ISSN: 0579-3920

INTERNATIONAL PACIFIC HALIBUT COMMISSION

ESTABLISHED BY A CONVENTION BETWEEN
CANADA AND THE UNITED STATES OF AMERICA

Technical Report No. 45

A study of the dynamics of a small fishing ground in British Columbia

by

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SEATTLE, WASHINGTON
2000

The International Pacific Halibut Commission has three publications: Annual Reports (U.S. 0074-7238), Scientific Reports, and Technical Reports (U.S. ISSN 0579-3920). Until 1969, only one series was published (U.S. ISSN 0074-7426). The numbering of the original series has been continued with the Scientific Reports.

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Abstract

In 1988 the International Pacific Halibut Commission (IPHC) conducted a study of the dynamics of the commercial halibut fishery on a small fishing ground in the northern portion of Area 2B. The effects of continuous fishing on the abundance of halibut within a small area was examined. In two research trips to the survey grounds, fishing for a combined total of 21 days, 2,652 halibut were tagged and released. Halibut catch varied with time but no trend was observed. In contrast, dogfish catches decreased markedly over time. By the end of 1997 nearly half of the tags were recovered, indicating a high exploitation rate on the grounds. Very little movement out of the study area was seen with nearly 90% of tags recovered on or adjacent to the release area. A subsample of the tagged fish were sexed at release. A near equal number of females and males were released as well as recovered. Legal-sized tagged fish were recovered at a higher rate than sublegal-sized fish, suggesting size selectivity occurred in the recoveries.

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Introduction

Halibut catch in British Columbia (IPHC regulatory Area 2B) represents approximately 19% of the total allowable catch on the Pacific coast (IPHC 1998). The fishing grounds in Area 2B vary in productivity and size, and often consist of small, localized spots with high catch rates, separated by large areas of low halibut density. Spot fishing may be typical of the southern extreme of the Pacific halibut's range (Trumble et al. 1991). Two hypotheses exist about these spots: (1) the population of halibut in a given spot may home to the spot causing it to be isolated from the rest of the grounds; or (2) high density on a spot could represent a temporary stop on a migration route or an area of preferred habitat that attracts halibut. If the first hypothesis holds true, the population of halibut could be locally fished down or "depleted." Conversely, if the second hypothesis is accepted depletion would not occur, as the halibut on the spot would be continually replenished. Migration into a fishing ground was observed in a 1987 experiment where halibut depletion was attempted[1] ; however the ground was not identified as an area of spot fishing. Examination of commercial fishing data in Area 2B has identified several small, seemingly isolated fishing grounds.

In 1988, the International Pacific Halibut Commission (IPHC) carried out an experiment in the eastern end of Dixon Entrance on one such ground, known locally as the Sitka Spot (Fig. 1). The Sitka Spot consistently produces between 2 - 4% of the Area 2B landings (based on commercial logbook data) but the ground is only 10 km^2 in area. In years prior to 1991, the commercial halibut fishery openings in British Columbia were typically four to seven days long, usually occurring twice a year, depending on the catch quotas set by the IPHC. Though the number of vessels fishing halibut in British Columbia was limited to 435, there was no limit on vessel catch for each opening. In 1991, an Individual Vessel Quota (IVQ) system was implemented, allowing a nearly year-round fishery (mid-March to mid-November). Under the IVQ system, the halibut quota for each year is divided among the licensed vessels using a share system. A formula based on vessel size and catch history determined the number of shares assigned to each vessel.

Because of the small size of the Sitka Spot, it was traditionally fished by only two to three commercial halibut vessels during the open access fishery in the 1980s. Competition for the spot was intense and usually only one vessel could fish the best ground at any one time. After the IVQ system was implemented in 1991, the time restriction was lifted and the number of vessels targeting the Sitka Spot more than tripled.

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[1]Deriso, R. B. and Kaimmer, S. K. 1988. Continuous Fishing Studies in Area 2B and 3A. Int. Pac. Halibut Comm. Stock Assessment Document II, 1987. 82-97.

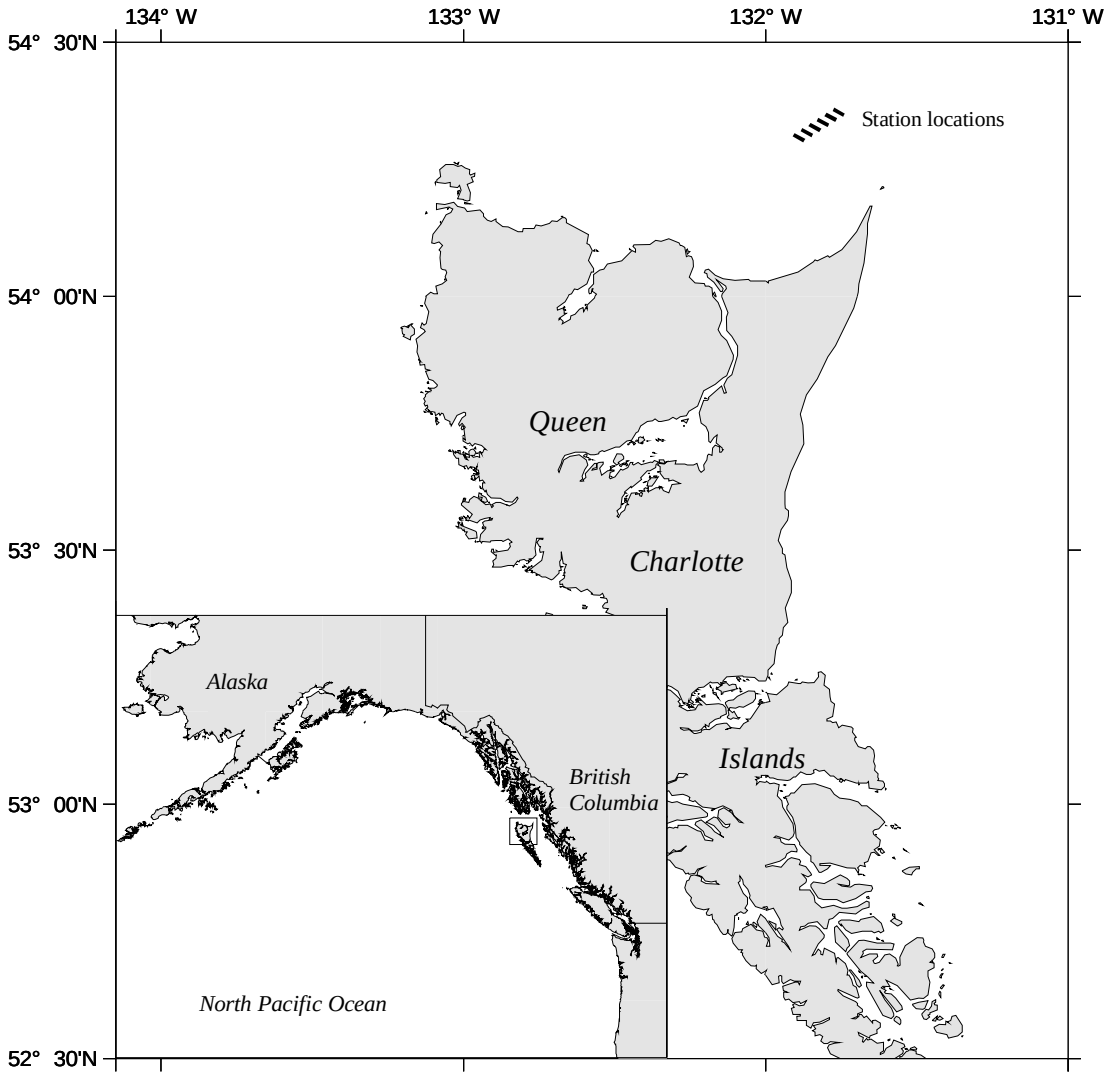


Figure 1. Location of study area.

