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Assessment of Groundfish Stocks Off the West Coast of Canada in 1979 and Recommended Total Allowable Catches for 1980

S. J. Westrheim (Editor)

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Canadian Data Report of Fisheries
and Aquatic Sciences No. 208

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ASSESSMENT OF GROUND FISH STOCKS OFF THE WEST COAST OF CANADA IN 1979
AND RECOMMENDED TOTAL ALLOWABLE CATCHES FOR 1980

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ABSTRACT

Westrheim, S. J., editor. 1980. Assessment of groundfish stocks off the west coast of Canada in 1979 and recommended total allowable catches for 1980. Can. Data Rep. Fish. Aquat. Sci. 208: 265 p.

Recommended Total Allowable Catches (TACs) for 1980, are included for all commercially important groundfish stocks off British Columbia, by statistical area (3C, 3D, 4B, 5A, 5B, 5C, 5D, and 5E). These TACs are based on the best available information, but many are not considered to be precise values, due to the limited information available. Total (all species, all areas) recommended TAC for 1980 is 89,885 t, compared to 80,210 t for 1979. TAC estimates for principal species in 1980 (1979 in parentheses) were: Pacific hake, 30,000 t (35,000 t); dogfish, 9,000 t (9,000 t); walleye pollock, 8,750 t (5,800 t); Pacific cod, 6,500 t (6,000 t); yellowtail rockfish, 3,950 t (3,850 t); Pacific ocean perch, 3,200 t (2,670 t); and arrowtooth flounder, 3,050 t (900 t). For all other species, recommended TACs for 1980 were less than 1,600 t each. Canada-U.S. all-species landings from B.C. waters totalled 34,579 t in 1978, and 38,551 t in 1977.

RÉSUMÉ

Westrheim, S. J., editor. 1980. Assessment of groundfish stocks off the west coast of Canada in 1979 and recommended total allowable catches for 1980. Can. Data Rep. Fish. Aquat. Sci. 208: 265 p

Le rapport présente les totaux des prises admissibles (TPA) recommandés pour tous les stocks importants de poisson de fond exploités au large de la Colombie-Britannique, classés par zones statistiques (3C, 3D, 4B, 5A, 5B, 5C, 5D et 5E). Ces TPA sont fondés sur la meilleure information disponible, mais certains ne sont pas considérés comme précis à cause de l'insuffisance des données. Le TPA total (toutes les espèces, toutes les zones) recommandé pour 1980 se monte à 89 885 t, alors qu'il était de 80 210 t en 1979. Les estimations des TPA des principales espèces pour 1980 (chiffres de 1979 entre parenthèses) étaient les suivantes: merlu du Pacifique, 30 000 t (35 000 t); aiguillat, 9 000 t (9 000 t); morue du Pacifique occidental, 8 750 t (5 800 t); morue du Pacifique, 6 500 t (6 000 t); sébaste à queue jaune, 3 950 t (3 850 t); sébaste du Pacifique, 3 200 t (2 670 t); et flétan du Pacifique, 3 050 t (900 t). Pour toutes les autres espèces, les TPA recommandés pour 1980 étaient inférieurs à 1 600 t chacun. Les débarquements canadiens pour toutes les espèces capturées dans les eaux de la Colombie-Britannique totalisaient 34 579 t en 1978 et 38 551 t en 1977.

FOREWORD

This report was prepared by the Groundfish Program staff (Resource Services Branch), and contains proposed Total Allowable Catches (TACs) of groundfish for 1980 as recommended by scientists of the Resource Services Branch. The TACs are based primarily on biological considerations, and may not necessarily be the same as those finally adopted by Fisheries Management, Pacific Region. The latter will be based on consultations which take into account not only biological considerations, but also economic, social, enforcement and other factors. As a consequence the TACs finally announced by Fisheries Management may in some cases be higher (but rarely lower) than those recommended by Resource Services.

SUMMARY

Most groundfish species in British Columbia waters comprise relatively isolated regional groups -- for example the Pacific cod of Hecate Strait, Queen Charlotte Sound, Strait of Georgia, and Southwest Vancouver Island. Also, regional differences in abundance of most groundfish species cause their relative importance to vary among regions -- for example, rock sole which is relatively important only in Hecate Strait and Queen Charlotte Sound. From a biological and management standpoint, it therefore seems appropriate to summarize this report by region rather than by species.

BRITISH COLUMBIA COAST

For all but two species, 1980 TACs have been recommended for individual major statistical areas, or combinations of no more than two such areas. Dogfish shark and sablefish are the exceptions. No TAC is recommended for albacore tuna.

For dogfish, the recommended TAC for 1980 is 9,000 t coastwide, of which 3,000 t applies to Georgia Strait and vicinity (Area 4B) (Fig. 1, Table 1). Coastwide landings were 3,146 t in 1978 and 1,772 t in 1977. Most of these dogfish were caught in Area 4B.

For sablefish, the recommended TAC for 1980 is 3,500 t, to be applied coastwide. Canada-U.S. landings off British Columbia were 830 t in 1978, and 1,213 t in 1977. All-nation catch totalled 3,241 t in 1978, and 4,602 t in 1977.

All-species recommended TAC for 1980 is 80,210 t, compared to 89,885 t in 1979. Principal change was a reduction in the TAC for Pacific hake, from 35,000 t in 1979 to 30,000 t in 1980, as a result of refined estimates of total biomass. All-species Canada-U.S. landings from B.C. waters totalled 34,579 t in 1978, compared to 38,551 t in 1977.

GEORGIA STRAIT AND VICINITY (Area 4B)

Principal species (based on 1978 records) in the Canadian landings from Georgia Strait and vicinity were dogfish (2,830 t), Pacific cod (1,410 t), lingcod (589 t), and walleye pollock (380 t) (Table 2). Landings in 1978 did not exceed 155 t for any other species.

For dogfish, the recommended TAC for 1980 is 3,000 t -- unchanged from 1979. Total landings from Area 4B were 2,830 t in 1978, and 1,637 t in 1977.

For Pacific cod, the recommended TAC for 1980 is 1,000 t, compared to 900 t in 1979. Trawl landings of Pacific cod from Area 4B totalled 1,410 t in 1978, and 1,168 t in 1977.

For walleye pollock, the recommended TAC for 1980 is 3,400 t, down from 4,000 t in 1979. Trawl landings from Area 4B were 380 t in 1978 and 51 t in 1977.

For lingcod, no TAC is recommended.

For Pacific hake, the recommended TAC for 1980 is 10,000 t. No landings were recorded from Area 4B in 1978 or 1977. Some fishing took place in 1979.

