

INCIDENTAL CATCH OF PACIFIC SALMON IN BRITISH COLUMBIA COASTAL
MIDWATER TRAWL FISHERIES, 1977-1980.

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Introduction

The incidental catch of salmon in non-North American fisheries operating in Canada's zone of extended fisheries jurisdiction has been monitored since 1977. These fisheries are principally midwater trawl fisheries for hake (Merluccius productus) in Canadian fisheries management sub-zones 5-1 and 5-2 of INPFC Vancouver area. In 1977 an experimental midwater fishery for dogfish (Squalus accenthius) was observed to catch salmon incidentally in sub-zone 5-1 and in Hecate Straits. This fishery has since, however, been discontinued. Domestic midwater fisheries for pollock (Theragra chalcogramma) and hake in Dixon Entrance and the Strait of Georgia catch salmon incidentally and are included in this paper to complete the summary of incidental salmon catches.

Foreign midwater fisheries off Canada's west coast have been limited to independent fisheries by Japan, Poland and the USSR, and cooperative ventures between Canada and Poland, the USSR, and Greece. Annual summaries of the incidental catch of prohibited species in fisheries between 1977-1979 are reported in Leaman et al. (1978, 1980, 1981). This paper summarizes observer reports on the incidental catch of salmon in foreign and domestic midwater trawl fisheries in the Canadian economic zone between 1977 and 1980 and documents the recovery of coded-wire tagged chinooks from these fisheries.

Methods

Observer effort on foreign vessels fishing hake has been limited since 1977. Priority has been given to observing sablefish and rockfish fisheries due to greater Canadian domestic interests in these resources.

Also, less effort was devoted to the hake fishery because the catch in Canadian waters is a minor component of the total exploitation of a stock primarily located in U.S. waters (Dark et al. 1980). Table 1 summarizes the observer coverage of fisheries discussed.

Procedures for estimation of non-salmon catch weight and species composition in observed hauls are outlined in Leaman et al. (1978, 1980, 1981). Prohibited species landed are recorded per haul but the biological data collected is inconsistent, apparently reflecting how prohibited species are handled by crewmen. Salmon landed may be recorded as pieces, pieces and length, or estimated total weight (individual weights are seldom recorded). Species names are commonly recorded and observers are instructed to sample for coded-wire tags if feasible. Frequently, the weight of salmon in a haul is recorded as a "trace" presence in species composition tables. Trace is not however a standardized measure but commonly indicated a total weight of salmon less than 100 lb (43.4 kg). When length data were specified for chinooks, weight (kg) was estimated from weight-length regressions estimated from Canadian troll caught chinooks. There were no instances when length data were specified for salmon other than chinooks. In order to utilize all observer reports, criteria were selected for the interpretation of imprecise recordings: a trace record was assigned a weight of 10 kg, and an individual salmon was assumed to average 4 kg unless described as small in which case the weight assigned was 2.5 kg, the sample average from one sample for 46 "small" salmon.

The annual biomass of incidentally caught salmon was estimated by prorating the incidence of salmon in observed catches by the annual catch

within each fishery and country grouping. Each fishery is defined by its target species and location. Analysis of rates of incidental catch by finer strata (net size, haul duration and depth, time of day etc) were not undertaken because of the inconsistencies in reporting formats. Further, there has been an increasing proportion of the hake fishery taken in cooperative fishing ventures (Table 2). Codend transfer from Canadian catcher vessels to foreign processors is used to transfer catches. Catch, effort and incidental catches per haul are not available for these domestic vessels.

Results

Hake Fisheries:

Catch rates of salmon by foreign and domestic vessels in sub-zones 5-1 and 5-2 have not exceeded 0.317 kg salmon per metric ton (t) of hake landed (Table 3a, 4a). The rate has apparently been decreasing since 1977, being reduced to 0.086 kg/t in 1980. These rates translate into a seasonal total of 1636 kg of salmon in 1977 and 1395 kg in 1980. Biological sampling of the salmon landed is infrequently recorded but indicates that 90+% of the salmon caught are chinook. The average weight of chinooks caught in sub-zone 5-2 is 3.8 kg (n = 27 fish, range 2.8 - 6.0 kg). Coho, sockeye and chum are infrequently caught and most observer records of non-chinooks are labelled as "unknown species". No data regarding sex ratios was found and individual size data for salmon caught in sub-zone 5-1 is lacking.