The purpose of this study was twofold: (1) to examine the effect of continuous fishing on the abundance of halibut within a small area, with the hypothesis that if the area were isolated from other grounds depletion of halibut would occur and (2) to conduct an extensive tagging operation to track movement of halibut off the Sitka Spot to other parts of Area 2B and beyond.

Methods

The Sitka Spot fishing ground, located inside Dixon Entrance at the northern end of Area 2B (Fig. 1), encompasses an area of about two by five kilometres with optimum fishing depths ranging between 170 and 200 metres. It represents a zone of shallow water that lies in a major migration path for fish entering Dixon Entrance. Depth is 170 m at the shallowest and falls off to over 200 m on three sides.

The IPHC conducted two fishing trips to the area in 1988. The first trip used the Canadian F/V *Snowfall* for 12 fishing days from May 31 to June 20. On the second trip, the U.S. F/V *Cape Flattery* was chartered from July 17 to 27 for nine fishing days. This experiment was conducted before the IVQ system was in place and the trips were timed to fall between the two commercial fishing periods scheduled for Area 2B (May 6-14 and August 19-25). Fishing on Trip 1 started 17 days after the end of the first commercial fishing period in Area 2B. The second commercial fishing period in Area 2B started 23 days after the end of the second research trip. These breaks in fishing allowed "rest periods" ensuring fish tagged during either trip would be available to the commercial fleet during the August fishing period.

All fishing was conducted with 1500-foot skates using 16/0 circle hooks (O. Mustad and Sons, Quality 39965), a size and style which are common in the fishery for Pacific halibut, and which are standard for surveys by the IPHC. Hooks were attached by 81-cm (32-inch) gangions to a 0.8-cm (5/16-inch) diameter groundline. Alternate hooks were baited with 0.17-kg (1/3-lb) pieces of skin-on, chum salmon (*Oncorhynchus keta*) fillet, and whole herring (*Clupea harengus pallasi*) weighing about 0.22 kg (1/2-lb). Six stations were fished; spaced 0.8 km apart and laid out in a northwest-southeast orientation (Fig. 2). The six stations covered an area 1.8 by 4.6 km over the fishing ground. An attempt was made to fish six sets daily, three in the morning and three in the afternoon, with each set

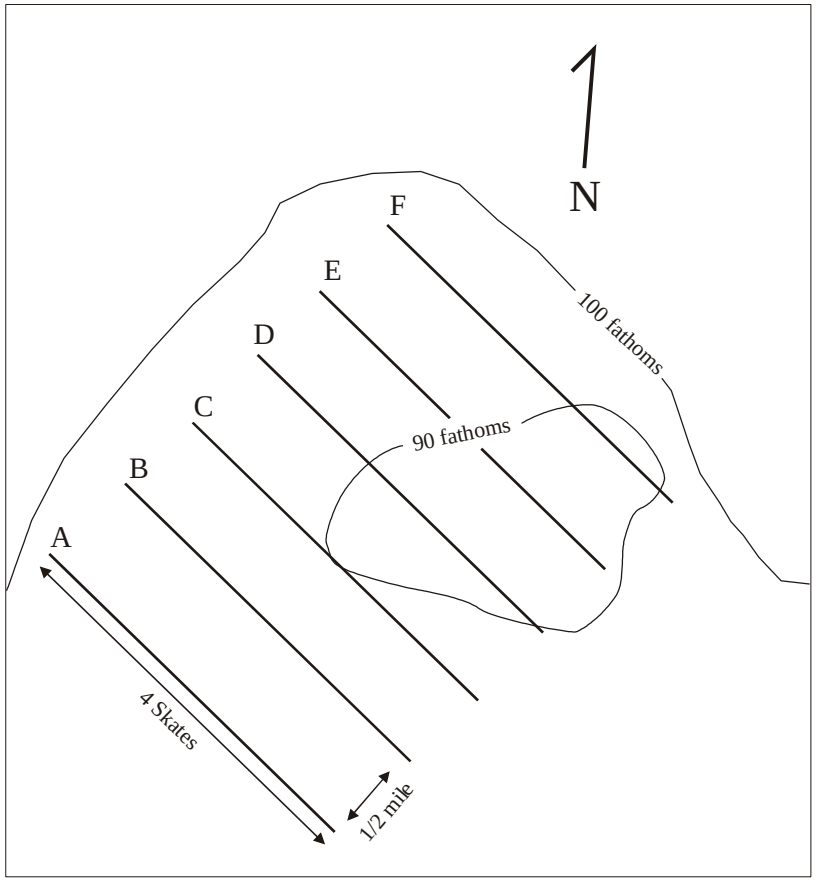


Figure 2. Layout of fishing gear on the study area.

consisting of four 85-hook skates. The fishing pattern was repeated each day on the same grounds, alternating the setting and retrieval order to vary soak times among the sets from day to day. Soak times varied from two to five hours. Gear was set between 0500 and 0600 (PDT) each morning and between 1300 and 1400 (PDT) each afternoon.

Each fish caught was brought on board the vessel and, if assessed as healthy, was measured and tagged with a wire spaghetti tag. IPHC spaghetti tags consist of a nickel alloy wire covered with polyethylene plastic printed with a unique number (Trumble et al. 1990). The tag was inserted between the opercular and preopercular bones and then through the preopercular on the dark side cheek and twisted down creating a closed loop. Information about the tagging program, including posters describing the tags and rewards, was sent to processing plants and the Canadian Department of Fisheries and Oceans in hopes of increasing public awareness of the tagging program. The IPHC staff mounted a special effort to collect tags and sample the commercial catch for age and size composition from vessels targeting this fishing ground.

Prior to release, a sample of tagged fish was sexed using a method developed by St-Pierre (1992). During the first trip, 114 of the fish determined as female and 87 of those judged as male were sacrificed to confirm the external sexing methodology. Running males (those fish extruding sperm from the vent) from the first trip and all fish tagged on the second trip were included in a known-sex data set.

Data analysis

A χ^2 test was used to test recovery rates from the sublegal and legal-sized fish as well as the recovery rates for male and female fish. A t-test was performed to test the difference in catch rates between the two tagging trips. In both tests, the level of significance was set at 0.05. A linear regression was used to examine the correlation between time and halibut catch within each trip.

Results

Of the total fish tagged, 2,395 were legal-sized ($\geq$82 cm) and 257 were sublegal-sized (< 82 cm). The average fish length was 97 cm, with a range from 57 to 171 cm (Fig. 3).

Fishing results

The number of fishing days totaled 21, with 12 on the first trip and nine on the second (Table 1). The average weight of the legal-sized halibut increased from 21.4 pounds on the

Table 1. Summary of catches by trip.