For all other species, no recommended TAC for 1980 exceeds 90 t.

SOUTHWEST VANCOUVER ISLAND (Area 3C)

Important species (based on Canada-U.S. 1977 landings¹) in the Canadian portion of Area 3C are Pacific cod (2,898 t), and lingcod (1,159 t) (Table 3). Secondary species are rockfish other than Pacific ocean perch (737 t), sablefish (690 t), petrale sole (315 t), and arrowtooth flounder (294 t).

For Pacific hake, the recommended TAC for 1980 is 20,000 t (35,000 t in 1977), most of which will probably be harvested by foreign vessels. Canadian sales at sea to foreign processing vessels were 1,836 t in 1978, and nil in 1977.

For Pacific cod, the recommended TAC for 1980 is 1,500 t unchanged from 1979 for the Canadian portion of Areas 3C plus 3D. Furthermore, if low abundance is predicted for the winter spawning stock in Area 3C, an area-time closure will be imposed, as in 1978 and 1979. A prediction of the winter spawning abundance will be available early in November. Canada-U.S. landings in 1977 were 2,898 t.

For lingcod, the recommended TAC for 1980 is 600 t (1,000 t in 1979). Canada-U.S. landings totalled 1,159 t in 1977.

For secondary species, recommended TACs in 1980 are: 600 t² for Pacific ocean perch (50 t in 1979); 570 t for Other rockfish (no change from 1979); 500 t for petrale sole (same in 1979); and 200 t for arrowtooth flounder (same in 1979). Sablefish have been treated in a preceding section.

¹1978 data for U.S. not available.

²Includes Area 3D.

NORTHWEST VANCOUVER ISLAND (Area 3D)

Principal species, based on 1978 landings, were rockfish other than Pacific ocean perch (1,155 t), sablefish (237 t), lingcod (392 t), and Pacific cod (146 t) (Table 4). All other species amounted to less than 62 t each.

For Other rockfish, the recommended TAC for 1980 is 1,270 t (1979 TAC = 1,220 t), of which 500 t is allocated to S. pinniger (500 t), and 200 t each to S. brevispinis (150 t), S. flavidus (200 t), and S. paucispinis (200 t). Total Canada-U.S. landings were 1,155 t in 1978, and 626 t in 1977. Species composition of U.S. landings is not available at this time.

For lingcod, the recommended TAC for 1980 is 200 t (same as 1979). Canada-U.S. landings were 392 t in 1978, and 275 t in 1977.

For Pacific cod, the recommended TAC for 1980 is included with that for the Canadian portion of Area 3C. Canada-U.S. landings were 146 t in 1978, and 106 t in 1977.

QUEEN CHARLOTTE SOUND (Areas 5A and 5B)

Principal species in the 1978 Canada-U.S. landings, from Queen Charlotte Sound (Areas 5A and 5B) were Other rockfish (3,781 t), Pacific cod (1,962 t), Pacific ocean perch (1,336 t), and arrowtooth flounder (670 t) (Table 5). No other species amounted to more than 313 t.

For Other rockfish, recommended total TAC for 1980 is 5,175 t (5,075 t in 1979). Canada-U.S. landings were 3,781 t in 1978, and 4,470 t in 1977. Principal species is S. flavidus for which the recommended TAC for 1980 is 3,000 t (same in 1979). Canadian landings of S. flavidus in 1978 totalled 1,644 t, and probably represented about 85% of the Canada-U.S. landings of this species from Queen Charlotte Sound. Recommended TACs in 1980 for secondary species are: 600 t for S. brevispinis (1978 Canadian landings = 724 t) and 500 t for S. pinniger (1978 Canadian landings = 263 t).

For Pacific cod, the recommended TAC for 1980 is 2,000 t. Canada-U.S. landings in 1978 were 1,962 t, and in 1977, 1,268 t. Pacific cod landings continue to fluctuate without trend. Recommended TACs in 1980 for associated species are: 300 t each for lingcod and rock sole. Canada-U.S. landings for lingcod were 318 t in 1978 and 447 t in 1977. Comparable values for rock sole were 296 and 272 t, respectively.

For Pacific ocean perch, the recommended TAC for 1980 is 2,000 t, the same as in 1979. Canada-U.S. landings were 1,336 t, in 1978, and 2,104 t in 1977.

For arrowtooth flounder, the recommended TAC for 1980 is 500 t, no change from 1979. Canada-U.S. landings were 670 t in 1978, and 253 t in 1977.

HECATE STRAIT AND DIXON ENTRANCE (Areas 5C and 5D)

Principal species, based on Canadian landings⁴ in 1978, were Pacific cod (2,100 t), walleye pollock (1,707 t), and arrowtooth flounder (1,365 t) (Table 6). Secondary species were rock sole (874 t), Other rockfish (970 t), English sole (559 t), and Dover sole (356 t). No other species amounted to more than 106 t.

For Pacific cod, the recommended TAC for 1980 is 2,000 t. Canadian landings were 2,100 t in 1978, and 3,522 t in 1977. Preliminary data for 1979 suggest that cod abundance is rising once more.

For walleye pollock, the recommended TAC for 1980 is 3,350 t. Canadian landings were 1,707 t in 1978, and 583 t in 1977.

For arrowtooth flounder, the recommended TAC for 1980 is 2,100 t (Table 6). Canadian landings were 1,365 t in 1978, and 1,023 t in 1977. Arrowtooth flounder are ubiquitous, and hence are associated with all important species.

For secondary species, the recommended TACs for 1980 are 960 t for rock sole; 1,175 t for Other rockfish; 750 t for English sole; and 300 t for Dover sole. Canadian landings in 1978 (and 1977) were 874 (847) t for rock sole; 970 (807) t for Other rockfish; 559 (1,178) t for English sole; and 356 (474) t for Dover sole. For rock sole, the 1980 TAC is 460 t for the area north of 53°50'N lat., and 500 t south of that latitude. For Other rockfish, principal species (and their recommended TACs for 1980) were S. flavidus (450 t) and S. brevispinis (300 t). Canadian landings in 1978 were 382 t of S. flavidus, and 232 t of S. brevispinis.

WEST COAST QUEEN CHARLOTTE ISLANDS (Area 5E)

Principal species (based on 1978 Canadian landings³ are Pacific ocean perch (2,427 t), and Other rockfish (1,725 t) (Table 7). No other species, or species group, contributed more than 345 t. All Canadian landings of rockfishes originated from grounds south of 54°N lat.

³Negligible landings by U.S. vessels.