No consistent differences in incidental catch rate of salmon between sub-zones 5-1 and 5-2 were observed. A significant area in sub-zone 5-1 is shallower than 50 fm and constitutes a major salmon troll fishery region.

Waters between the 50 and 100 fm contours in area 5-1 are apparently the primary hake fishing regions (Fig. 1). Similarly, water between 50-100 fm in area 5-2 are most frequently fished (Fig. 1). Trawl net depths in area 5-2 during 1977 and 1978 averaged 74 fm (range 27-135 fm, n = 270) and averaged 123 min (range 20-510 min) in duration. Comparable data for domestic vessels in sub-zone 5-1 are lacking for 1978 (no area 5-1 fishery in 1977). Domestic trawlers, however, reportedly fish between 30-65 fm and catches are concentrated between 45-60 fm.

Domestic fishing for hake in the Straits of Georgia commenced in 1979. The 1979 fishery occurred from February through May and was largely experimental. Extensive monitoring (94.1%) of the total hake catch (516.5 t) was undertaken. In 1980, the total catch was 508.1 t but no sampling of the spring fishery was conducted and a November fishery occurred. Thirty-six per cent of the November catch (74.4 t, 14.6% annual total) was sampled.

Incidental catch of salmon in 1979 was very limited (33 salmon in 79 hauls observed, total weight of salmon = 85 kg) and was not uniformly distributed over the hauls (11 of 79 hauls containing between 1 and 19 chinooks, McFarlane et al. 1981). Nineteen chinook were caught in the tow of longest duration (415 min) and shallowest depth (49 fm). Hake were scattered during the tow (CPUE = 0.033 t/hr) and walleye pollack predominated the catch. The incidence of the remaining 14 chinooks was uncorrelated with CPUE per haul or depth. Salmon are frequently observed to be in the top of the codend and observers speculate that salmon are incidentally caught while retrieving the net. A higher catch rate for salmon (35 kg in 5 hauls) was observed in the limited 1980 sampling. The pattern of salmon catches in 1980 were consistent with the

1979 observation of non-uniform distribution of salmon incidence. The first two hauls during Nov., 1980 accounted for all the salmon caught. These hauls only contributed 5.7% of the observed hake catch, had the lowest CPUE values (0.45 t/hr vs 11.1 t/hr), were deeper (73-86 fm) than the remainder (54-78 fm) and of longer duration. The rate of incidental salmon catch in the spring Strait of Georgia hake fishery (Table 5) is similar to those estimated for the offshore fisheries (Table 4a). Incidence in the fall fishery may be greater but the data are very limited and variations in trawl depth and hake density confound between haul comparisons.

Dogfish:

Rates of incidental salmon catch in the 1977 Polish experimental fishery were the highest recorded for any fishery in Canadian waters (Table 4b). A total incidental catch of 5.7 t occurred during this fishery. This rate of incidence was deemed unacceptably high by the Canadian Department of Fisheries and the fishery has not reopened. Dogfish fisheries in Canadian waters now use sunken longline gear.

Incidence of salmon in the catch was substantially greater in sub-zone 5-1 fisheries than in Hecate Strait fisheries (Table 4b). Hauls in sub-zone 5-1 were consistently shallower ($\bar{X} = 43$ fm, range 27-54 fm, $n = 22$) than those in Hecate Straits ($\bar{X} = 64$ fm, range 51-113 fm, $n = 43$) but hauls in Hecate Strait were on average longer in duration (158 min, range 8-282) than in sub-zone 5-1 (117 min, range 30-180). Observed catch per unit of effort (t/hr) for dogfish in Hecate Strait has only one half of that in sub-zone 5-1 (0.62 vs 1.24). However, the CPUE required to catch the non-sampled portion

of the Hecate Strait catch would have to have been 2.02 t/hr. CPUE and numbers of salmon caught per haul are not significantly correlated in this fishery but the 3 correlations estimated (one vessel, 22 hauls in sub-zone 5-1; 2 vessels in Hecate Strait, 14 and 29 hauls) were all negative ($r=-0.135$, -0.107 , -0.210 , respectively).