	Trip 1	Trip 2
Number of days fished	12	9
Total skates fished	264	168
Number of legal halibut caught	1,871	778
Number of sublegal halibut caught	197	71
Number of females not tagged	114	29
Number of males not tagged	87	19
Pounds of legal halibut caught	39,956	19,018
Average catch rate (lbs/skate)	151	113
Average weight (lbs)	21.4	24.4
Number of dogfish	2,221	404

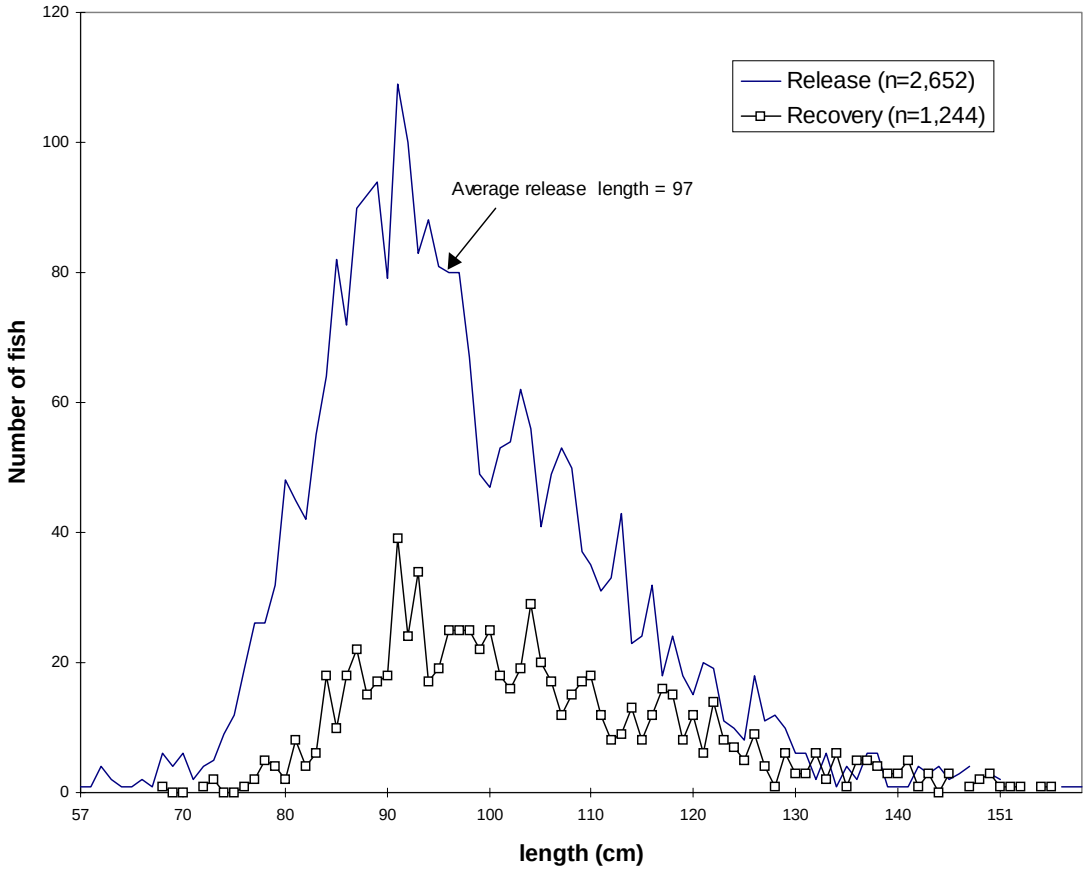


Figure 3. Length frequencies of tag releases and recoveries.

first trip to 24.4 pounds on the second trip. Dogfish and halibut were the dominant species in the total catch of both trips with 2,625 and 2,917 individuals, respectively. Catch rates by set position changed between trips (Fig. 4). In Trip 1, there were significant differences between set locations where Position D and E ranked first and second in terms of overall average catch rates (216 and 185 pounds per skate) while catches on position A and B averaged the lowest (78 and 74 pounds per skate). Almost all the positions had similar catches during Trip 2, ranging from 94 to 106 pounds per skate with the exception of Position B which averaged 29 pounds per skate. Each position had less fishing on the second trip because of poor weather.

A significant halibut depletion effect did not occur within either of the two trips, although the average catch rate dropped from 151 pounds per skate on the first trip to 113 pounds per skate on the second trip. The halibut catch showed no significant downward trend when the average daily catch in weight and number of fish was plotted over time (Fig. 5). Total catch by position ranged from a high of 1,911 pounds on the first trip to a low of 38 pounds on the second trip. Out of 66 sets on the first trip, 35 (53%) had catches of less than 500 pounds while nine (14%) had catches of over 1,000 pounds per set. On the second trip, 27 (64%) out of the total 42 sets had catches of less than 500 pounds while only one (2%) had a catch over 1,000 pounds.

The catch rate of dogfish dropped substantially over time within each trip (Fig. 5). On the first trip, dogfish abundance peaked on the second fishing day at 390 individuals and

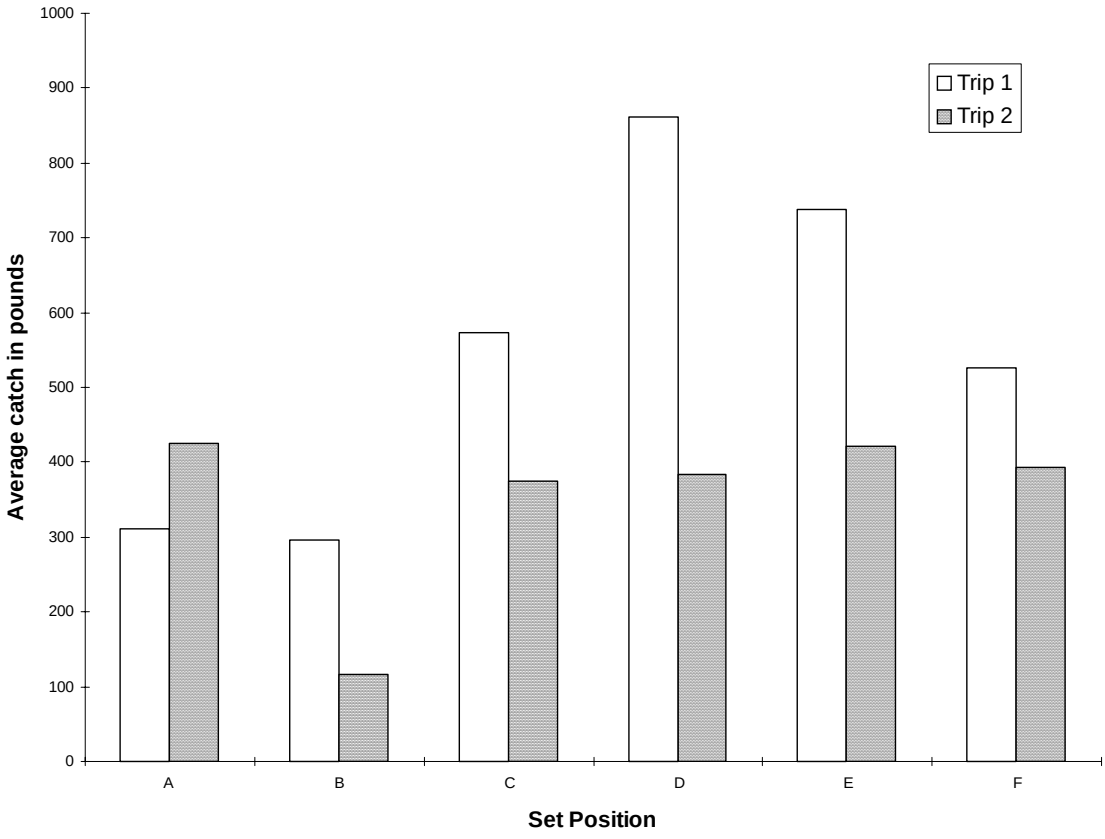


Figure 4. Average daily catch of halibut by position for Trips 1 and 2.

dropped to a low of 66 on the last day. Conversely, halibut abundance on the first trip was lowest on the second day of fishing with 54 fish and peaked the fifth day at 270. On Trip 2, fewer sets were fished but the dogfish depletion was still evident. The second day of fishing had the highest abundance of dogfish with 113 fish. Over the nine days of fishing, dogfish numbers decreased to lows of four and 16 on the last two days. Halibut numbers varied from a low of 38 on the first day to highs of 145 and 146 on the second and last days of fishing. Weather days interfered with fishing on both trips but the decreasing trend in numbers of dogfish per skate was still evident. Dogfish seemed to be fished down in four days to less than six fish per skate on Trip 1 and less than two fish per skate on Trip 2. Halibut numbers increased somewhat with the initial dropping dogfish concentration with no evident halibut depletion over time. To see a maximum scenario for halibut depletion, the number of dogfish occupied hooks was subtracted from the number halibut hooks set and then halibut catch per hook was calculated (Fig. 6). A linear regression on the data showed the correlation was not significant for either trip (trip 1 r^2=0.072 ; trip 2 r^2 = 0.002) but a t-test indicated the average halibut catch per hook when calculated for each trip was significantly different ($p < 0.001$).

