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Effects of Domestic Trawling on the Halibut Stocks of British Columbia

by

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The International Pacific Halibut Commission was established in 1923 by the Convention between Canada and the United States for the preservation of the halibut fishery of the North Pacific. The Convention was the first international agreement providing for joint management of a marine fishery. The Conventions of 1930, 1937, and 1953 extended the Commission's authority and specified that the halibut stocks be developed and maintained at levels consistent with the maximum sustained yield.

Three Commissioners are appointed by the Governor General of Canada and three by the President of the United States. The Commissioners appoint the Director of Investigations who supervises the scientific and administrative staff. The scientific staff collects and analyzes statistical and biological data to manage the halibut fishery. The headquarters and laboratory are located at the University of Washington in Seattle, Washington. Each country provides one-half of the Commission's annual appropriation.

The Commissioners meet annually to review the regulatory proposals made by the scientific staff and consider advice from the Conference Board that represents vessel owners and fishermen. The regulatory measures are submitted to the two governments for adoption, and the citizens of both nations are required to observe these regulations.

The Commission publishes three series of reports: Annual Reports, Scientific Reports and Technical Reports. This report is the fifty-third of the Scientific Report series.

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ABSTRACT

The growth of the Canadian and United States trawl fishery has increased the incidental catch of halibut. Regulations prohibit the retention of trawl-caught halibut but the released halibut may not survive. The incidental catch was calculated by two methods using the estimated catch of halibut per hour and the estimated proportion of halibut in the trawl catch. Both methods resulted in a mean annual catch of 3.2 million pounds from 1962 through 1969. The catch varied by season, area, and target species.

EFFECTS OF DOMESTIC TRAWLING ON THE HALIBUT STOCKS IN BRITISH COLUMBIA

by
Stephen H. Hoag

INCIDENTAL CATCH OF HALIBUT BY TRAWLS

The retention of net-caught halibut has been prohibited by the International Pacific Halibut Commission since 1944. The evidence in North American and in European fisheries indicated that many halibut caught with bottom trawls were under the optimum harvesting size required to produce the maximum yield from recruits (Jespersen, 1917, 1948; McIntyre, 1952, 1956; Bell, 1956). Myhre (1969) estimated a selection curve for the standard commercial trawl and concluded that the gear was inimical to maximizing the yield of halibut. Although the retention of halibut is prohibited, the species is taken incidentally by both domestic (Canadian and United States) and foreign trawlers while fishing for other groundfish. The effect of trawling on yield of halibut depends on the magnitude of the incidental catch. This report deals only with the domestic trawl fishery.

Bell (1956) concluded that the incidental catch of halibut in the domestic trawl fishery was not significant prior to 1939. The trawl fleet was small and fishing was concentrated on grounds where the abundance of halibut was low. The annual production of groundfish was about 15 million pounds, most of which was taken off Northern California. By 1943 the fleet had expanded and the fishery extended northward; the trawl catch increased sharply to 80 million pounds and included 528,000 pounds of halibut. During the 1960's trawl landings increased to an average of over 150 million pounds and in recent years catch and effort have increased markedly in Queen Charlotte Sound and Hecate Strait *(Figure 1)*. These grounds are on or near productive halibut grounds.

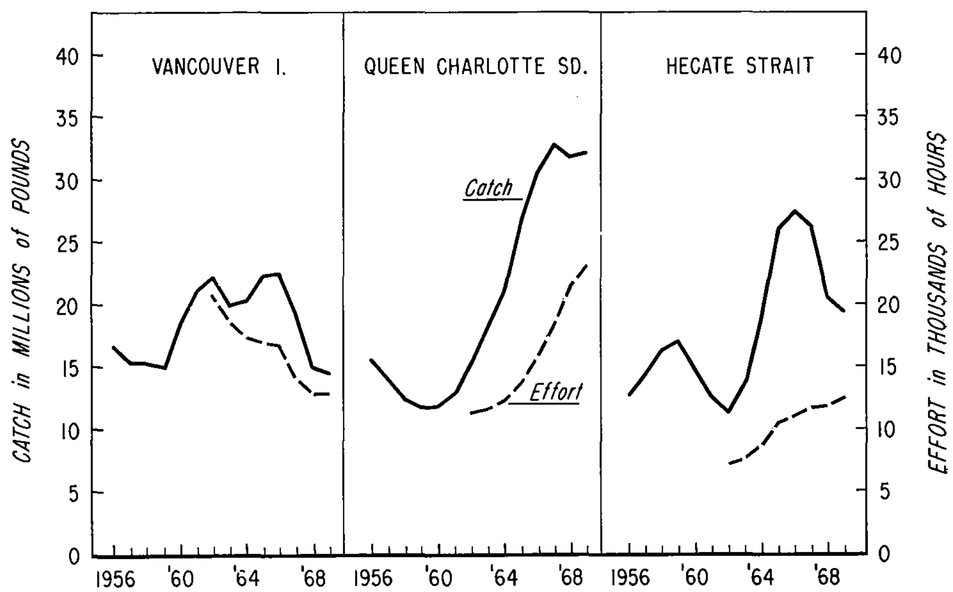

Figure 1. Annual trawl catch and effort from Vancouver Island, Queen Charlotte Sound, and Hecate Strait (Pacific Marine Fisheries Commission). Data smoothed by three-year averages.