Pollock:

Rates of incidental salmon catches vary between fisheries in Dixon Entrance (8.6 kg/t pollock) and the Strait of Georgia (1.37 kg/t pollock) and cumulatively resulted in the largest one year incidental catch of salmon (Table 3c,4c; 7.069 t in 1979). Salmon caught in Dixon Entrance during the 1980 fishery were estimated by assuming the 1979 rate of incidence, however, experimental fisheries in Dixon Entrance during 1978 had a 1.566 kg salmon/t pollock incidental catch rate. The 1980 catch of salmon may therefore be an overestimate. Pollock catches in Dixon Entrance have been decreasing recently due to the undesirably small fillet produced in this fishery. In the Strait of Georgia, sampling of the 1979 fishery focused on vessels operating in the eastern part of the Strait near Vancouver. In 1980, however, two vessels operating in the western Strait off Mayne Island were the only vessels sampled. Sampled landings from both years were pooled to provide a single estimate of incidence rate in 1979 and 1980.

Fisheries in Dixon Entrance differ from Strait of Georgia fisheries in several ways which may contribute to greater rates of incidental catch. Vessels fish deeper (range 64-160 fm vs 20-87 fm) for a longer duration (average hauls 5.3 hr vs 2.7 hr) in the northern area; their CPUE is lower

(0.89 vs 2.15 t/hr) and catch is more varied in composition. Pollock commonly comprises 90+% of the Strait of Georgia landings but observed catches in Dixon Entrance vary between 43-85% pollock.

Biological data on salmon caught in the 1979 Dixon Entrance fishery were available for 322 chinooks, but no quantitative data were available for Georgia Strait chinooks. Fish length varied from 30-81 cm fork length and the average length and weight were 50.6 cm and 1.6 kg. Eighty-five per cent of the samples were less than 60 cm. The sex ratio was 52.5% male.

Incidental catch summary:

Domestic inshore fisheries for pollock exceed the foreign and domestic offshore fisheries for hake in annual incidental salmon catches (Table 6). The discrepancy is greater in numbers of salmon since the average size of the salmon sampled inshore was less than offshore. In total, the 1980 estimate of 4.6 t of salmon incidentally caught represents between 1000-2000 chinook salmon.

Coded-wire tag recoveries:

Twenty-one coded-wire tagged chinooks have been recovered in these fisheries. Only one tag has been recovered in the offshore fishery. A Deschutes River chinook was recovered aboard the Polish hake trawler Otol between September and October, 1980. The only location information available on the recovery is that it occurred in sub-zone 5-2, off Barkley Sound. Twenty tags were recovered during the 1979 pollock fishery in Dixon Entrance (Fig. 2). The locations of these recoveries are not available but the tagging

location and numbers of tags recovered were:

Quinsam Hatchery, B.C.	1
Willamette Hatchery, Oregon	10
Tanner Creek Hatchery, Oregon	1
S. Santiam Hatchery, Oregon	2
Klickitat Hatchery, Washington	1
Cowlitz Hatchery, Washington	4
Kalama Hatchery, Washington	1

All the American tagging locations are ones which feed into the Columbia River or directly into the Pacific Ocean. The marked-to-unmarked ratio in this sample was 0.058:1 or 1:17. The chinooks recovered in Hecate Strais were 2 sea-year fish and varied in fork length from 45-63 cm.

Discussion

The impact of 1977 through 1980 midwater trawl fisheries on salmon fisheries and stocks in the Canadian fishing zone is apparently insignificant. Two fisheries which in the past may have been detrimental to salmon stocks have been eliminated (offshore dogfish) or curtailed (Dixon Entrance pollock). In 1981 the Dixon Entrance pollock fishery was further reduced to 44.3 t, 6.7% of the 1979 landed catch. Pieces of salmon incidentally caught in 1980 were equivalent to 0.2% of the total commercial catch of chinooks and would actually have contributed less to the fishery due to the sub-legal size of many of the salmon caught. Impacts of trawl fisheries on specific chinook stocks are very unlikely given the fisheries' locations and durations. Areas of extensive midwater trawl fishing coincide

with areas of extensive stock mingling of salmon, as demonstrated by the coded-wire tag program on chinooks (Table 7). Inshore domestic fisheries occur between January and May, consequently avoiding the abundance of mature salmon in these waters between June and October.

