	63	19:39	0		5
			WOB	41	19:41	2	104,-	0
			WB	47	19:44	1	75	2
			WOB	61	19:48	1	94	0
			WB	78	19:50	0		10
			WOB	76	19:53	1	85	17
			WB	72	19:56	0		36
			WOB	41	19:59	2	78,59	35
			WB	44	19:59	1	69	17
			WOB	45	20:01	1	81	25
8/14	59:39N X 140:01W	22	WOB	40	20:46	2	84,94	0
			WB	43	20:43	1	77	0
			WOB	56	20:39	4	84,105,123,96	8
			WB	58	20:36	0		3
			WOB	80	20:33	1	94	5
			WB	90	20:29	1	51	15
			WOB	85	20:26	0		10
			WB	80	20:23	1	99	6
			WOB	80	20:19	2	73,122	23
			WB	81	20:16	0		16
8/15	59:42N X 139:58W	23	WOB	26	20:02	2	83,79	0
			WB	30	20:04	2	84,91	0
			WOB	65	20:11	3	96,73,70	9
			WB	68	20:12	1	71	22
			WOB	67	20:19	1	68	5
			WB	64	20:23	0		24
			WOB	60	20:27	1	79	4
			WB	58	20:31	0		14
			WOB	55	20:34	1	73	10
			WB	44	20:39	1	70	25
8/15	59:43N X 139:57W	24	WB	39	21:21	2	77,71	0
			WOB	29	21:16	2	80,100	0
			WB	30	21:13	0		0
			WOB	61	21:11	1	77	5
			WB	63	21:08	1	106	5
			WOB	58	21:05	0		36
			WB	54	21:02	1	85	19
			WOB	49	20:51	Lost Pot		0
			WB	45	20:49	0		3
			WOB	38	20:44	2	73,75	0
8/16	59:41N X 139:58W	25	WB	68	21:33	1	81	0
			WOB	81	21:34	2	77,77	3
			WB	81	21:36	0		33
			WOB	77	21:41	0		0
			WB	68	21:45	0		18
			WOB	71	21:47	3	92,94,124	11
			WB	70	21:50	0		18
			WOB	66	21:54	1	89	28
			WB	63	21:57	2	89,71	28
			WOB	62	22:01	1	80	2
8/16	59:40N X 140:00W	26	WOB	80	22:38	1	97	4
			WB	72	22:35	0		17
			WOB	79	22:33	1	130	9
			WB	88	22:29	1	86	9
			WOB	87	22:24	3	90,110,110	7
			WB	65	22:21	1	82	32
			WOB	76	22:14	1	97	29
			WB	71	22:08	0		46
			WOB	67	22:06	5	65,72,77,81,101	15
			WB	62	22:03	0		43

Appendix Table 3. Size composition of the Tanner crab catch in Experiment I by sex and pot type. Carapace width is in mm.