In this report, I have estimated the annual incidental catch of halibut by Canadian and United States trawlers off British Columbia (Cape Flattery to Dixon Entrance) and examined the potential effect on the yield of halibut.

CATCH AND EFFORT DATA

Between 1962 and 1970 the Halibut Commission collected data on the incidental trawl catch of halibut off British Columbia by placing observers on commercial trawlers. The observer program was expanded during 1969 and as of April 1970, 3,031 hauls had been sampled during 120 commercial trips on 32 trawlers. The number of hauls sampled each year ranged from 117 to 352 except for 1969 when 1,040 hauls were sampled.

Data collected on each haul included the haul duration and weight of the trawl catch by species (estimated by the captain of the vessel). In this report the trawl catch is defined as the fish retained for sale and excludes discards of scrap fish, undersized marketable species, and halibut. The estimated weight of the trawl catch for each trip varied less than 5% from the weight measured at the end of the trip. The

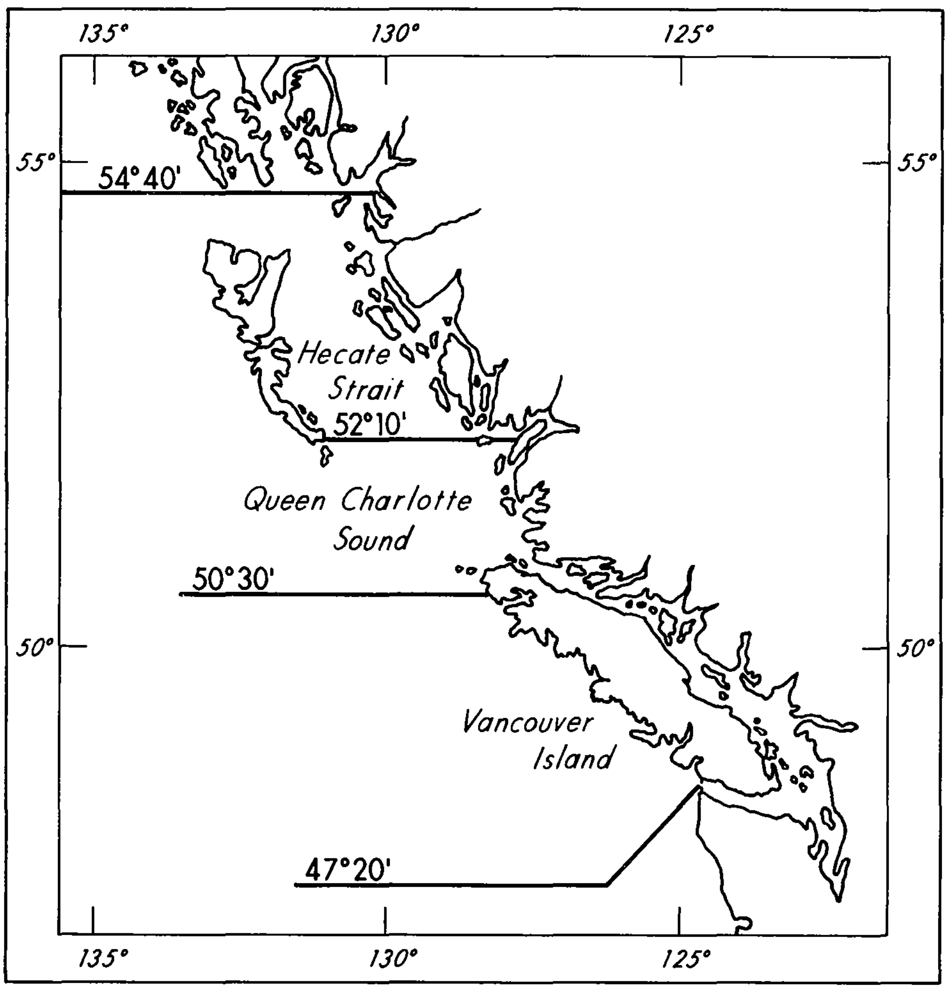

Figure 2. British Columbia sampling areas.

length and number of halibut were also recorded and weight (heads-on, dressed) calculated from an established length-weight relationship.

The most abundant species in each haul was identified and designated as the target species. Target species were grouped into categories: (1) flatfish – including all species of flounder, (2) Pacific ocean perch *(Sebastodes alutus)* and (3) other groundfish – including ling cod *(Ophiodon elongatus)*, Pacific cod *(Gadus macrocephalus)*, and rockfishes *(Sebastodes* spp.*)* other than Pacific ocean perch. In 90% of the hauls the target species constituted over 60% of the trawl catch and for the three categories the target species averaged between 86 and 88% of the trawl catch.

The coast of British Columbia was divided into three fishing areas by combining Pacific Marine Fisheries Commission (PMFC) statistical areas. These are depicted in *Figure* 2: (1) Vancouver Island – 3C and 3D, (2) Queen Charlotte Sound – 5A and 5B, and (3) Hecate Strait – 5C and 5D. Table 1 shows the bimonthly distribution of fishing effort (PMFC, 1962-1969) and sampling effort for each area. Sampling was not proportional to fleet effort but was concentrated from May through August when halibut were most available to trawl gear. For the three areas the catch of halibut per hour trawled (CPUE) generally increased in May and remained relatively high through August *(Figure* 3*)*. By September the CPUE declined to near winter levels. This seasonal change in CPUE was probably due to the movement of halibut onto the shallower feeding grounds in the summer from the deep trenches where halibut spend the winter.