Tagging results

A χ^2 test showed recovery of tagged fish from both trips combined was dependent on size (χ^2=23.75, df = 1, $p > 0.001$). Legal-sized fish were recovered in a higher proportion than the sublegal-sized fish (Table 2). Legal-sized fish had a recovery rate of 48% or 1,161 tags of the 2,395 legal releases. Sublegal-sized fish were caught in lower numbers with 83 tags recovered of the 257 released, a rate of 32%.

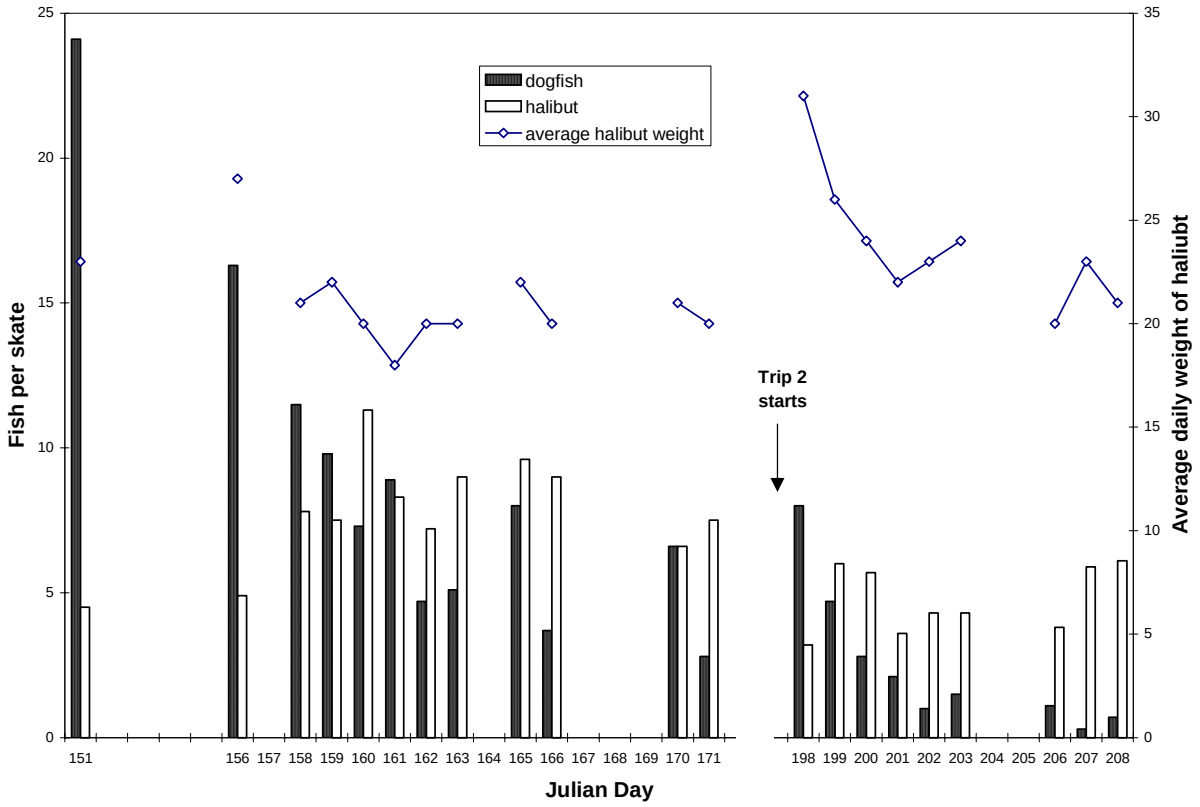


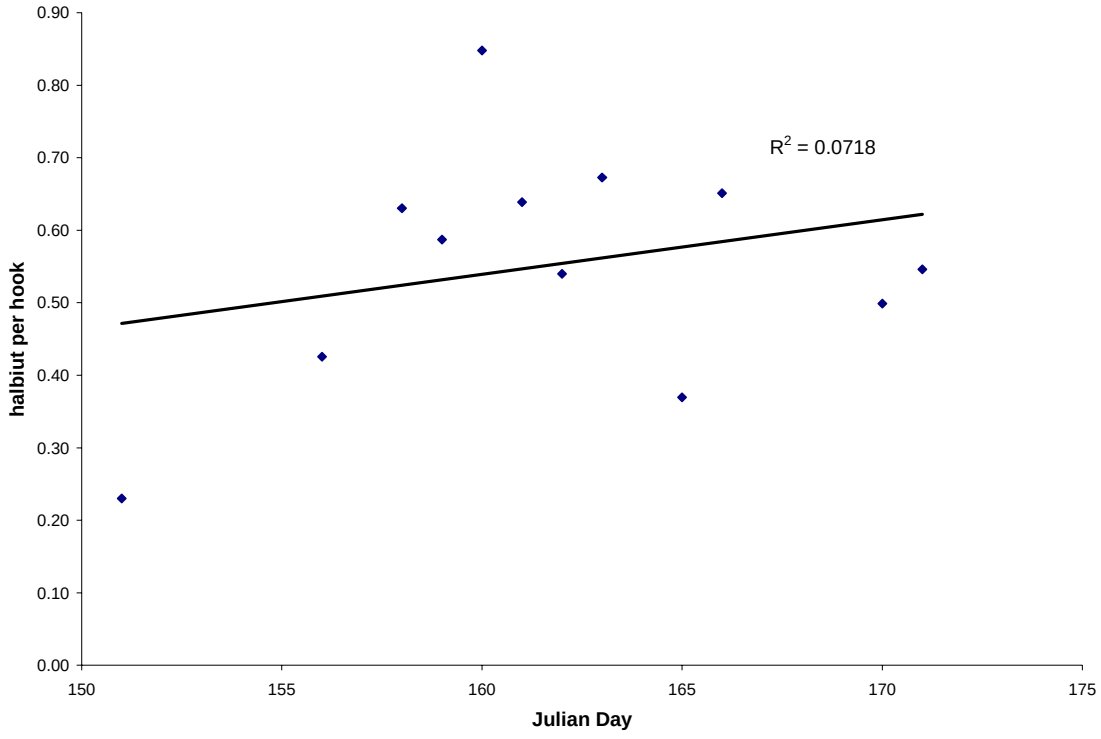
Figure 5. Dogfish and halibut numbers by skate and average daily catch (lbs) over time.