Carapace Width	Side-Entry Male	Side-Entry Female	Top-Entry Male	Top-Entry Female	Carapace Width	Side-Entry Male	Side-Entry Female	Top-Entry Male	Top-Entry Female
65	0	0	0	0	125	7	0	5	0
66	0	0	0	0	126	9	0	8	0
67	0	3	0	0	127	11	0	8	0
68	0	2	0	0	128	7	0	6	0
69	0	0	0	0	129	14	0	18	0
70	0	4	0	0	130	5	0	13	0
71	0	2	0	0	131	10	0	16	0
72	0	5	0	0	132	11	0	7	0
73	1	5	0	0	133	14	0	12	0
74	0	4	0	0	134	10	0	15	0
75	0	6	0	0	135	13	0	10	0
76	0	2	0	2	136	9	0	12	0
77	1	6	0	0	137	3	0	5	0
78	0	7	0	0	138	4	0	6	0
79	0	4	0	0	139	7	0	8	0
80	0	7	0	1	140	5	0	7	0
81	0	3	0	1	141	5	0	6	0
82	1	1	0	0	142	7	0	5	0
83	0	4	0	1	143	10	0	6	0
84	1	2	0	0	144	3	0	7	0
85	0	2	0	0	145	7	0	5	0
86	1	2	0	0	146	6	0	2	0
87	3	0	0	1	147	4	0	2	0
88	1	5	0	2	148	1	0	4	0
89	0	4	0	0	149	4	0	1	0
90	1	2	0	0	150	2	0	4	0
91	2	2	0	0	151	1	0	3	0
92	0	0	0	0	152	3	0	6	0
93	0	1	0	1	153	4	0	2	0
94	1	0	0	0	154	2	0	2	0
95	2	0	1	0	155	0	0	1	0
96	0	1	0	0	156	3	0	0	0
97	1	1	1	0	157	4	0	1	0
98	3	0	1	0	158	1	0	2	0
99	0	0	0	0	159	0	0	2	0
100	0	0	0	1	160	0	0	0	0
101	0	0	1	0	161	1	0	0	0
102	1	1	0	0	162	0	0	0	0
103	0	0	0	0	163	0	0	0	0
104	3	0	0	0	164	0	0	0	0
105	2	0	0	0	165	0	0	0	0
106	1	0	1	0	166	0	0	0	0
107	2	0	0	0	167	1	0	0	0
108	2	0	3	0	168	0	0	0	0
109	3	0	0	1	169	0	0	0	0
110	2	0	1	0					
111	2	0	1	0					
112	3	0	1	0					
113	1	0	3	0					
114	2	0	2	0					
115	4	0	0	0	No. Sublegal (<140 mm)	215	88	199	11
116	1	0	1	0					
117	1	0	3	0	No. Legal				
118	4	0	1	0	(>139 mm)	74	0	68	0
119	5	0	4	0					
120	4	0	4	0	Total	289	88	267	11
121	5	0	5	0					
122	2	0	6	0					
123	7	0	2	0					
124	5	0	8	0					

Appendix Table 4. Size composition of the Tanner crab catch in Experiment II by sex and pot type. Carapace width is in mm.

Carapace Width	With Boards Male	With Boards Female	Without Boards Male	Without Boards Female
65	0	0	0	0
66	0	0	0	0
67	0	0	0	0
68	0	0	0	0
69	0	0	0	0
70	0	0	0	0
71	0	0	0	0
72	0	0	0	0
73	0	0	0	0
74	0	1	0	0
75	0	0	0	0
76	0	0	0	1
77	0	0	0	0
78	1	1	0	1
79	0	0	0	2
80	0	0	0	0
81	0	0	0	2
82	0	0	0	1
83	0	1	0	2
84	0	5	0	9
85	0	2	0	3
86	0	2	0	1
87	0	3	0	4
88	0	2	0	4
89	0	1	1	3
90	0	5	0	5
91	0	5	1	7
92	0	6	1	4
93	0	4	1	3
94	0	4	1	8
95	0	3	1	4
96	0	6	0	3
97	0	6	4	7
98	0	4	1	4
99	0	3	0	3
100	0	1	0	3
101	1	0	2	5
102	0	0	2	7
103	0	2	4	2
104	1	1	3	0
105	0	0	5	1
106	0	0	0	0
107	0	0	1	0
108	2	1	3	2
109	0	0	2	0
110	0	1	4	0
111	1	0	1	0
112	2	0	4	2
113	2	0	2	0
114	2	0	2	0
115	0	0	5	0
116	1	0	3	0
117	2	0	3	0
118	8	0	5	0
119	3	0	7	0
120	3	0	4	0
121	5	0	6	0
122	6	0	8	0
123	8	0	7	0
124	4	0	15	0
125	2	0	6	0
126	7	0	12	0
127	3	0	16	0
128	6	0	9	0
129	11	0	20	0
130	8	0	12	0
131	14	0	14	0
132	9	0	11	0
133	4	0	14	0
134	9	0	22	0
135	9	0	11	0
136	10	0	12	0
137	10	0	13	0
138	5	0	10	0
139	6	0	3	0
140	3	0	3	0
141	5	0	5	0
142	3	0	4	0
143	3	0	5	0
144	3	0	0	0
145	5	0	6	0
146	5	0	2	0
147	3	0	7	0
148	4	0	1	0
149	9	0	4	0
150	1	0	4	0
151	1	0	4	0
152	1	0	4	0
153	4	0	3	0
154	3	0	4	0
155	2	0	2	0
156	2	0	3	0
157	0	0	2	0
158	0	0	0	0
159	2	0	1	0
160	1	0	0	0
161	2	0	0	0
162	2	0	2	0
163	1	0	2	0
164	0	0	1	0
165	0	0	0	0
166	0	0	0	0
167	0	0	0	0
168	0	0	0	0
169	0	0	0	0
No. Sublegal (<140 mm)	165	70	294	103
No. Legal (>139 mm)	65	0	69	0
Total	230	70	363	103

Appendix Table 5. Catch of species other than halibut and crab by experiment and pot type.