Table 1. Bimonthly distribution of fishing effort and sampling effort in number of hours trawled by area, 1962-1969.

Months	Vancouver Island			Queen Charlotte Sound			Hecate Strait		
	Fleet effort	Sampling effort		Fleet effort	Sampling effort		Fleet effort	Sampling effort	
	Hours	Hours	Hauls	Hours	Hours	Hauls	Hours	Hours	Hauls
January-February	14,353	0	0	1,944	0	0	15,757	77	66
March-April	35,981	205	96	11,143	96	27	22,114	246	128
May-June	29,461	318	166	45,763	842	325	15,201	355	234
July-August	25,987	990	514	32,933	1,747	740	10,810	550	410
September-October	18,202	236	123	25,046	227	79	9,230	102	83
November-December	7,314	65	31	11,612	0	0	7,429	10	9
Total	131,298	1,814	930	128,441	2,912	1,171	80,541	1,340	930

The bimonthly samples were grouped into two periods based on the halibut CPUE to increase sample size for statistical purposes: (1) "summer" (May through August), and (2) "winter" (September through April). Although the CPUE was not homogeneous within a season, the mean for each month was greater than 50 pounds per hour during the summer and with one exception in Hecate Strait less than 50 pounds per hour during the winter.

In summary, data from each haul were categorized into one of 18 possible categories – three target species, three areas, and two seasons.

ANALYSIS AND RESULTS

Annual observations by area and season were lacking or insufficient to make an independent estimate of the incidental catch each year so in the initial analysis years were combined and a mean annual catch estimated for 1962 through 1969. This

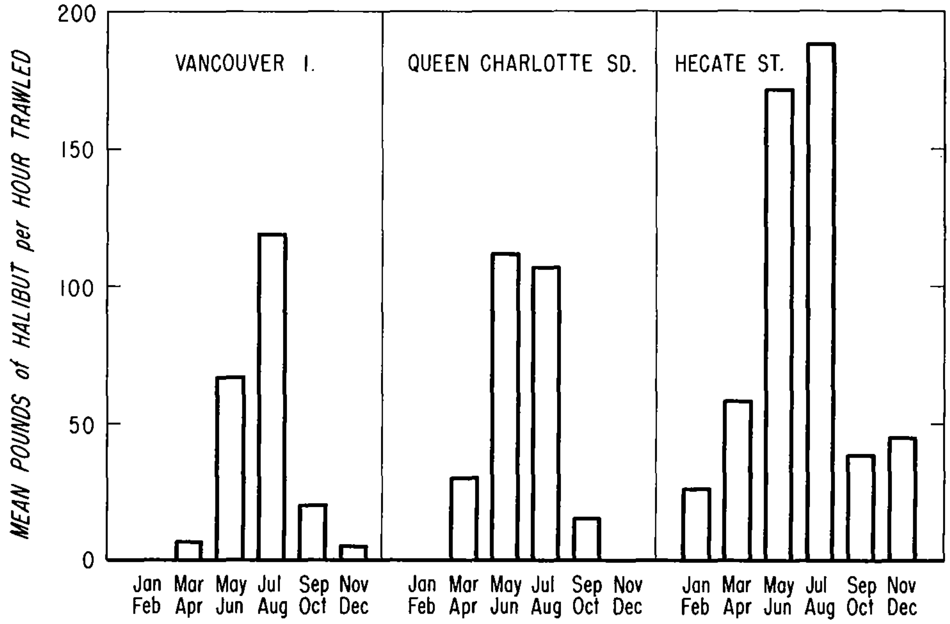

Figure 3. Estimated bimonthly CPUE of halibut by area for sampled trawlers.

method gives the 1969 sampling disproportionate weight in the results because of the larger number of observations made during this year.

Two methods were used to estimate the incidental catch of halibut: (1) expanding the estimated CPUE of halibut by the mean annual effort (hours trawled) by the fleet, and (2) expanding the estimated catch ratio (catch of halibut/trawl catch) by the mean annual trawl landings by the fleet. The catch and effort data from the fleet (PMFC) included the years 1962 through 1969 (1970 was not available).

Incidental Catch — CPUE Method

Variability in the CPUE of halibut between hauls was examined by plotting the frequency distribution of the CPUE during the summer by target species *(Figure 4)*. Sources of variability include fishing techniques and the spatial distribution of halibut on the grounds. For all three distributions (flatfish, Pacific ocean perch, other groundfish), the most frequent CPUE class was no halibut. The distributions when flatfish and other groundfish were target species show slowly declining and extremely long right hand tails. Although fish populations are seldom randomly distributed, the CPUE distributions were compared to a Poisson, a random distribution. Discrete variables are required to fit a Poisson so the frequency distributions of the number of halibut per haul were calculated. The right hand tails were much too long to fit a Poisson; chi squares were not calculated. This suggests that the halibut are clustered rather than distributed randomly over the trawl grounds. The highest CPUE was 6,823 pounds per hour and 54 hauls had a CPUE of more than 1,000 pounds per hour. These occasional large catches result in a high mean CPUE and are the primary source of variability between hauls.