For Pacific ocean perch, recommended TACs in 1980 are 600 t for Area 5E-S (South of 54°N lat.). In Area 5E-N, the recommended TAC for 1980 is 400 t of rockfishes (all species). Corresponding recommended TACs for 1979 were 600 t and 10 t (for ocean perch), respectively. Canadian trawl landings of Pacific ocean perch in 1977 were 1,551 t from Area 5E-S, and nil from Area 5E-N.

For Other rockfish, recommended TACs for 1980 are 400 t (including ocean perch) for Area 5E-N, and 2,125 t for Area 5E-S. Canadian trawl landings from Area 5E-N were nil in 1978 and 1977; and 1,931 and 1,637 t, respectively, from Area 5E-S during the same years.

For Area 5E-S, additional fishery restraints are recommended to prevent rockfish landings from inadvertently exceeding TACs, as occurred in 1979. It is recommended that all fishing for rockfishes be prohibited during the months of March and April, to protect Pacific ocean perch from excessive fishing during spawning, and permit optimization of yields from all rockfish species.

For Area 5E as a whole, a TAC of 100 t is recommended for Dover sole.

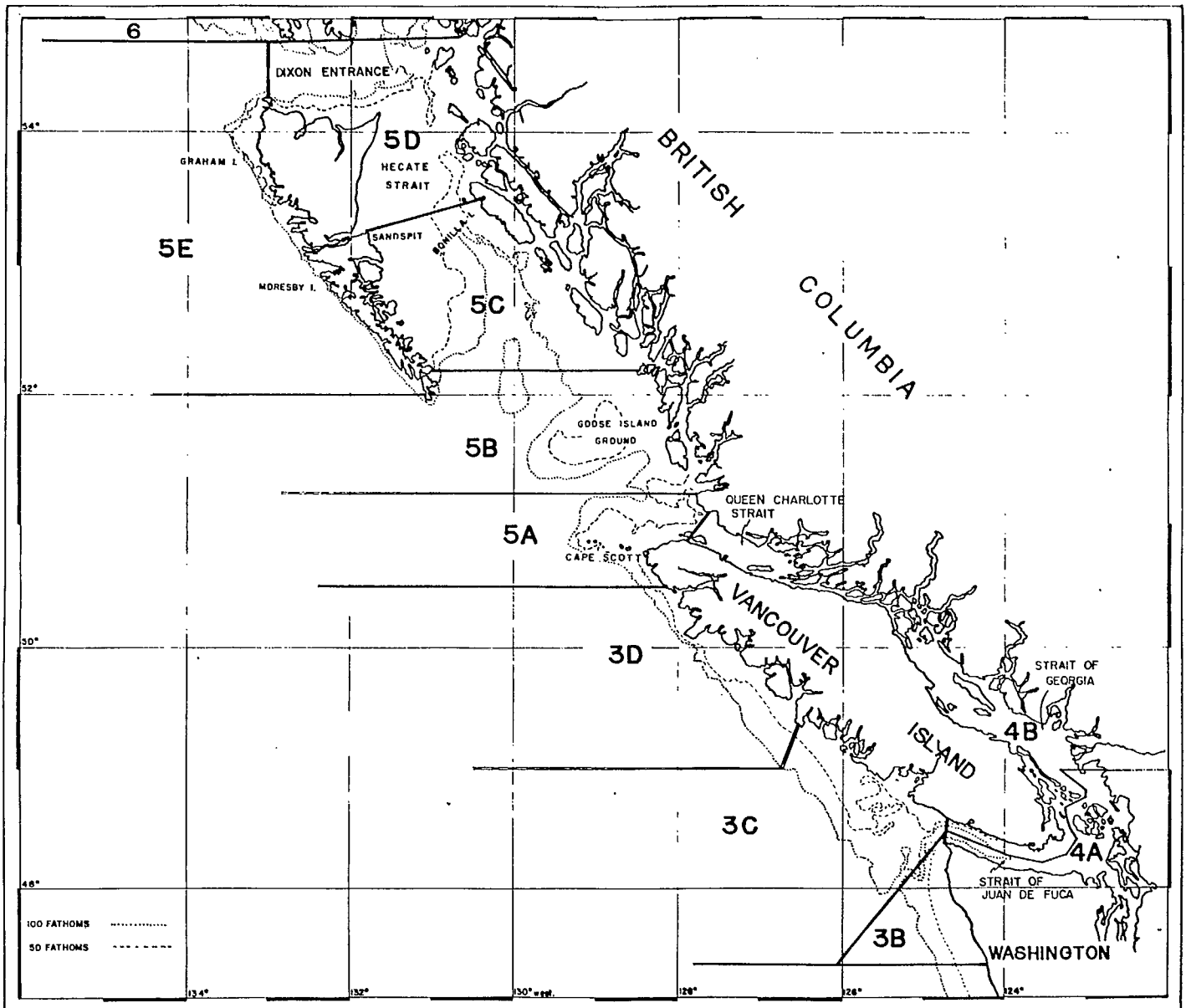


Fig. 1. International (Pacific Marine Fisheries Commission) Statistical Areas along the British Columbia coast.

Table 1. Recommended TACs (t) in 1980 and 1979, and Canadian landings (t) in 1978 and 1977, by species, for all areas combined.

Species	Section No. ^a	Recommended TAC (t)		Canada-U.S. ^b landings (t)	
		1980	1979	1978	1977
Pacific ocean perch	1	3,200	2,670	3,926	3,772
Other rockfish	2	10,315	9,965	8,000	8,443
<u>S. aleutianus</u>	2.9	150	150	Incomplete	Incomplete
<u>S. babcocki</u>	2.10	340	340		
<u>S. brevispinis</u>	2.4	1,550	1,500		
<u>S. entomelas</u>	2.7	550	550		
<u>S. flavidus</u>	2.2	3,950	3,850		
<u>S. paucispinis</u>	2.6	700	700		
<u>S. pinniger</u>	2.3	1,450	1,450		
<u>S. proriger</u>	2.8	425	475		
<u>S. reedi</u>	2.5	1,200	950		
Other	2.11	710 ^c	-		
Dogfish	6	9,000	9,000	3,146	1,772
Lingcod	5	1,300	1,700	1,999	2,600
Pacific cod	4	6,500	6,000	6,979	8,969
Pacific hake	13	30,000	35,000	1,836	-
Sablefish	3	3,500	3,500	830	1,433
Walleye pollock	12	8,750	5,800	2,406	935
Arrowtooth flounder	11	3,050	900	2,326	1,612
Butter sole	14	F ^d	F ^d	-	-
Dover sole	8	610	520	759	712
English sole	9	895	820	814	1,509
Petrale sole	10	600	500	247	474
Rock sole	7	1,375	1,010	1,311	1,299
Total		80,210 ^e	89,885	34,579	38,551

^aLocation in report.