Rates of incidental salmon catches in offshore trawl fisheries reported in this paper are very similar to those estimated for foreign fisheries off the Washington and Oregon coasts in 1977 and 1978 (French et al. 1978, 1979). However, the decrease in rates of incidental catch from 1977 to 1980 in Canadian fisheries is not as pronounced in the American fisheries. In 1979, foreign and joint venture fisheries in American waters caught 0.274 kg salmon per tonne of hake whereas in Canadian waters the incidence was reduced to 0.088 kg/t. Species composition and size distributions of salmon incidentally caught in U.S. waters are also very similar to those reported in Canadian waters.

Coded-wire tags recovery in the trawl fisheries reflect the high incidence of U.S. chinooks in Canadian waters (Table 7). American agencies apply 8 to 10 times the numbers of tags applied by Canada so the qualitative data presented cannot be extrapolated to relative proportions of stocks. Mark-to-unmarked ratios in the commercial troll fishery are most frequently greater than 1 in 30. A mark recovery ratio of 1 in 17 unmarked fish is unusually high and may indicate non-random distribution of small salmon from individual release groups.

While the current trawl fisheries probably have an insignificant effect on salmon abundance, these fisheries have the potential for substantial expansion. Offshore hake catches in 1980 were half of the allowable catch but

even if the quota was caught, only 2.6 t of salmon would be incidentally caught. Within the Strait of Georgia, expansion of the pollock fishery to its 3400 t quota and of the hake fishery to its potential yield of 30,000 t would increase the incidental salmon catch to nearly 10 t. These estimations assume that increasing fishing effort will not substantially change the observed rates of incidental capture. The frequency of salmon occurrence in hauls and observations that salmon commonly are in the top of the codend suggest that CPUE, simply t/hr, and rate of capture may not be associated. Remaining parameters such as tow depth, duration, net opening dimensions, fishing zone, season, target species, and their interactions are more likely to determine the rates of incidental capture of salmon. Experiments to evaluate effects of the latter parameters and observations of annual variation in rates of incidental capture should probably be undertaken if expansion of Canadian domestic fisheries occur, particularly in the Straits of Georgia.

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Table 1a. Observer coverage of foreign vessels fishing for hake.

Nation Sub-zone ^a	Japan 5-2	USSR 5-2	USSR 5-1	Poland 5-2	Poland 5-1	Greece 5-1
Vessel hours in area						
1977	878.6	252.2	- ^c	817.7	-	-
1978	331.1	b	-	b	b	-
1979	555.2	0	b	1240.7	b	-
1980	b	b	b	b	b	b
% sampled						
1977	37.3	0	-	3.4	-	-
1978	59.8	b	-	b	b	-
1979	0.0	0	b	5.2	b	-
1980	b	b	b	b	b	b
Total catch (t)						
1977	1918.5	544.3	-	2698.9	-	-
1978	3238.5	699.8	-	585.6	1836.2	-
1979	3762.0	0.0	1131.0	4888.0	2114.0	-
1980	284.5	0.0	4377.9	3648.6	4559.9	3354.6
% monitored						
1977	48.8	0.0	-	2.9	-	-
1978	63.8	9.8	-	10.2	62.3	-
1979	0.0	0.0	20.4	5.2	0.0	-
1980	7.5	0.0	57.2	41.6	42.3	88.4

^aZone 5-1 deliveries to foreign processors indicates cooperative ventures.

^bNot available.

^cDash indicated no fishery.

Table 1b. Observer coverage of 1977 experimental dogfish fishery.

Nation Sub-zone	5-1	Poland	Hecate Strait
Vessel hours fished	a		249.2
Hours observed	40.3		108.9
Total catch (t)	92.2		354.1
% monitored	57.7		19.9

^aLogbooks unavailable

Table 1c. Observer coverage of pollock roe fishery.

Nation Area		Canadian domestic vessels Dixon Entrance	Georgia Strait
Vessel hours fished	1979	605.6	695.0
	1980	40.9	419.1
% monitored	1979	18.3	15.0
	1980	0.0	10.5
Total catch (t)	1979	662.6	991.0
	1980	220.9	843.7
% monitored	1979	16.4	18.6
	1980	0.0	16.1

Table 2. Hake allocations by country and area.