When Pacific ocean perch was the target species the mean and standard deviation were considerably lower than for the two other target species. The tail of the distribution declined rapidly and the highest CPUE was only 377 pounds per hour indicating that large clusters of halibut seldom occur on these grounds. However, some clustering was probably present as the distribution of the number of halibut per hour did not fit the Poisson (chi square = 328).

Table 2 lists the mean CPUE of halibut and the standard error of the mean by area, season, and target species. The mean CPUE of halibut was: (1) higher in Hecate Strait than in other areas for all seasons and target species except for Queen Charlotte Sound when other groundfish was the target species in the winter; (2) higher in the summer than in the winter when flatfish and other groundfish were target species; and (3) lower for Pacific ocean perch than for the other target species in all areas and seasons except Hecate Strait in the winter. Confidence limits (.95) indicate that most of these differences were significant. Normal limits were deemed satisfactory because of the large sample size in most categories even though the CPUE was not normally distributed (D. G. Chapman, personal communication). The Pacific ocean perch fishery is insignificant in Hecate Strait and this target species was deleted from the calculations for this area.

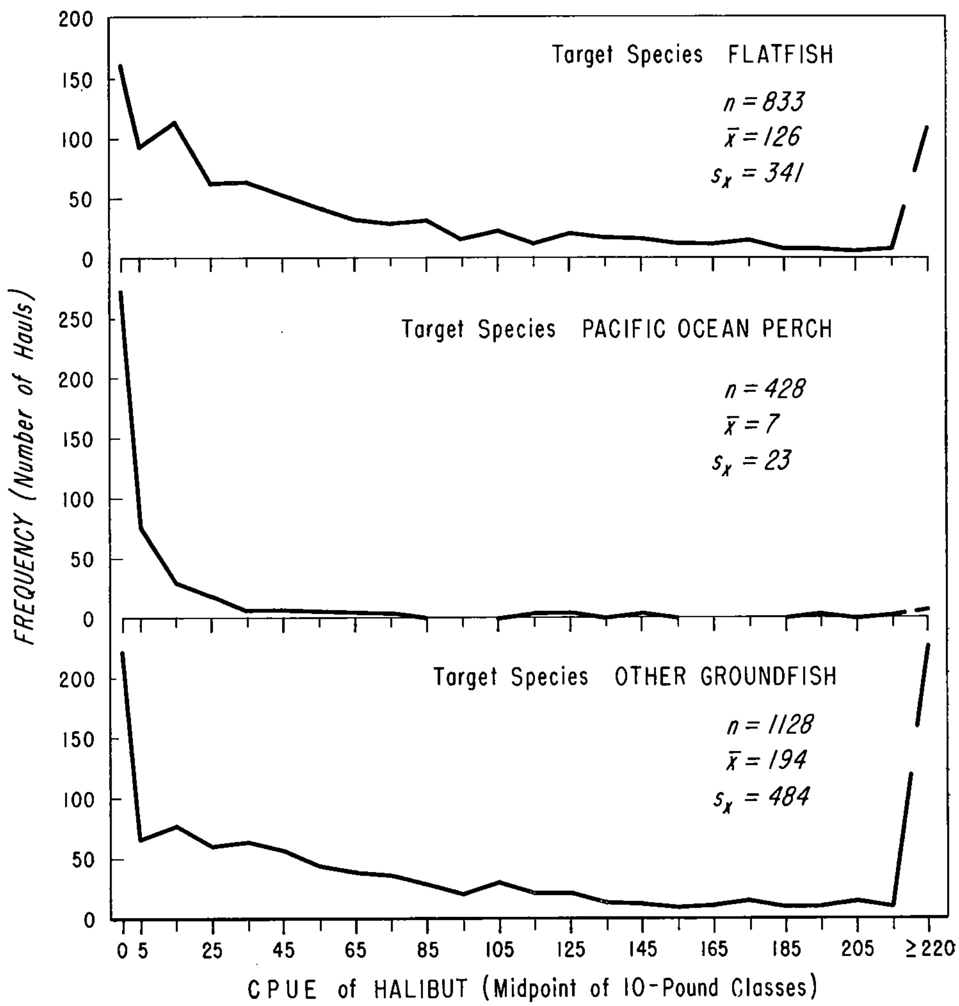

Figure 4. The frequency distribution of the CPUE of halibut by target species during the summer. (n = number of hauls, $\bar{x}$ = mean CPUE, s_x = standard deviation)

Table 2. **Number of hauls, mean weight (lbs.) of halibut per hour trawled and its standard error by area, season, and target species.**

Area - Season	Flatfish			Pacific Ocean Perch			Other Groundfish		
	No. Hauls	Halibut CPUE		No. Hauls	Halibut CPUE		No. Hauls	Halibut CPUE	
		$\overline{x}$	$s_{\overline{x}}$		$\overline{x}$	$s_{\overline{x}}$		$\overline{x}$	$s_{\overline{x}}$
VANCOUVER ISLAND									
Summer	188	102	18.8	51	4	1.2	441	136	13.1
Winter	71	21	8.5	61	6	3.0	118	18	3.2
QUEEN CHARLOTTE SND.									
Summer	253	84	15.1	375	7	1.3	437	221	21.6
Winter	9	13	6.6	47	7	2.1	50	35	9.2
HECATE STRAIT									
Summer	392	165	21.2	2	28	22.6	250	249	47.3
Winter	176	63	8.6	2	37	36.9	108	35	6.4