^bU.S. data not available at this time for all areas.

^cApplies to area west of fishery closing line (Area 5A + 5B).

^dF = free fishing.

^eIncludes 400 t of Pacific ocean perch and other rockfish in Area 5E, north of 54° N lat.

Table 2. Recommended TACs (t) in 1980 and 1979, and Canadian landings (t) in 1978 and 1977. For Area 4B (Georgia Strait and vicinity), by species.

Species	Section No. ^a	Recommended TAC (t)		Canadian landings (t)	
		1980	1979	1978	1977
Pacific ocean perch	1	F ^b	F	1	1
Other rockfish	2	F	F	202	166
<u>S. aleutianus</u>	2.9	-	-	0.1	Not available
<u>S. babcocki</u>	2.10	-	-	-	
<u>S. brevispinis</u>	2.4	-	-	-	
<u>S. entomelas</u>	2.7	-	-	-	
<u>S. flavidus</u>	2.2	-	-	14	
<u>S. paucispinis</u>	2.6	-	-	0.1	
<u>S. pinniger</u>	2.3	-	-	0.1	
<u>S. proriger</u>	2.8	-	-	-	
<u>S. reedi</u>	2.5	-	-	-	
Other	2.11	-	-	-	
Dogfish	6	3,000	3,000	2,830	1,637
Lingcod	5	F	F	589	502
Pacific cod	4	1,000	900	1,410	1,168
Pacific hake	13	10,000	10,000 ^c	-	-
Sablefish	3	F	F	10	27
Walleye pollock	12	3,400	4,000	380	51
Arrowtooth flounder	11	50	50	33	6
Butter sole	14	F	F	-	-
Dover sole	8	40	40	102	40
English sole	9	90	90	155	202
Petrale sole	10	F	F	6	2
Rock sole	7	20	20	62	52

^aLocation in report.

^bF = free fishing.

^cCorrected value.

Table 3. Recommended TACs (t) in 1980 and 1979, and Canada-U.S. landings (t) in 1978 and 1977 for the Canadian portion of Area 3C (S.W. Vancouver Island), by species.

Species	Section No. ^a	Recommended TAC (t)		Canada-U.S. ^b landings (t)	
		1980	1979	1978	1977
Pacific ocean perch	1	600 ^c	50	(49)	21
Other rockfish	2	570	570	(167)	737
<u>S. aleutianus</u>	2.9	F ^d	F	-	Not available
<u>S. babcocki</u>	2.10	20	20	-	
<u>S. brevispinis</u>	2.4	100	100	(1)	
<u>S. entomelas</u>	2.7	100	100	-	
<u>S. flavidus</u>	2.2	100	100	(43)	
<u>S. paucispinis</u>	2.6	50	50	(4)	
<u>S. pinniger</u>	2.3	100	100	(15)	
<u>S. proriger</u>	2.8	50	50	-	
<u>S. reedi</u>	2.5	50	50	-	
Other	2.11	F	F	-	
Dogfish	6	e	e	(171)	64
Lingcod	5	600	1,000	(583)	1,159
Pacific cod	4	1,500 ^c	1,500 ^c	(1,358)	2,898
Pacific hake	13	20,000 ^c	35,000 ^c	(1,836) ^f	-
Sablefish	3	e	e	(107)	(690)
Walleye pollock	12	700 ^c	500 ^c	(5)	21
Arrowtooth flounder	11	200	200	(221)	294
Butter sole	14	F	F	(-)	-
Dover sole	8	100	100	(63)	-
English sole	9	40	40	(68)	101
Petrale sole	10	500	500	(108)	315
Rock sole	7	100 ^d	40 ^d	(62)	88

^aLocation in report.

^b1978 U.S. data not available at this time--Canadian data in parentheses.
1977 data not available by species at this time.

^cIncludes Area 3D.

^dF = free fishing.

^eIncluded in coastwide TAC. See text.

^fCanada only. Sales at sea to foreign processing vessel.

Table 4. Recommended TACs (t) in 1980 and 1979, and Canada-U.S. landings (t) in 1978 and 1977 for Area 3D (N.W. Vancouver Island), by species.

Species	Section No. ^a	Recommended TAC (t)		Canada-U.S. ^b landings (t)	
		1980	1979	1978	1977
Pacific ocean perch	1	c	10	35	21
Other rockfish	2	1,270	1,220	1,155	626
<u>S. aleutianus</u>	2.9	F ^d	F	(-)	(-)
<u>S. babcocki</u>	2.10	20	20	(0.4)	(-)
<u>S. brevispinis</u>	2.4	200	150	(21)	(10)
<u>S. entomelas</u>	2.7	50	50	(2)	(-)
<u>S. flavidus</u>	2.2	200	200	(37)	(8)
<u>S. paucispinis</u>	2.6	200	200	(19)	(10)
<u>S. pinniger</u>	2.3	500	500	(54)	(97)
<u>S. proriger</u>	2.8	50	50	(7)	(-)
<u>S. reedi</u>	2.5	50	50	(-)	(-)
Other	2.11	F	F	(31)	
Dogfish	6	e	e	(65)	53
Lingcod	5	200	200	(392)	275
Pacific cod	4	c	c	146	106
Pacific hake	13	F	F	-	-
Sablefish	3	e	e	(237)	161
Walleye pollock	12	F	F	0.4	-
Arrowtooth flounder	11	200	200	(7)	5
Butter sole	14	F	F	-	-
Dover sole	8	40	40	61	26
English sole	9	F	F	5	3
Petrale sole	10	100 ^f	100 ^f	21	58
Rock sole	7	c	c	16	35

^aLocation in report.

^bCanada only, in parentheses.

^cIncluded in TAC for Area 3C.

^dF = free fishing.

^eIncluded in coastwide TAC. See text.

^fApplies only to January-March.

Table 5. Recommended TACs (t) in 1980 and 1979, and Canada-U.S. landings (t) in 1978 and 1977 for Areas 5A and 5B (Queen Charlotte Sound), by species.