		Quota (t)			
		1977	1978	1979	1980
Japan	5-2	5000	3000	6000	6000
Poland	5-2	7500	6500	6700	5000
Russia	5-2	7500	6500	3000	0
Joint venture:	5-1	0			
Poland			5000	3000	5000
Russia				6000	8000
Greece					6000
% Joint venture of total quota		0	23.8	36.4	63.3

Table 3. Annual incidental catch of salmon (kg) by fishery, country and area.

A. Hake in Area 5-2 and 5-1 Joint ventures.

Country	Japan	USSR	Poland	USSR	Poland	Greece
Sub-zone		5-2			5-1	
kg salmon caught during observation						
1977	90	- ^a	38	-	-	-
1978	133	80	0	-	85	-
1979	b	-	12	92	b	-
1980	11	33	72	156	70	480
Total weight salmon landed (kg)						
1977	186	157	1292	-	-	-
1978	208	693	0	-	136	-
1979	171	-	226	230	423	-
1980	148	-	178	359	164	543

^aDash indicated no fishing occurred;

^bNo observation periods.

B. Polish-Canadian experimental dogfish fishery, 1977.

Sub-zone	5-1	Hecate Strait
kg salmon caught during observation	1253	780
Total wt of salmon landed (kg)	2172	3561

Table 3c. Domestic pollock fishery.

<u>Area</u>	<u>Dixon Entrance</u>	<u>Georgia Strait</u>
kg salmon caught during observation		
1979	855	338
1980	-	100
Total wt of salmon landed (kg)		
1979	5711	1358 ²
1980	19041	11562

¹No sampling was conducted in Dixon Entrance, 1980; 1979 % incidence by weight was assumed consistent for 1980.

²Only 2 observation periods exist for 1980 and these differ in location from 1979 samples, 1979 and 1980 observations were pooled to estimate % incidence of salmon per tonne pollock caught.

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Table 4. Annual incidental catch of salmon by fishery, area and country.

A. Hake (incidence by weight, kg salmon/t hake).

Country	Japan	USSR	Poland	Total	USSR	Poland	Greece	Total	Pooled
Sub-zone		5-2				5-1			5-1 + 5-2
Year									
1977	0.097	0.288	0.479	0.317	-	-	-	-	0.317
1978	0.064	0.990	0.0	0.199	-	0.074	-	0.074	0.163
1979	0.045	0.0	0.046	0.046	0.203	0.200	-	0.201	0.088
1980	0.520	0.0	0.049	0.083	0.082	0.036	0.162	0.092	0.086

B. Dogfish (incidence by weight, kg salmon/t dogfish).

	Sub-zone 5-1	Hecate Straits	Pooled
1977	23.557	10.056	12.854

C. Pollock (incidence by weight, kg salmon/t pollock).

	Dixon Entrance	Georgia Strait	Pooled
1979	8.619	1.3701	4.275
1980	8.6191	1.3701	2.874

1See footnotes Table 3C.

Table 5. Catch of hake and incidental catches of salmon observed in the Georgia Strait hake fishery.

	Spring 1979	Spring 1980	November 1980
Total catch (t)	516.5	433.7	74.4
Proportion of catch sampled	0.941	0.0	0.355
Weight of salmon observed (kg)	85	0.0	35
Incidence in sampled catch (kg salmon/t hake)	0.175	-	1.324
Total weight of salmon landed (kg)	90	761	98

¹Incidence assumed equal to 1979 estimate.

Table 6. Summary of incidental salmon catch (t) prorated to total annual catch of midwater trawl fisheries.

	Fishery				Total
	Hake Sub-zone 5-1, 5-2	Hake St. of Georgia	Dogfish	Pollock	
1977	1.635	-1	5.733	-	7.368
1978	1.037	-	-	-	1.037
1979	1.050	0.090	-	7.069	8.209
1980	1.392	0.174	-	3.060	4.626

¹Dash indicates no fishery.

Table 7. Estimated stock composition of British Columbia salmon catch by troll gear in northern B.C., west coast Vancouver Island and the Straits of Georgia (Canadian Dept. Fisheries, unpubl. data). Difference between 100% and sum of row totals is predominately composed of Canadian wild stocks.