The mean CPUE of halibut and its variance for all areas, seasons, and target species combined was calculated by weighting the mean and the variance for each category by the total effort reported by the fleet within each category:

$$\overline{Y} = \frac{1}{N}\sum_{i=1}^{6}\sum_{j=1}^{3} N_i \frac{n_{ij}}{n_i}\overline{y}_{ij} \qquad (1)$$

$$\text{Var.}(\overline{Y}) = \frac{1}{N^2}\sum_{i=1}^{6}\sum_{j=1}^{3} N_i^2 \frac{n_{ij}^2}{n_i^2}(\text{Var.}\,\overline{y}_{ij}) \qquad (2)$$

where $\overline{Y}$ = weighted mean CPUE of halibut for all areas, seasons and target species,
i = area and season category ($a = 6$),
j = target species category ($b = 3$),
$\overline{y}_{ij}$ = mean CPUE of halibut for target species j within area - season i,
N = annual mean effort of the fleet (1962 - 1969),
N_i = mean effort of the fleet (1962 - 1969) within area - season i,
n_i = sampled fishing effort in area - season i, and
n_{ij} = sampled fishing effort for target species j within area - season i.

The total effort by the fleet was available by area and season but not by target species. The proportion of effort directed at each target species was assumed to be the same for the fleet as for the vessels sampled. This assumption was tested by comparing the estimated CPUE of the trawl catch by species (flatfish, Pacific ocean perch, and other groundfish) with that reported for the entire fleet (*Figure 5*). The CPUE was similar for all areas and seasons except for flatfish and other groundfish in Hecate Strait. The estimated CPUE was higher for flatfish and lower for other groundfish in Hecate Strait than those reported for the same area by the PMFC. The difference may be due to the large number of observations made in this area in 1969. Catch and effort data for Hecate Strait (PMFC, 1969) indicate 1969 to be a year of low abundance of Pacific cod resulting in more effort being directed toward flatfish. However, even in this area the estimated and reported CPUE is of similar magnitude and I concluded that the observed hauls were representative of the trawl fleet during this period.

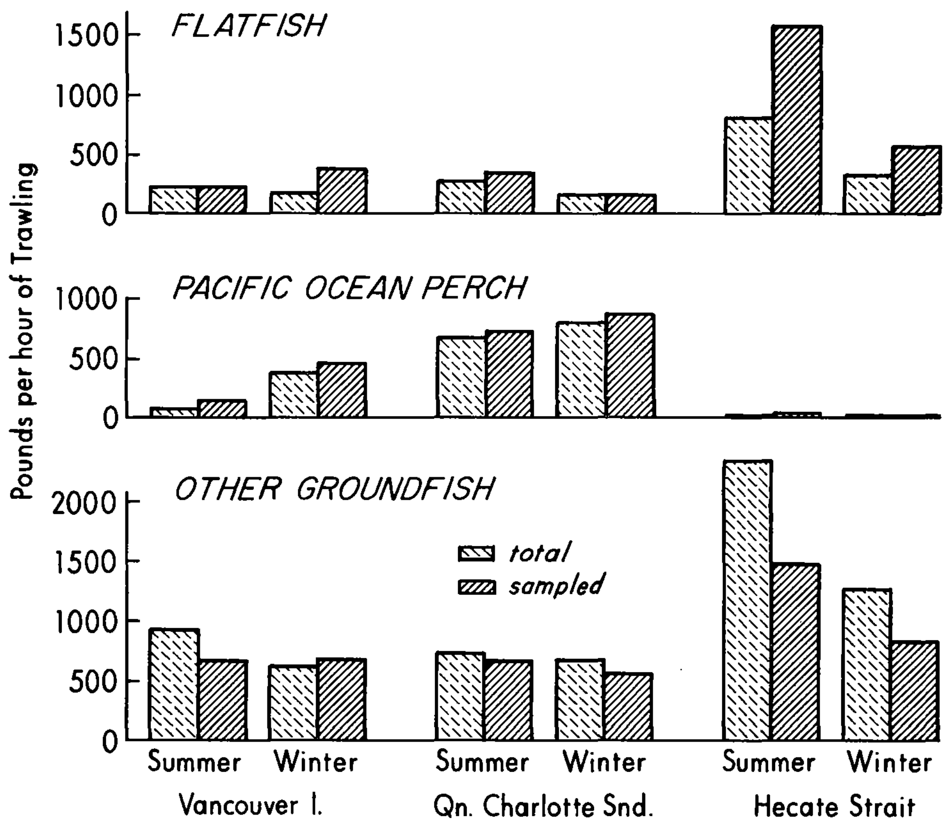

Figure 5. The CPUE of trawl species by season and area for sampled vessels and total fleet.