Species	Section No. ^a	Recommended TAC (t)		Canada-U.S. ^b landings (t)	
		1980	1979	1978	1977
Pacific ocean perch	1	2,000	2,000	1,336	2,104
Other rockfish	2	5,175	5,075	3,781	4,470
<u>S. aleutianus</u>	2.9	F ^c	F	(1)	(1)
<u>S. babcocki</u>	2.10	200	200	(73)	(20)
<u>S. brevispinis</u>	2.4	600	600	(724)	(198)
<u>S. entomelas</u>	2.7	250	250	(144)	(86)
<u>S. flavidus</u>	2.2	3,000	3,000	(1,644)	(1,012)
<u>S. paucispinis</u>	2.6	300	300	(133)	(42)
<u>S. pinniger</u>	2.3	500	600	(263)	(123)
<u>S. proriger</u>	2.8	75	75	(20)	(49)
<u>S. reedi</u>	2.5	50	50	(109)	(336)
Other	2.11	710 ^d	F	(85)	(2,603)
Dogfish	6	e	e	48	6
Lingcod	5	300 ^e	300 ^e	(318)	447
Pacific cod	4	2,000	1,600	1,962	1,268
Pacific hake	13	F	F	-	-
Sablefish	3	e	e	(39)	96
Walleye pollock	12	1,300	1,300	295	268
Arrowtooth flounder	11	500	500	670	253
Butter sole	14	F	F	-	-
Dover sole	8	130 ^f	130 ^f	58	71
English sole	9	20	20	27	23
Petrale sole	10	F	F	62	73
Rock sole	7	300 ^g	150 ^h	296	272

^aLocation in report.

^bCanada only, in parentheses.

^cF = free fishing.

^dOutside fishery closing line; see Addendum to 2.11.

^eIncluded in coastwide TAC. See text.

^f30 t in 5A; 100 t in 5B.

^g100 t in 5A; 200 t in 5B.

^h50 t in 5A; 100 t in 5B.

Table 6. Recommended TACs (t) in 1980 and 1979, and Canadian landings (t) in 1978 and 1977 for Areas 5C and 5D (Hecate Strait and Dixon Entrance), by species.

Species	Section No. ^a	Recommended TAC (t)		Canadian landings (t) ^b	
		1980	1979	1978	1977
Pacific ocean perch	1	F ^c	F ^c	78	74
Other rockfish	2	1,175	1,225	970	807
<u>S. aleutianus</u>	2.9	F	F	-	1
<u>S. babcocki</u>	2.10	75	75	30	13
<u>S. brevispinis</u>	2.4	300	300	232	234
<u>S. entomelas</u>	2.7	50	50	-	4
<u>S. flavidus</u>	2.2	450	450	382	295
<u>S. paucispinis</u>	2.6	100	100	54	60
<u>S. pinniger</u>	2.3	150	150	101	15
<u>S. proriger</u>	2.8	F	50	3	1
<u>S. reedi</u>	2.5	50	50	-	4
Other	2.11	F	F	69	
Dogfish	6	d	d	32	11
Lingcod	5	200	200	106	206
Pacific cod	4	2,000	2,000	2,100	3,522
Pacific hake	13	F	F	-	-
Sablefish	3	d	d	92	80
Walleye pollock	12	3,350 ^e	2,300 ^f	1,707	583
Arrowtooth flounder	11	2,100 ^g	2,100 ^g	1,365	1,023
Butter sole	14	-	-	-	-
Dover sole	8	300 ^h	210	356	474
English sole	9	750 ⁱ	670	559	1,178
Petrale sole	10	-	-	13	25
Rock sole	7	960 ^j	800	874	847

^aLocation in report.

^bNo U.S. landings.

^cF = free fishing.

^dIncluded in coastwide TAC. See text.

^e800 t for Area 5C; 2,100 t for Rose Spit-Two Peaks-Dundas-Zayas Is.; 450 t for Cape Chacon.

^fArea 5D only.

^g100t in 5C; 2,000 t in 5D.

^h30 t in 5C; 270 t in 5D.

ⁱ70 t in 5C; 680 t in 5D.

^j500 t south of 53°50'; 460 north of 53°50'.

Table 7. Recommended TACs (t) in 1980 and 1979, and Canadian landings (t) in 1978 and 1977 for Area 5E South of 54°N lat., by species.

Species	Section No. ^a	Recommended TAC (t)		Canadian landings (t) ^b	
		1980	1979	1978	1977
Pacific ocean perch	1	600	600	2,427	1,551
Other rockfish	2	2,125	1,875	1,725	1,637
<u>S. aleutianus</u>	2.9	150	150	134	76
<u>S. babcocki</u>	2.10	25	25	5	2
<u>S. brevispinis</u>	2.4	350	350	Tr	Tr
<u>S. entomelas</u>	2.7	100	100	56	12
<u>S. flavidus</u>	2.2	200	100	Tr	Tr
<u>S. paucispinis</u>	2.6	50	50	Tr	Tr
<u>S. pinniger</u>	2.3	200	100	Tr	Tr
<u>S. proriger</u>	2.8	250	250	229	156
<u>S. reedi</u>	2.5	800	750	973	1,257
Other	2.11	400 ^c	-	-	-
Dogfish	6	d	d	-	1
Lingcod	5	-	-	11	11
Pacific cod	4	-	-	3	7
Pacific hake	13	-	-	-	-
Sablefish	3	d	d	345	159
Walleye pollock	12	700 ^e	200 ^e	19	12
Arrowtooth flounder	11	100 ^e	100 ^e	30	31
Butter sole	14	-	-	-	-
Dover sole	8	100 ^e	-	119	101
English sole	9	-	-	-	2
Petrale sole	10	-	-	37	1
Rock sole	7	-	-	-	5

^aLocation in report.

^bNo U.S. landings.

^cAll rockfishes, north of 54°.

^dIncluded in coastwide TAC. See text.

^eAll of Area 5E.

ACKNOWLEDGMENTS

This document is the second report containing comprehensive assessments of all commercially important groundfish stocks off the west coast of Canada together with recommendations on catch limits, this time for 1980. It also represents the efforts of the entire Groundfish Program staff (Marine Fish Division, Resource Services Branch). Principal contributors are R. J. Beamish, A. J. Cass, R. P. Foucher, D. Fournier, C. Houle, K. S. Ketchen, R. Kieser, L. Lapi, B. M. Leaman, M. Stocker, F. H. C. Taylor, J. M. Thompson, and S. J. Westrheim. Numerous other members of the staff play key roles in the collection and processing of catch statistics, collection of biological data at sea and at ports at landing, and the analysis of results.