		% Composition by regions of origin					
Fishery location	Year ¹	Canadian hatcheries only	Washington ² Puget Sd.	Washington west coast	Washington Columbia R.	Oregon Columbia R.	Oregon west coast
Hecate Straits & Dixon Entrance	1977	4.8	2.1	9.3	5.8	14.8	6.9
	1978	5.3	3.7	4.4	7.8	6.9	4.1
West coast Vancouver Island	1977	1.2	19.9	3.0	36.4	9.5	2.5
	1978	1.2	34.5	1.6	16.0	15.4	1.3
Strait of Georgia	1977	1.9	5.8	0.1	0.2	0.0	0.0
	1978	4.8	14.7	0.0	0.8	0.4	0.0

¹Percent composition for 1979, 1980 incomplete.

²Washington and Oregon % composition include hatchery and wild production.

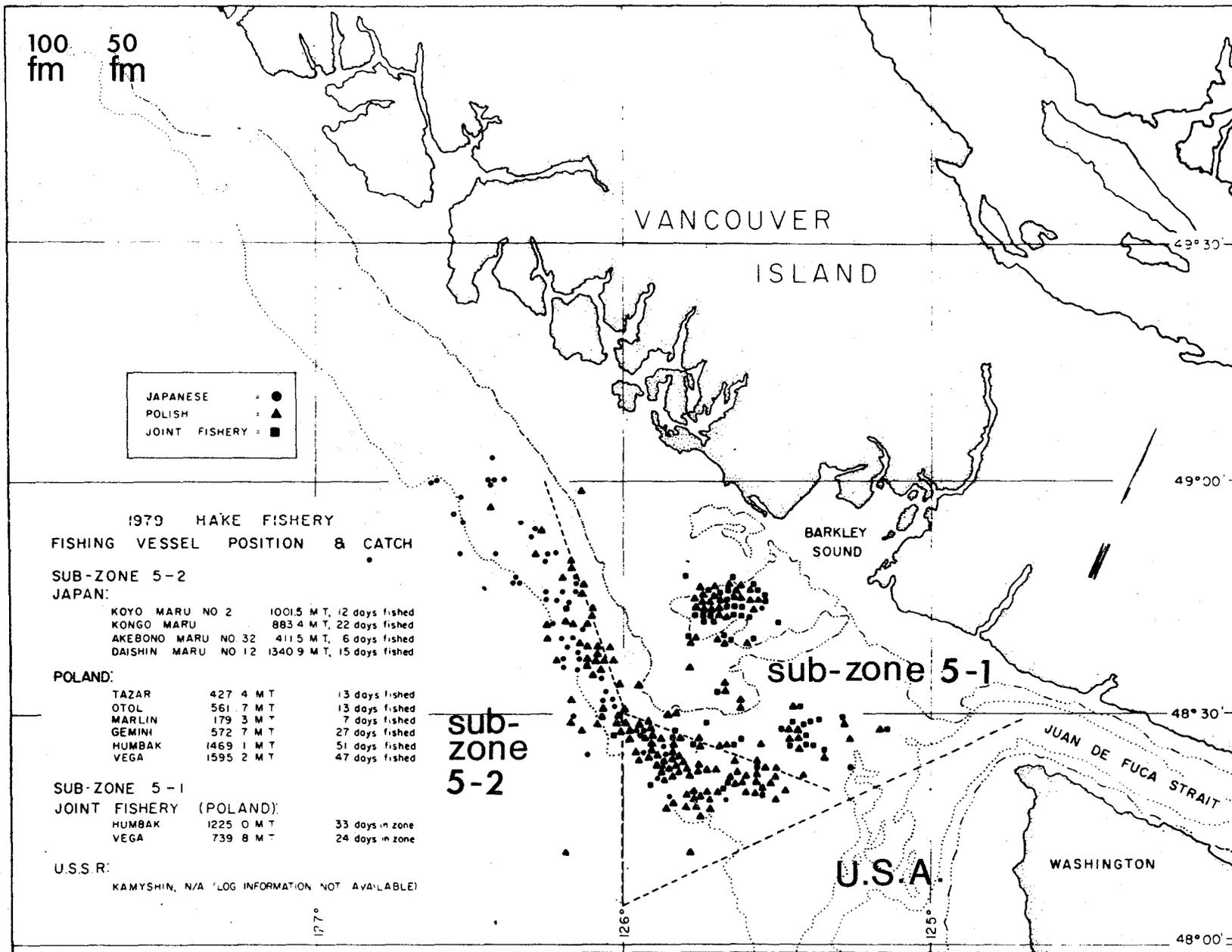


Fig. 1. Example of foreign and domestic trawler distributions during 1979 hake fishery in Sub-zones 5-2 and 5-1. Periods of fishing and hake catch are listed by nation and vessel, from Leaman et al. (1981).