The seasonal mean effort by the fleet in each area from 1962 to 1969 and the sampling effort for each target species within area and season are listed in Table 3. Equations (1) and (2) resulted in an estimated CPUE of 74.95 with a variance of 12.5. The mean annual catch of incidental halibut between 1962 and 1969 was estimated by expanding this estimate by the mean annual effort for the fleet. The

Table 3. Mean seasonal effort (hrs.) by the fleet in each area (1962-1969) and sampling effort (hrs.) by target species.

Area - Season	Mean Seasonal Effort(N_i)[1]	Sampling Effort by Target Species (n_{ij})			
		Flatfish	Pacific Ocean Perch	Other Groundfish	Total (n_{ij})
WEST COAST VANCOUVER ISLAND					
Summer	6,937	391	136	781	1,308
Winter	9,481	160	96	250	506
QUEEN CHARLOTTE SOUND					
Summer	9,837	506	982	1,101	2,589
Winter	6,220	30	135	158	323
HECATE STRAIT					
Summer	3,252	517	—[2]	388	905
Winter	6,810	255	—[2]	180	435
TOTAL (N)	42,537				

[1] Source: Pacific Marine Fisheries Commission, Statistical series, Bottom fish section, 1962-1969.
[2] Fishery was insignificant in Hecate Strait.

result was a mean annual catch of 3.188 million pounds with a confidence interval (.95) of ± .301 million pounds.

Table 4 shows the estimated mean seasonal catch of halibut by area. The mean annual catch for the three study areas was approximately the same with most of the catch occurring during the summer. In Hecate Strait a greater percentage of the estimated catch occurred in the winter than in other areas.

Table 4. Estimated mean seasonal catch of incidental halibut (millions of lbs.) by area, 1962 - 1969.

Season	West Coast Vancouver Island	Queen Charlotte Sound	Hecate Strait	Total
Summer	.778	1.117	.653	2.548
Winter	.158	.132	.350	.640
Annual	.936	1.249	1.003	3.188

Annual estimates of incidental catch from 1962 through 1969 were made by using the annual effort by area and season in equation (1) and are listed in Table 5. The estimated annual catch generally increased in Queen Charlotte Sound and Hecate Strait but decreased off Vancouver Island. For the British Columbia Coast the estimated catch ranged from 2.496 million pounds in 1963 to 4.228 million pounds in 1969.

Table 5. Estimated catch of incidental halibut (millions of lbs.) by area, 1962 - 1969.

Year	Vancouver Island	Queen Charlotte Sound	Hecate Strait	Total
1962	1.326	.848	.552	2.726
1963	.981	.941	.574	2.496
1964	.791	.966	.806	2.563
1965	1.200	.958	1.170	3.328
1966	1.055	1.172	1.268	3.495
1967	.696	1.398	.947	3.041
1968	.590	1.678	1.320	3.588
1969	.841	1.992	1.395	4.228

The method of estimation assumes that the observed CPUE and proportion of effort directed toward each target species were constant each year. The CPUE of halibut caught by setline gear off British Columbia was generally constant from 1962 through 1969 which indicates that the availability of halibut to trawlers may not have changed.

The proportion of effort directed toward each target species undoubtedly changed but it is difficult to quantify because annual changes in the species composition of the trawl catch may be due to changes in either abundance or effort. However, PMFC (1962-1969) generally showed no large fluctuations in the species composition with the exception of Pacific cod. Therefore, while the assumptions required to estimate the incidental catch annually are not completely satisfied, the error due to these sources may not be large.

Incidental Catch — Ratio Method

To corroborate the estimate from the CPUE method, the trawl catch for each haul was used as an auxiliary variable and a catch ratio (halibut catch/trawl catch) calculated from the sampled hauls. Multiplying the catch ratio by the trawl landings by the fleet yields an estimate of the incidental catch of halibut.

The ratio method is more precise than the CPUE method only if the correlation coefficient (r_{xy}) between the halibut catch (y) and the trawl catch (x) exceeds $c_x/2c_y$ where c is the coefficient of variation (Snedecor, 1956). To test this precision, the halibut catch and the trawl catch (standardized to a one hour haul) were correlated by target species during the summer and the results were:

	r_{xy}	$c_x/2c_y$
Flatfish	−0.001	0.21
Pacific ocean perch	−0.027	0.12
Other groundfish	0.043	0.34

All correlation coefficients were substantially less than $c_x/2c_y$ indicating less precision than the CPUE method.

The catch ratio can be regarded as an indirect estimate of the halibut CPUE since the trawl catch is a function of effort if the abundance of trawl species is constant from year to year. The abundance of trawl species is not constant and the ratio method will tend to overestimate the incidental catch because of the large number of observations in 1969 when Pacific cod were in low abundance. However, the ratio method avoids bias possibly found in the CPUE method, *i.e.*, where a standard unit of effort was assumed for fishing vessels of various sizes with different kinds of gear. Therefore, the ratio method was used to provide a second independent estimate of the incidental catch of halibut.

Table 6. Catch ratios by area, season and target species.