Of the 2,652 fish released, 1,080 were sexed: 538 were female and 542 were male. A portion of the fish were sacrificed to verify sex determination methodology; 114 female and 87 male fish on Trip 1 and 29 female and 19 male halibut on Trip 2. The average length of female and male fish was 103 cm and 93 cm, respectively (Fig. 7). Male and female fish were recovered in near equal proportion (Table 2). A χ^2 test showed tag recovery rate was independent of sex (χ^2=0.507, df = 1, 0.90 <P<0.75). Of the recovered fish, 424 had known sexes at release and these are split evenly: 51% male and 49% female. A total of 96 fish were sexed when they were recovered and again the sex ratio was close to 1:1 (52% male to 48% female). While there appears to be a relatively greater number of males returned in later years, this difference is not significant (χ^2=1.830, df = 6, P≥0.05) (Fig. 8). The 1995 data point was dropped from the analysis because of the small number of recoveries. Recovery rates by 10-cm category of release size were plotted separately for the first two years' recoveries to separate growth of fish from selectivity (Fig. 9). The selection curve for the Sitka Spot recoveries was compared to two similar experiments; one near Kodiak, Alaska and the other in the Goose Grounds of Area 2B (Myhre 1969). The recovery rates were scaled to one and plotted in 5-cm groups (Fig. 10).

Through 1997[2] a total of 1,244 tags have been recovered from the 2,652 released; an overall recovery rate of 47 %(Fig. 11). This is a relatively high recovery rate when compared to similar experiments in Area 2B (Thompson and Herrington 1930). The overall recovery rate for recent years' Area 2B tag releases was 23%. For experiments with more than 1,000 releases, the recovery rate averaged 35%, and ranged from 18 to 51%. During the year of the Sitka Spot releases, 11% of the tagged fish were recovered; 16% were recovered in 1989, and 8% in 1990 (Fig. 11). In 1991, an IVQ system was implemented in the B.C.

[2] Between 1998 and 1999 one additional tag was recovered in Dixon Entrance.

Trip 1



Trip 2

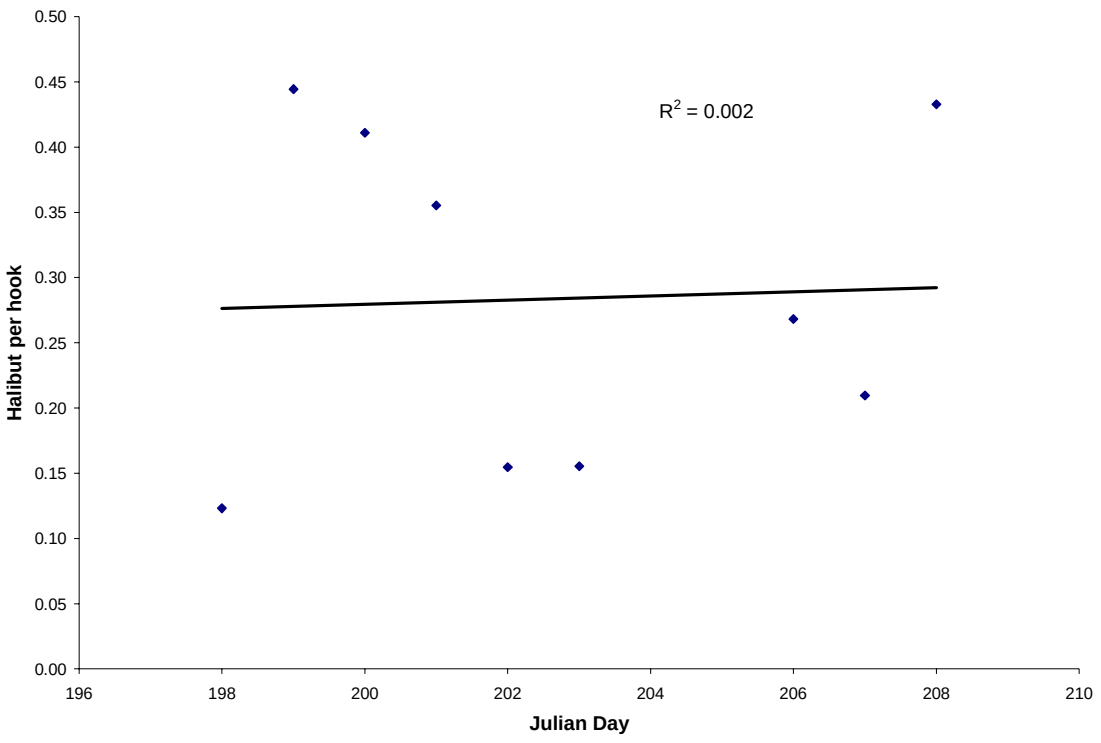


Figure 6. Net halibut catch per hook for both trips (subtracting dogfish occupied hooks).

Table 2. Breakdown of tag releases and recoveries by size and sex.

	Total released	Number recovered	Recovery rate
Sublegal-sized fish (< 82 cm)	257	83	32%
Legal-sized fish (≥ 82 cm)	2,395	1,161	48%
Male	542	218	40%
Female	538	206	38%

halibut fishery, allowing vessels to fish the Sitka Spot almost throughout the year. While coastwide tag recoveries declined in 1991, those on the Sitka Spot (Area 132) actually increased from 130 to 163 (Table 3). The following year Sitka Spot recoveries dropped to less than 20 percent of the 1991 total.

Nearly 90 % of the recoveries occurred on or in statistical areas adjacent to the release area (Fig. 12). The small numbers of tagged fish that left the area were recovered from central Oregon to Unalaska Island on the Aleutian Chain. More of these migrating fish traveled north than south and tended to be of legal size at release, reflecting the greater proportion of legal-sized releases (9:1). In August of 1992, a tagged fish was recovered off Unalaska Island, representing the farthest movement from point of release (1,200 nautical miles) for the experiment. With the commercial fisheries concentrating their effort during the spring and summer, most of the recoveries occurred during these months. Only 1% of the recovered tags were caught in the winter months (October to March).

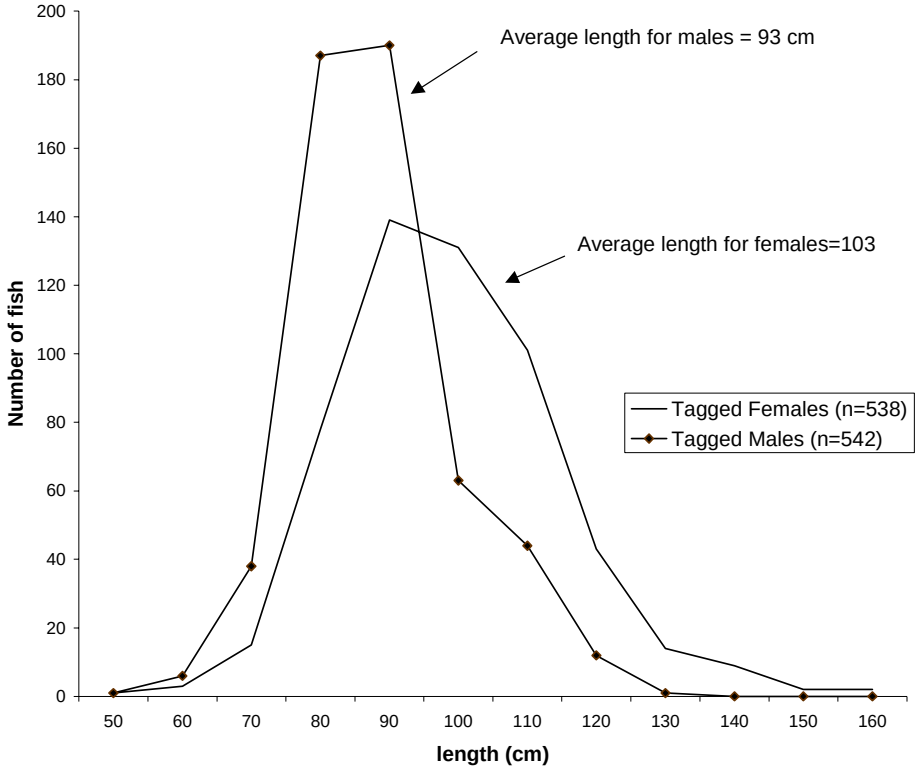


Figure 7. Length frequency of halibut that were sexed at release.