Species	Experiment I		Experiment II	
	Side-entry	Top-entry	With boards	Without boards
Cottids *(Hemilepidotus* spp.*)*	1	—	—	—
Lingcod *(Ophiodon elongatus)*	15	—	—	—
Pacific cod *(Gadus macrocephalus)*	27	2	1	2
Sablefish *(Anoplopoma fimbria)*	2	—	—	—
Skate *(Raja* spp.*)*	1	—	—	—
Spiny dogfish *(Squalus acanthias)*	1	—	—	1
Turbot *(Atheresthes stomias)*	3	—	—	—
Walleye pollock *(Theragra chalcogramma)*	—	—	2	—
Yelloweye rockfish *(Sebastes rubberimus)*	1	—	—	—

Appendix Table 6. Results from analysis of variance on Experiment 1.

Source	Degrees of freedom	Day 1 Sum of squares	Day 1 Mean square	Day 1 F	Day 2 Sum of squares	Day 2 Mean square	Day 2 F	Day 3 Sum of squares	Day 3 Mean square	Day 3 F	Day 4 Sum of squares	Day 4 Mean square	Day 4 F	Day 5 Sum of squares	Day 5 Mean square	Day 5 F
Catch of Halibut																
Total	40	91.00			193.80			71.00			30.00			54.00		
Mean	1	30.62			68.00			27.23			4.90			19.60		
Row	3	2.87			30.20			0.27			0.90			3.40		
Column	9	4.13			32.00			2.03			6.10			3.40		
Pot type	1	27.23	27.23	26.96*	54.50	54.50	155.71*	24.03	24.03	35.87*	4.90	4.90	9.61*	16.90	16.90	41.22
Residual	26	26.15	1.01		9.10	0.35		17.44	0.67		13.20	0.51		10.70	0.41	
Catch of Tanner Crab																
Total	40	830.00			7.00			29.00			8595.00			2162.00		
Mean	1	72.90			0.63			3.03			3822.02			940.90		
Row	3	151.70			1.08			7.07			427.07			320.90		
Column	9	209.10			1.13			5.73			3150.23			303.10		
Pot type	1	0.40	0.40	0.03	1.25	1.25	11.36*	0.03	0.03	0.06	164.03	164.03	4.14*	8.10	8.10	0.36
Residual	26	395.90	15.23		2.93	0.11		13.14	0.51		1031.25	39.66		589.00	22.65	

*Significant at p = 0.01

Appendix Table 7. Results from analysis of variance on Experiment II.

Sources	Degrees of freedom	Day 1 Sum of squares	Day 1 Mean square	Day 1 F	Day 2 Sum of squares	Day 2 Mean square	Day 2 F	Day 3 Sum of squares	Day 3 Mean square	Day 3 F
Catch of Halibut										
Total	20	42.00			37.00			59.00		
Mean	1	24.20			24.50			26.50		
Row	1	0.80			0.50			0.50		
Column	9	8.80			7.00			17.00		
Pot type	1	5.00	5.00	12.50*	1.40	1.40	2.75	8.50	8.50	10.49*
Residual	8	3.20	0.40		3.60	0.51		6.50	0.81	
Catch of Tanner Crab										
Total	20	5170.00			3623.00			10,010.00		
Mean	1	2737.80			1549.40			6,195.20		
Row	1	192.20			53.40			245.00		
Column	9	1539.20			1367.10			1,951.80		
Pot type	1	7.20	7.20	0.08	46.70	46.70	0.54	924.80	924.80	10.67*
Residual	8	693.60	86.70		606.40	86.60		693.20	86.65	

*Significant at p = 0.01

Note: On Day 2, the degrees of freedom for the total, main effects and residual are 18, 1, 1, 8, 1 and 7, respectively.