Area - Season	Flatfish	Pacific Ocean Perch	Other Groundfish	All target species
VANCOUVER ISLAND				
Summer	0.175	0.003	0.109	0.102
Winter	0.013	0.003	0.009	0.008
QUEEN CHARLOTTE SND.				
Summer	0.063	0.003	0.138	0.063
Winter	0.019	0.003	0.030	0.012
HECATE STRAIT				
Summer	0.060	0.008	0.060	0.060
Winter	0.064	0.045	0.015	0.036
All areas - seasons	0.066	0.003	0.088	0.059

The catch ratios by area, season, and target species are listed in Table 6. These ratios were: (1) highest for Vancouver Island when flatfish was the target species in the summer, (2) higher in the summer than in the winter for most areas and target species, and (3) lower when Pacific ocean perch was the target species than for the other target species for all areas and seasons except Hecate Strait in the winter. These results with the exception of (1) show a similar pattern to that shown by the CPUE data (Table 2).

The mean annual incidental catch of halibut for the 1962-1969 period was calculated by multiplying each catch ratio (Table 6) by the respective landing of the target species by the fleet and summing the products:

$$\bar{C} = \sum_{i=1}^{6} \sum_{j=1}^{3} R_{ij} L_{ij} \quad (3)$$

where $\overline{C}$ = annual mean catch of halibut,

i = area and season category ($a = 6$),

j = target species category ($b = 3$),

R_{ij} = estimated catch ratio for target species j within area - season i, and

L_{ij} = reported mean landings by the fleet of target species j within area - season i.

Ideally, the catch ratios should have been multiplied by a portion of the landing of each target species as the entire trawl catch (including non-target species) was used to calculate the above catch ratios. However, the procedure was not thought to bias the result appreciably as the target species consistently composed most of the trawl catch (*p.7*).

The above calculations resulted in a mean incidental catch of 3.232 million pounds of halibut. While the estimate from this method is considered less precise than the estimate from the CPUE method (3.188 million pounds) the two estimates agree quite closely.

Size Composition

The length distribution by area and season of 32,120 halibut measured on commercial trawlers off British Columbia between 1962 and 1970 is shown in *Figure 6*. Halibut of sublegal size (less than 65 cm. or 5 lbs.) were 32.5% of the total number measured. Most legal sized halibut were less than 100 cm. (20 lbs.). Myhre (1969) and IFC (1948) reported a similar size composition off British Columbia.

The size composition varied by area, season, and target species. Halibut were largest in the most southern area, Vancouver Island, and decreased progressively in size from south to north. IFC (1948) reported a similar spatial trend in the size composition on grounds off British Columbia. In Queen Charlotte Sound and Hecate Strait halibut were smaller in the winter than in the summer. This seasonal change probably reflects the larger mature fish moving to the deeper water for spawning during the winter. In Queen Charlotte Sound during the summer there were fewer

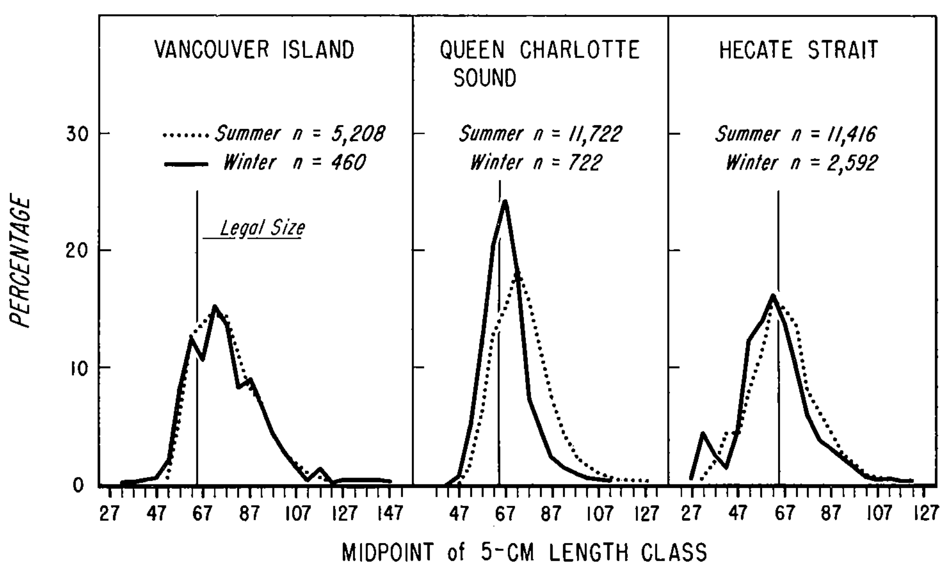

Figure 6. Length distribution by area and season of halibut caught by commercial trawlers.

small halibut when Pacific ocean perch was the target species (14% sublegal) than when flatfish or other groundfish were the target species (22% sublegal). This difference may be caused by the depth of fishing; usually over 200 m. for Pacific ocean perch and less than 125 m. for the other species.

DISCUSSION AND CONCLUSION

Change in Fishing Power

In estimating the incidental catch of halibut by the CPUE method the fishing power applied to each unit of effort was assumed to be constant; however, an increase in fishing power undoubtedly occurred as larger vessels entered the fishery. *Figure 1* indicates an increase in fishing power as the yield increased faster than effort from 1962 to 1967 in Queen Charlotte Sound and Hecate Strait. Part of this increase in CPUE may be attributed to an increased abundance of Pacific cod and a developing fishery for Pacific ocean perch (K. S. Ketchen, personal communication). If fishing power increased, the incidental catch of halibut would be overestimated in the earlier years of the study and underestimated in the latter years by the CPUE method. However, this change should not appreciably bias the estimate of the mean annual catch, and the ratio method which did not assume constant fishing power resulted in a similar estimate.