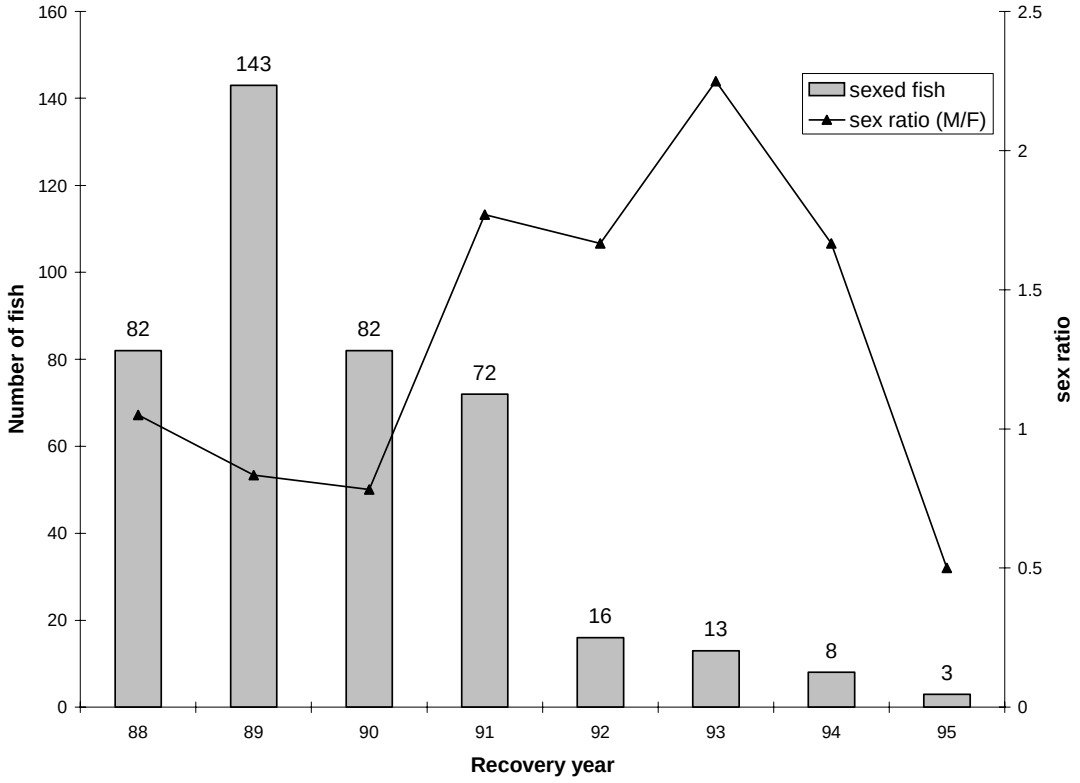


Figure 8. Recovery rate of sexed halibut and the sex ratio over time.

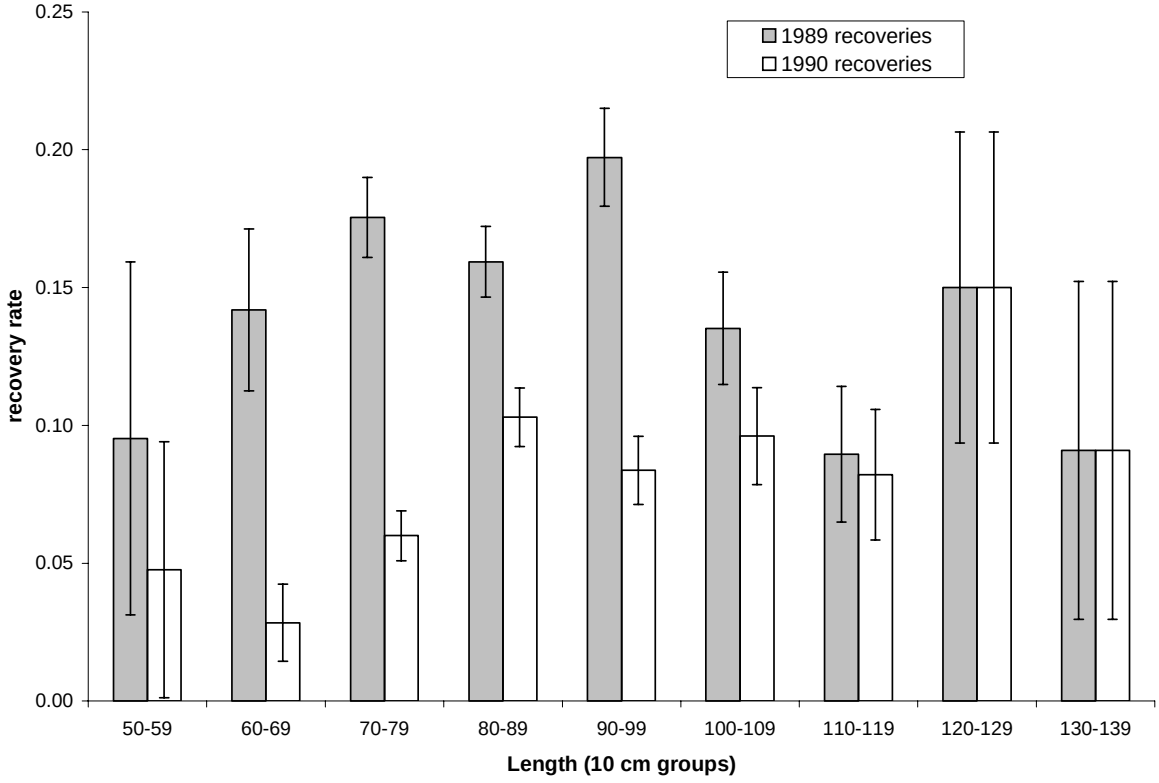


Figure 9. Recovery rates by 10 cm groups over the first two years.