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INTRODUCTION

In 1977, extension of jurisdiction to include management of fisheries within a 200-mile zone along Canada's west coast placed an obligation on Resource Services and its Groundfish Program to make annual assessments of the actual and potential productivity of stocks occurring within the zone. Assessment documents forming the basis for management actions in 1977 and 1978 were concerned with species/stocks which were of continuing interest to foreign nations (other than the U.S.A.). However, the requirement for all-inclusive assessment of stocks whether they are fished internationally or domestically was not long in coming, because by 1978 an almost explosive demand for quality fish products (stimulated in part by the indirect effects of extended jurisdiction) resulted in the development of new domestic fisheries and increased fishing pressure on stocks of traditional interest. The need for information on stock conditions and sustainable yields was made even more urgent by recognition of the fact that the reciprocal fishing privileges agreement between Canada and the United States, which essentially provided for free fishing within each other's zone, would have to be renegotiated with explicit catch limits on species/stocks of mutual interest.

The mounting demand for fish products in general and Canada's rapidly changing relationship with other countries fishing within the Canadian zone presage a new era in the west coast groundfish fishery -- an era characterized by rational management of resources through limitation of fishing effort, limitation of catch and other measures as may be required to achieve optimum sustainable yield.

This report is the second in the new series which provides a comprehensive assessment of almost all commercially important groundfish stocks in Canadian waters. Contained herein are compilations and analyses of available, pertinent data, and recommended Total Allowable Catches (TACs) for the 1980 season.

DEFINITION OF TERMS

With the advent of extended jurisdiction, the term Total Allowable Catch or TAC has become widely recognized as the maximum yield to be permitted from a stock in a given year. It is the ultimate management decision upon which national allocations are made. Not so widely accepted is a term describing the catch,⁴ which on the basis of biological

⁴The term "catch" is conventionally, but at times inaccurately, used as a synonym for landings. More accurately the term net catch should be used, because in almost all groundfish fisheries, some of the catch is discarded at sea (undersized, or unsaleable at the time), and rarely is accurate information on gross catch available. Hence TAC (Total Allowable Catch) and CPUE (Catch per unit effort) usually would more accurately be referred to as TAL (Total Allowable Landing) and LPUE (Landing Per Unit Effort).

consideration alone, is recommended by scientists to managers. While Allowable Biological Catch (ABC) is gaining recognition in some circles, it has been decided for the time being to use the expression RECOMMENDED TAC in order to avoid confusion.

A recommended TAC is what the biologist considers to be a desirable level of catch based on whatever information is available on the condition of a stock; its vital statistics of growth and natural mortality; its geographical and bathymetric (depth) distribution; its association with other species/stocks; and its ability to withstand or respond to various fishing intensities. A stock may be at a level where it is capable of sustaining only a modest yield. A greater yield would reduce the stock while a lesser one would permit the stock to increase to a higher, more economically attractive level of abundance. The biologist may recommend a relatively low TAC in order to achieve the increase as quickly as possible, and the manager may accept the biologist's advice. On the other hand the manager may decide, in consultation with industry and economists, that the recommended TAC is so low that its adoption would disrupt the fishery and force fishermen to suspend their operation or turn to other species whose productivity might be decreased by the additional fishing effort. Faced with this prospect, the manager may opt for a higher level of yield and hence a longer period for the stock to increase, in which case the TAC would be greater than that recommended by the biologist.

STOCK ASSESSMENT TECHNIQUES

The reader will quickly note a lack of uniformity in the treatment of the numerous species/stocks covered by this report. To a large extent this is a reflection of the quality and quantity of data available for stock assessment and the extent to which such data submit to analytical techniques. For the majority of stocks, conclusions regarding stock condition and TACs, for want of sufficient time or reliable data, are based on a review of recent trends in catch, fishing effort and catch per unit of effort (CPUE). For new fisheries there is of course no past history and hence insufficient data, except possibly for results of research vessel surveys, upon which to base tentative conclusions. Finally, for only a very few stocks has it been possible to make use of mathematical modelling to arrive at TAC recommendations, which is not to say that the conclusions are necessarily any more reliable than those reached by other means. Indeed, it is important for the reader, particularly the fisheries manager, to recognize that ALL RECOMMENDED TACs ARE AT BEST ROUGH APPROXIMATIONS SUBJECT TO REVIEW AND MID-SEASON REVISION.

Except where indicated, we are not yet in a position to set confidence limits to our estimated TACs. Some may be overly generous while others may be unduly stringent. However, because the history of groundfish fisheries elsewhere in the world has been one of overexploitation followed by sometimes fruitless efforts at restoration, we have generally taken a conservative approach to our recommendations. Only a few species (e.g. Pacific cod and possibly pollock) seemingly possess the ability to rebound

quickly should the catch limit mistakenly be set too high. For most other species, and particularly the large group of rockfishes, which are characterized by relatively slow growth and low rates of reproduction, errors can take a long time to repair. Some stocks already have been decimated by foreign and domestic fisheries during the past decade and may require a decade or more to return to levels where they will support economically viable operations. Thus, managers are cautioned to exercise circumspection in setting TACs and to recognize the need for flexibility during this initial stage of management where the approach to management must be on a rather empirical basis.

Four other guiding considerations deserve mention at this time:

First, it must be recognized that groundfish fisheries are of extreme complexity mainly because the numerous species/stocks inhabiting particular areas are intermixed, or at least so finely separated from one another that a TAC cannot be imposed on one without affecting others. Once the TAC of a target species is taken, fishing effort will automatically be diverted to other species in the same area or to other areas along the coast. Because of this chain reaction or domino effect, imposition of a TAC on one species/stock inevitably calls for a TAC on almost all other species/stocks.

Second, there are about 23 stocks (of roughly 10 species) which are sufficiently important to be regarded as primary targets. These major stocks cannot be exploited without the incidental catch of a number of secondary species in what may appear to be trivial amounts but which, in fact, constitute overfishing. In such cases TACs are fully warranted for both primary and secondary species. For other minor species which perhaps are underfished, our recommended TACs should be merely regarded as an acknowledgment or endorsement of the existence of a fishery. They should not be regarded as strict management proposals. TACs for minor species regardless of stock condition must be integrated with TACs for major target species and modified, where necessary in light of management strategy, to prevent premature closure of the more valuable fisheries for target species.

Third, Pacific cod, the most important species in the Canadian groundfish fishery, is subject to highly variable short-term fluctuations in abundance which are as yet unpredictable. Thus accurate estimation of TACs should not be expected. Figures for Pacific cod are subject to review and possible mid-season revision, much in the way the magnitude of salmon runs must be assessed while the fishery is in progress.