Multiple Capture

Multiple capture of the same fish was not considered in estimating the incidental halibut catch and therefore the catch estimate is high. Tagging studies provide an indication of the annual rate of single recapture. Although rates of recapture vary considerably during the first year, approximately 13% of the tags released during the summer of 1968 off British Columbia were recovered by trawlers within a year. This estimate is minimal as some tags were probably recovered but not reported.

The rate for single recapture can be extended to include multiple recaptures using the following model (Feller, 1957, p.211): E (Rate of recapture) = Ln [1/(1-rate of single recapture)]. This model increases the estimated rate for single recapture (13%) by only 2%. However, the model assumes that the probability of capture is independent of the frequency of capture which may not be true if captured halibut are debilitated and prone to recapture. The information needed to test this possibility is not presently available.

Relative Yield Loss

Discarded halibut that die represent a loss in biomass. This loss may not equal the loss in yield to the halibut fishery. If these dead halibut had lived, their growth and natural mortality would alter the biomass available for harvest. Ricker's (1958) yield-per-recruit model provides a convenient method of estimating the loss in yield which results from the removal of recruits of a given age. An estimate of the total loss in yield, relative to the recruit loss for all ages, can be obtained by multiplying the loss for each age by the proportion of each age in the lost recruitment and summing the products. This method requires knowledge of the age distribution of the incidental halibut catch, growth rate, and natural and fishing mortality. The age distribution by weight was derived from the known length frequency and from estimated length-weight and length-age relationships. The annual instantaneous growth rate used for each age was calculated from age-weight data for years 1936-1960 (Southward, 1967) and is discussed by Myhre (MS.). An annual instantaneous natural mortality of .175 was used (IPHC, 1960; Chapman, Myhre and Southward, 1962).

Instantaneous fishing mortalities (F) of .1, .2, .3 and .4 were used and are within the range Myhre (1967) reported for tagging experiments off British Columbia between 1925 and 1955. IPHC (1960) estimated the average fishing mortality for regulatory Area 2 (south of Cape Spencer) during the 1950's to be approximately .3. Since the fishing effort off British Columbia declined approximately 35% from the 1950's to the 1960's, a fishing mortality of .2 may be the most realistic estimate. Age of entry was assumed to be 6 years of age and setline selection properties reported by Myhre (1969) were applied to each fishing mortality.

Using the above values for the age distribution, growth, and natural mortality, the relative yield loss would be .93, 1.13, 1.27, and 1.19 for the respective fishing mortalities of .1, .2, .3 and .4. If a fishing mortality of .2 is accepted as the most realistic, the result is a loss of 1.13 units of yield for every unit of recruit loss by trawlers. Seventy-six percent of the yield loss would occur in the "medium" (10-60 lbs.) trade category with most of the balance (17%) in the "chicken" (5-10) lbs. trade category.

Actual Yield Loss

The actual annual yield loss can be obtained by multiplying the relative yield loss by the portion of the annual trawl catch which is discarded dead, but a satisfactory estimate of the portion discarded dead during commercial operations is not available.

Subjective estimates of trawl mortality reported by observers in Oregon, Washington, and British Columbia and reviewed by Bell (1956) and by observers from the Halibut Commission range from 5 to 25%. None of these estimates consider mortality due to time out of water or treatment during normal commercial fishing operations, both of which are likely to be important sources of trawl mortality.

Although the actual yield loss cannot be estimated, an upper limit was calculated by using a discard mortality of 100%. The relative yield loss (1.13) was multiplied by the mean annual catch of halibut between Cape Flattery and Dixon Entrance (3.2 million pounds) and resulted in approximately 3.6 million pounds. The Halibut Commission and the International Trawlers Association are now conducting research on the mortality of halibut caught in trawls and hopefully will provide a better estimate of the actual yield loss.

SUMMARY

The Halibut Commission placed observers on Canadian and United States commercial trawlers from 1962 to 1970 to estimate the incidental catch of halibut. The data from 3,031 hauls included the pounds of halibut per hour trawled and the ratio of the halibut catch to the trawl catch. Few halibut were caught when fishing for Pacific ocean perch. The largest catches of halibut occurred during the summer, May - August, when fishing for flatfish and other groundfish. Halibut catches during the winter, September - April, were smaller for all target species. Catches during the winter were larger in Hecate Strait than off Vancouver Island or in Queen Charlotte Sound.

Two methods were used to estimate the annual incidental catch of halibut: (1) expanding the estimated halibut catch per hour by the annual effort by the fleet and (2) expanding the expected catch ratio by the annual catch by the fleet. Both methods resulted in a mean annual catch of approximately 3.2 million pounds between 1962 and 1969. A confidence interval (.95) of approximately $\pm .3$ million pounds was calculated. Annual estimates ranged from 2.5 million pounds in 1963 to 4.2 million pounds in 1969.

The actual loss in yield to the halibut fishery due to discarding dead halibut could not be determined because a satisfactory estimate of discard mortality was not available. The loss in yield per unit of trawl loss was estimated at 1.13 using a Ricker yield-per-recruit model. Applying this to the mean annual catch places an upper limit of 3.6 million pounds on the actual loss in yield.

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