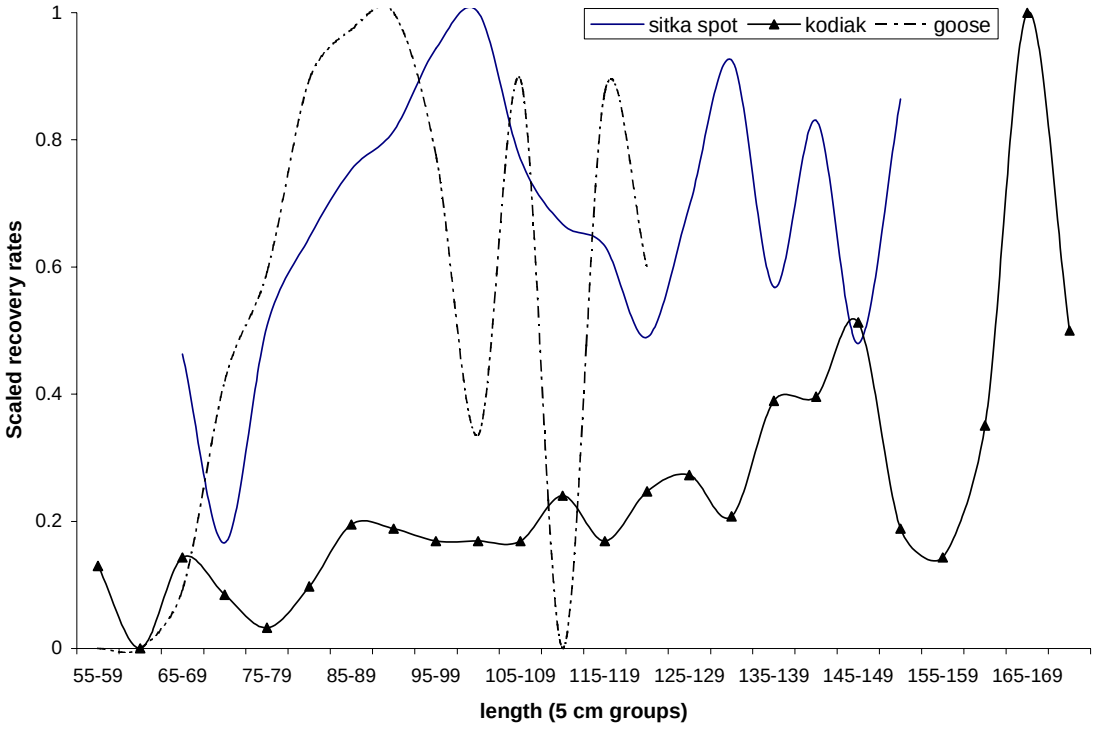


Figure 10. Scales selection curves for the Sitka Spot, Goose Island and Kodiak tagging experiments.

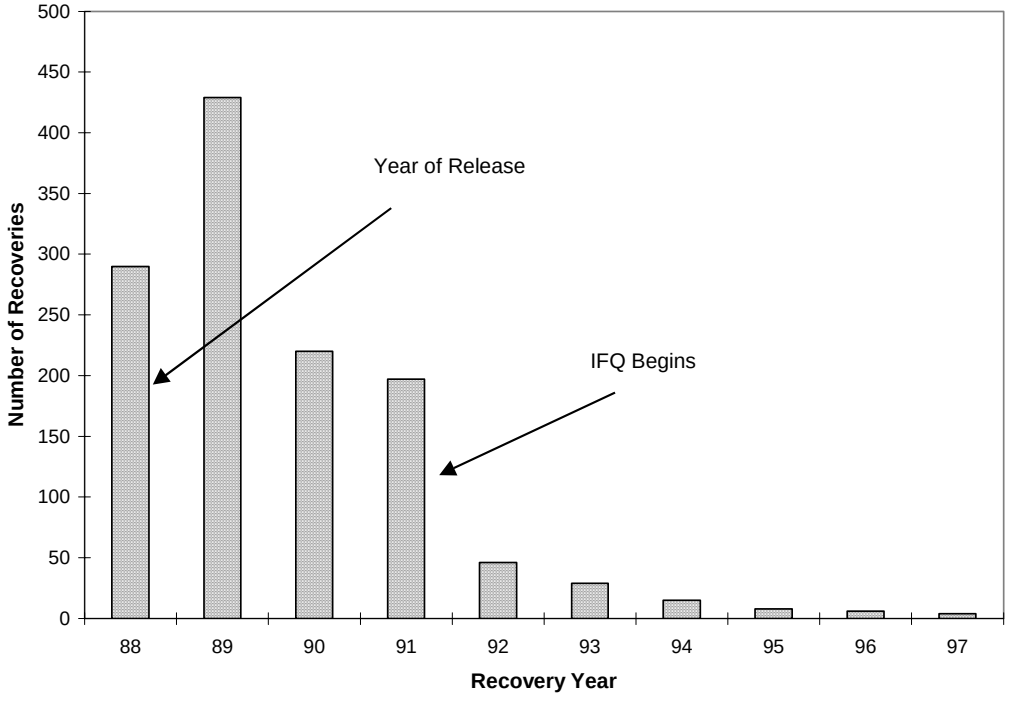


Figure 11. Tag recoveries by year.

Tags from known recovery gear types were caught almost exclusively on longline gear (93%) with the troll, trawl and sport fisheries catching only 91 (7%) tags of the total 1,244 recoveries (Fig. 13). Twenty two tags were recovered with an unknown gear type. The longline fishery recovered 73 sublegal fish with the troll and trawl fisheries catching only eight. The sport fishery had seven tag recoveries, all of legal-sized fish.

Table 3. Distribution of tag recoveries by year and statistical area.

Stat Area		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Total
	Unknown	37	28	17	5	2	1	1				91
S	20						1					1
o	30						1					1
u	50						1					1
t	90							1				1
h	102	1		1								2
	112	1		1								2
	114		1		1		1					3
↓	121	4	5									9
	130	1	5			1		2			1	10
	131		12	30	1	5	4	3	3	1	2	61
	132	185	281	130	163	29	14	3	3	3		811
	133	49	48	14	7	1	2		1	1		123
t	142	10	45	17	15	5	1	1			1	95
o	134							1				1
	140						1		1			2
	141				1					1		2
	143	1		1	1	1	1					5
↓	144			3								3
	150		2	2				2				6
	152			1								1
	153	1	1									2
N	160			2	1							3
o	162				1	1						2
r	170			1								1
t	185							1				1
h	240				1							1
	250		1									1
	300						1					1
	360					1						1
	Total	290	429	220	197	46	29	15	8	6	4	1244