Fourth, in addition to Pacific cod and a variety of other traditionally important but more stable contributors to the groundfish fishery, there are several large resources which are only now coming into production (pollock and dogfish); are as yet to be exploited (hake in inshore waters); or, for the lack of priority in earlier years, are only now being subjected to investigation (arrowtooth flounder and numerous rockfishes other than Pacific ocean perch). For these species the scientific basis for estimating TACs is understandably weak, and the figures provided can be little better than informed guesses.

With the substantially increased support recently provided for groundfish stock assessment investigations, accumulation of the basic information needed for management is progressing more rapidly, and with that, a growing capability to provide sound advice. In the meantime, it is of vital importance, as emphasized earlier, to recognize the provisional nature of the TACs contained in this report and the need for a review and revision process during the course of the 1980 fishery.

1. PACIFIC OCEAN PERCH STOCK ASSESSMENT

1.1 Introduction

Pacific ocean perch (Sebastes alutus) is the principal species in the rockfish catches off British Columbia. Commercially abundant stocks are located off West Vancouver Island, in Queen Charlotte Sound, off West Queen Charlotte Islands, and possibly in South Hecate Strait. The long-exploited stocks off West Vancouver Island and in Queen Charlotte Sound have been under joint study by Canadian and United States scientists since 1970. The West Queen Charlotte Islands stock was exploited exclusively by Japanese and USSR vessels prior to late 1976 when Canadian vessels began fishing inshore areas not available to foreign vessels. In South Hecate Strait, research vessel catch rates in 1973, 1974, and 1978 indicated the existence of a commercially abundant stock, but to date no major commercial fishery has developed, despite declining catch rates on traditional grounds in Queen Charlotte Sound.

This report presents stock assessments for the various Pacific ocean perch stocks off British Columbia, by major region.

1.2 Vancouver Area (Areas 3B, 3C, and 3D)

The Vancouver Area encompasses waters off West Vancouver Island and Northwest Washington State (approximating Statistical Areas 3B, 3C, and 3D). Off West Vancouver Island (Areas 3C and 3D), Pacific ocean perch ranks fourth in importance (12%), based on quantities landed, behind Pacific cod (33%), lingcod (21%), and Other rockfish (17%) (Westrheim 1977). Canadian share of Pacific ocean perch landings has been negligible from the Vancouver Area.

Canada-U.S. landings from the Vancouver Area have declined substantially since 1966 when the Japanese and USSR vessels began fishing in the region. Currently, about 75% of the Canada-U.S. landings originate from the U.S. portion of the Vancouver Area.

1.2.1 Landings and CPUE

All-nation landings of Pacific ocean perch from the Vancouver Area (Areas 3B, 3C, and 3D) totalled 825 t in 1978 (Table 1.1). Only Canadian and United States vessels participated in the 1978 fishery, and the Canadian participation was negligible. Most of the United States landings traditionally have originated from grounds south of the provisional Canada-U.S. boundary. During 1973-77, 76-97% of the Washington State landings originated from grounds south of the provisional boundary (Table 1.2). For Vancouver Area as a whole, landings continue to increase from the historical low of 287 t in 1974, but remain well below the level of 1963-65 (2,499-3,867 t), immediately prior to the arrival of the USSR and Japanese vessels.

Washington State CPUE was 0.309 t/hr in 1978, and lies within the range (0.202-0.317 t/hr) occurring during 1968-78. Values for 1963-66 were 0.404-0.718 t/hr.

1.2.2 Other information

The 1979 TAC report provided information, for the Vancouver Area as a whole, on age composition of Washington State landings, biological statistics, biomass estimates and exploitation rates. During 1979 the U.S. conducted a survey of S. alutus in its segment of the Vancouver Area to corroborate results obtained by a similar survey in 1977. The estimated marketable biomasses from (results of) these two surveys were 5,711 t and 7,730 t, respectively, for the U.S. portion of the Vancouver Area.

In September, 1979 Canada conducted a trawl survey of S. alutus off the central and southwest coast of Vancouver Island, encompassing the majority of the known areas of S. alutus abundance in the Canadian portion of the Vancouver Area. Analysis of the results of this survey indicate a marketable biomass of ~5,700 t, of which about 74% is S. alutus.

1.2.3 Stock assessment

While the overall abundance of S. alutus in the Vancouver Area has undoubtedly been reduced substantially from the virgin level, the 1979 survey results suggest that stocks may not be as depleted as catch statistics have indicated. This suggestion should be couched with an element of caution however, since the biomass estimate is extrapolated from catch rates in an area where no fishing for S. alutus has occurred for three years. It is an often-observed trait of rockfish populations that extensive fishing tends to dissipate fish schools and the high catch rates observed during the survey may have been an artifact of the lack of fishing effort in recent years.

1.2.4 Recommendations

A TAC of 600 t is recommended for Pacific ocean perch in the Areas 3C and 3D in total. In addition, it is recommended that directed fishing for this species be closely monitored for the persistence of catch rates observed during the 1979 survey.

1.3 Queen Charlotte Sound (Areas 5A and 5B)

Pacific ocean perch has been the most important species landed by the Canada-United States trawl fleet from Queen Charlotte Sound -- 43% of the mean annual landings during 1965-74 (Westrheim 1977). Other important species were Other rockfish (26%) and Pacific cod (12%). Canada-U.S. landings have declined steadily since USSR and Japanese trawlers began fishing, in 1965 and 1966, respectively.

1.3.1 Landings and CPUE

In 1978, all-nation landings of Pacific ocean perch from Queen Charlotte Sound (Areas 5A and 5B) totalled 1,336 t (Table 1.3). Only Canadian and United States vessels participated in the fishery. U.S. vessels terminated operations in June, and their 1978 landings from Queen Charlotte Sound were negligible. Canada-U.S. landings during 1976-78 remain at a low level (1,355-2,104 t) relative to 1966-70 (5,745-8,254 t). Evidently, Pacific ocean perch abundance in Queen Charlotte Sound was substantially greater than that in the Vancouver Area, because Canada-U.S. landings did not decline appreciably until after 1972, despite the sustained, large, all-nation production during 1966-70.

CPUEs for 1978 were 0.948 t/hr for Canadian vessels, and 0.705 t/hr for U.S. vessels. Both values are larger than the respective 1977 values, and probably reflect a decrease in fishing effort. Recent studies, still incomplete, suggest that nominal CPUE imperfectly reflects abundance of Pacific ocean perch.

1.3.2 Other information

The 1979 TAC report (Ketchen, ed. 1980) contained information on age composition of Canadian landings, and biomass estimates. No new information is currently available, and technical problems have not yet been resolved with respect to CPUE (used in age composition analysis) and biomass estimates (used in computing exploitation rates).