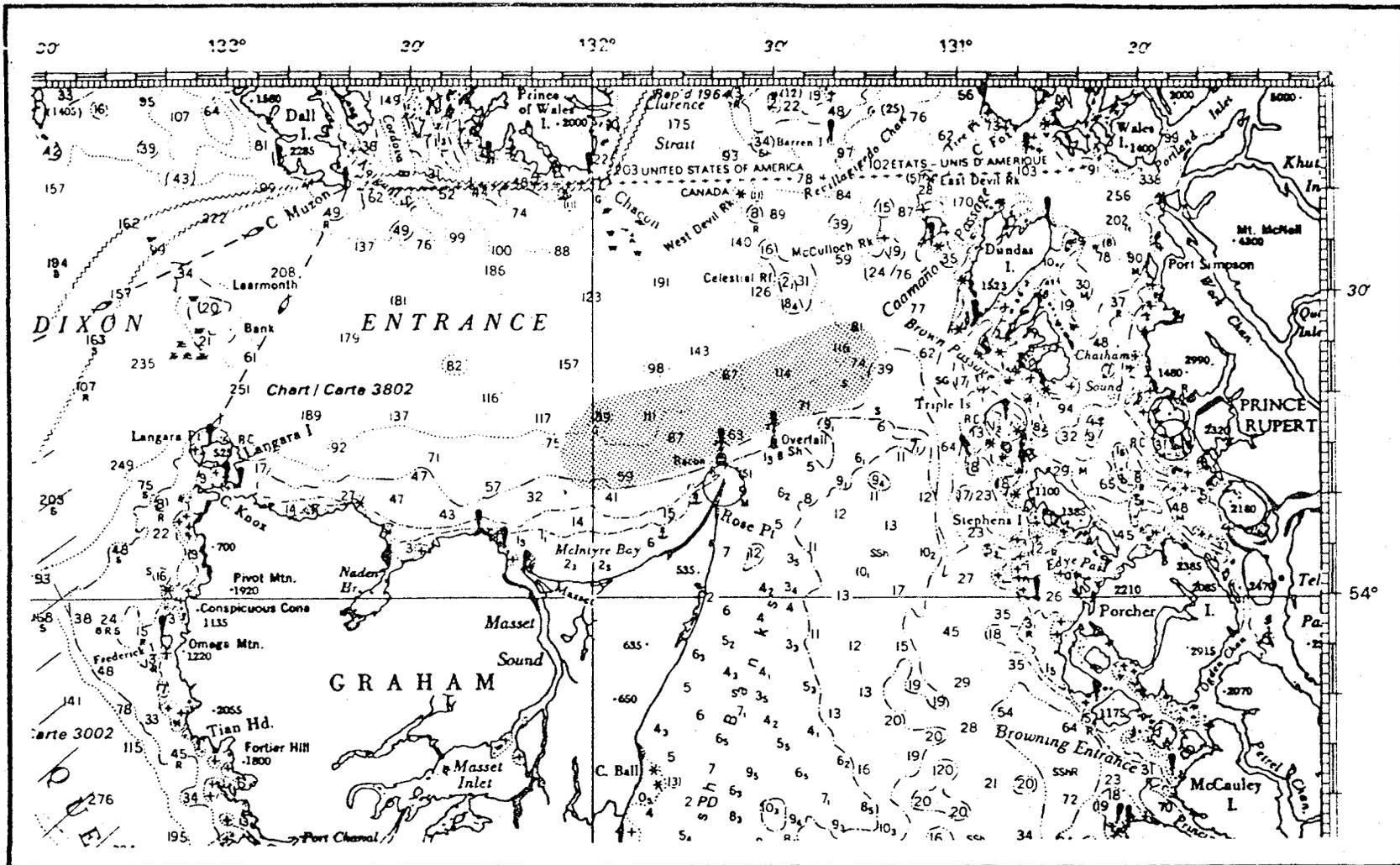


Fig. 2. Shading indicates 1979 pollock fishing area in Dixon Entrance. Twenty coded-wire tagged chinooks were recovered during this fishery.