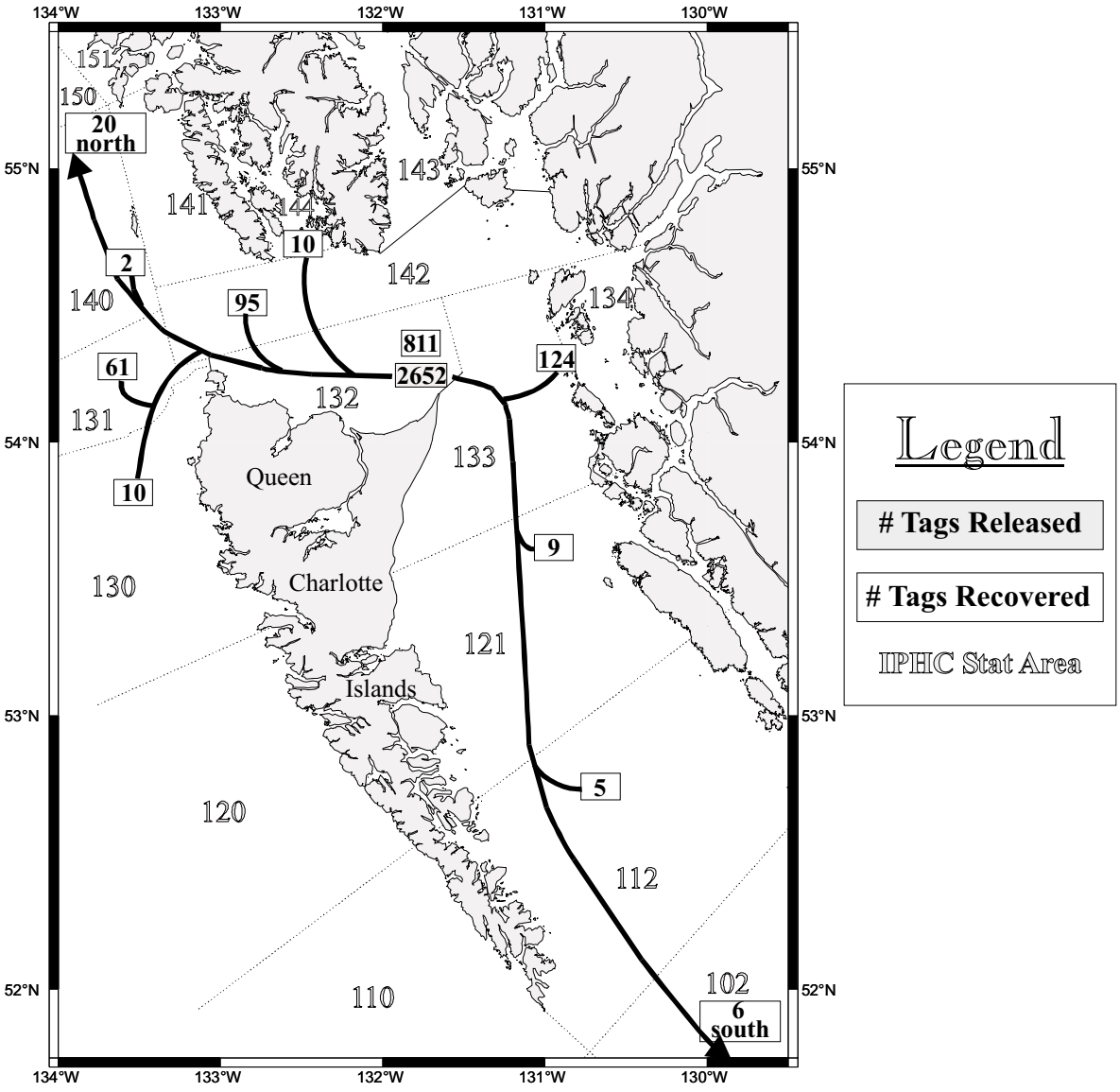


Figure 12. Distribution of tag recoveries by statistical area.

Discussion

The results suggest that the Sitka Spot cannot be considered isolated from other grounds. Halibut depletion did not occur either because of insufficient effort or migration into the area replenished the fishing ground. Fishing effort during the experiment mirrored the previous year's commercial trips and the gear repeatedly fished over the optimum ground. It is more likely that immigration occurred restocking the spot. After the tagging was completed, almost all the recoveries for the first year occurred adjacent to or inside of the release area. In later years, the same pattern was evident even though halibut move offshore in winter to spawn. Most of the tagged fish returned to their release area, migrating through Dixon Entrance (Table 3, Fig. 12). No tag returns occurred on the west coast of the Queen Charlottes even though this was an area of heavy fishing.

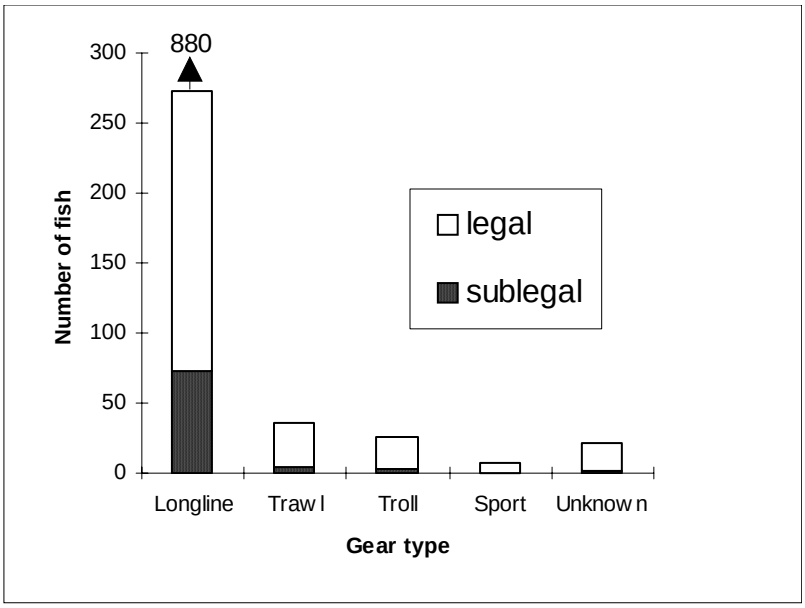


Figure 13. tag recoveries by gear type.

The average catch rate decreased from 151 pounds on Trip 1 to 113 pounds per skate on Trip 2 but this could have been an artifact of changing vessels between trips, changing migration rates, and/or weather effects. The numbers of halibut and catch per skate fluctuated over time with no obvious trend observed for either trip. In contrast, dogfish depletion did occur over time. Dogfish numbers in the top part of Hecate Strait are highest June through August and begin dropping in late fall as they migrate south (Ketchen, 1986). Our experiment occurred during the peak period of dogfish abundance. We did see a recovery in dogfish numbers at the beginning of the second trip after a twenty day break in fishing, which suggests some migration into the site occurred. Some emigration out of the area may have also occurred as the second peak was less than the first peak. During pre-IVQ fishing, many Canadian commercial halibut fishermen used the first part of a trip to fish down the dogfish as a way of increasing halibut catch. With the dogfish removed, more hooks are available for halibut. During both survey trips the higher halibut catch did occur after the initial peak in dogfish catch.

Male and female fish were tagged and recovered in equal numbers suggesting nearly equal selectivity by sex. This result was unexpected because female fish grow faster than males and represent a larger proportion of the commercially caught halibut. In the last years of the study there were too few recoveries to make significant conclusions. Legal-sized fish had a higher probability of being caught than sublegal-sized fish (48% to 32%). The longline fisheries represented most of the recoveries and tended to show selectivity toward catching legal verses sublegal-sized fish. Commercial fishermen may have discarded sublegal-sized halibut because they were unsure of the legality of retaining undersized tagged halibut. IPHC regulations stipulate that tagged fish may be kept legally in all fisheries, in any season and at any size.

The change in tag recovery rates for the first two years did not yield any new information about selectivity (Fig. 9). Variation in the recovery rates of the large sized fish was too great to draw any conclusions. Some of the smaller size classes showed a significant drop in recovery rate between the first and second year, possibly from growth

into the more vulnerable legal size categories. This study compares well to similar work in Area 2B (Goose Islands) where smaller fish are selected at a higher rate than Area 3A (Kodiak), though the Area 3A selection curve starts at a smaller size category than that of Area 2B (Fig. 10). After recruitment into the fishery there does not appear to be any selection by size on the Sitka Spot but the Kodiak study shows a trend towards selection of larger fish in the tag returns.

As with other IPHC tagging studies, it was shown adult halibut move very little summer to summer and they have a high affinity for their release area (Thompson and Herrington 1930; Skud 1977). Little evidence of year to year movement was seen on the Sitka Spot, as adjacent areas would have recovered a higher proportion of tags. Once the fish have reached a size where they are susceptible to commercial fishing they tend to return to the same feeding ground each summer (Thompson and Herrington 1930; Skud 1977).

Non-reporting of tags by fishermen has impacted IPHC tagging experiments in the past (Sullivan et al. 1993). The high recovery rate (nearly 50%) indicates this was less of a problem for this project. The strong emphasis the IPHC placed on collecting tags and the targeting of the Sitka Spot by the halibut fleet likely helped maximize the number of tag returns. The change in the management of the British Columbia halibut fishery greatly affected the tag returns. When the IFQ fishery began, a significant increase in tag returns was observed because the spot was available most of the eight month season. Commercial fishery logbook data showed the Sitka Spot was targeted heavily during the first year of the IVQ.

Acknowledgements

We would like to acknowledge IPHC staff, Ana Parma, Patrick Sullivan, and Stephen Kaimmer for their invaluable comments and suggestions in the preparation of this report. Thanks are also due to the captain and crews of the F/V *Snowfall* and F/V *Cape Flattery* for their expertise and help during the experiment. In addition, we appreciate the efforts of the British Columbia halibut fleet whose participation gave us the largest tag return of any IPHC tag experiment to date.

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