1.3.3 Stock assessment

Quantitative stock assessment is precluded for Pacific ocean perch stock(s) in the Queen Charlotte Sound region, because of currently unresolved problems of quantifying abundance. However, landing records of the Canada-U.S. fleet provide an adequate qualitative measure of the decline in abundance. The 1978 TAC for Canada-U.S. vessels, of 2,500 t, was only 54% filled, despite strong economic demand for Pacific ocean perch fillets.

1.3.4 Recommendations

Rehabilitation of the Pacific ocean perch stock(s) in Queen Charlotte Sound will require restraint by the trawl fleet for a number of years. However, currently available information does not indicate a need to eliminate the directed fishery, as was deemed necessary in the Canadian portion of the Vancouver Area. Until an adequate quantitative analysis is completed, a rough qualitative analysis must be employed. For 1980, a TAC of 2,000 t is recommended.

1.4 West Queen Charlotte Islands (Area 5E)

Rockfish exploitation off West Queen Charlotte Islands, Area 5E was initiated by USSR trawlers in 1965, followed by Japanese vessels in 1966. Soviet vessels abandoned the fishery by 1970, and Canadian vessels entered the fishery in late 1976.

The USSR-Japanese fishery was centered north of 54°00'N lat. -- 80% of the Japanese catch was taken in one offshore, 30-mi x 30-mi block (033540). The Canadian fishery has centered on inshore grounds south of 54°00'N, and appears to be exploiting a stock of ocean perch not previously fished by foreign fleets.

1.4.1 Landings and CPUE

In 1978, all-nation landings of Pacific ocean perch from the west coast of the Queen Charlotte Islands totalled 2,427 t (Table 1.4). Canadian vessels were the sole participants in this fishery. Their 1977 production was 1,551 t. Quantitative analysis of the historical landing statistics is virtually impossible. USSR data are not precise with respect to area, quantity, or species identification. Japanese data are not precise with respect to species composition. Furthermore, while 80% of the Japanese production originated from offshore grounds north of 54°00'N lat., virtually all of the Canadian production originated from inshore grounds south of 54°00'N lat.

CPUEs for Japanese vessels are of no interpretive value because species composition of catches was incorrectly reported, and was known to have changed from principally Pacific ocean perch during the early phase of the fishery (before 1970) to other species (probably S. reedi, S. proriger, S. zacentrus, and S. variegatus) since 1970. CPUEs for Canadian vessels yield little information yet because only two complete years of information are available at this time. Following are the January-July landing statistics for the two major fishing grounds exploited by Canadian vessels:

January-July	Rennell Sound	Buck Point
1977 Landing (t)	748	288
CPUE (t/hr)	2.42	1.91
1978 Landing (t)	234	194
CPUE (t/hr)	1.56	1.30
1979 Landing (t)	98	138
CPUE (t/hr)	0.76	1.40

Decline in production and CPUE for the Rennell Sound and Buck Point Grounds suggests that those local stocks have declined in abundance. Regional production has been sustained by discovery and exploitation of new grounds. However, no significant new grounds were discovered in 1979.

1.4.2 Other information

In July 1979, a biomass survey of rockfishes north of 54°00'N in Area 5E was conducted. This survey covered the area which was extensively fished by foreign fleets from 1966-1977 and within which the domestic fleet

has not operated. Preliminary results suggest a biomass of approximately 5,200 t of marketable rockfishes (~53% S. alutus).

Regression analysis of Japanese data alone suggests that the total "ocean perch" biomass in the 5E area prior to 1966 may have been as high as 104,000 t. The primary shortfall of this analysis (contamination of "ocean perch" statistics with other species in more recent years) would result in an underestimate of the virgin biomass. The estimated biomass of 104,000 t could have sustained an annual yield of ~6,000 t.

A survey of rockfish biomass south of 54°00'N was conducted in May 1979. Preliminary results indicate a biomass of ~16,000 t however only partial coverage of one area of known fish abundance was achieved. As such the estimate must be considered as a minimum estimate. Confidence intervals around this estimate are as yet unresolved.

Regression analysis of the data from the domestic fishery in Area 5E is somewhat confounded by a contamination of "ocean perch" with S. reedi in the first six months of the fishery. This analysis suggests a pre-1977 biomass of 38,000 t of S. alutus, from which a yield of ~2,300 t/yr might be sustainable. Since yields of less than this figure have resulted in decreased CPUEs, there is cause for considerable doubt as to the veracity of this yield. A more plausible figure is derived for the postulated yield of all rockfishes combined of 700-1,200 t/yr.

1.4.3 Stock assessment

Biomass surveys and regression estimates place some bounds around estimated yields from S. alutus stocks in the 5E area. The area north of 54°00'N has had a long history of overexploitation and considerable attention must be directed to rehabilitating the stock in that area. The considerations with regard to survey estimates generated in areas where there has been no fishing activity in recent years, noted in Section 1.2.3, are reiterated here. Similarly, the decreased catch rates observed in Area 5E(S) also counsel caution.

1.4.4 Recommendations

A TAC of 400 t for all rockfishes combined is recommended for Area 5E(N). In addition, the fishery is recommended as a permit fishery only. A TAC of 600 t of S. alutus for Area 5E(S) is recommended, together with the caveats of Appendix II.

Table 1.1. Pacific ocean perch catch (t) by nation and CPUE (t/hr) for United States vessels in the Vancouver Area, 1956-78.

Year	Catch (t)						CPUE (t/hr) U.S.A.
	Canada- U.S.A.	Japan	U.S.S.R.	Bulgaria ^a	Poland	E. Germany ^a	
1956	1,084	-	-	-	-	-	?
1957	1,154	-	-	-	-	-	?
1958	675	-	-	-	-	-	?
1959	968	-	-	-	-	-	0.341
1960	1,575	-	-	-	-	-	0.254
1961	2,485	-	-	-	-	-	0.327
1962	3,857	-	-	-	-	-	0.350
1963	3,867	-	-	-	-	-	0.435
1964	2,499	-	-	-	-	-	0.404
1965	3,046	-	500	-	-	-	0.718
1966	2,358	few	14,000	-	-	-	0.640
1967	805	6,678	6,000	-	-	-	0.434
1968	552	4,751	5,114	-	-	-	0.247
1969	583	1,787	1,040	-	-	-	0.242
1970	1,955	2,186	182	-	-	-	0.298
1971	1,155	1,838	900	-	-	-	0.317
1972	624	1,580	401	-	-	-	0.312
1973	344	2,989	490	-	-	-	0.228
1974	287	1,084	70	-	32	-	0.202
1975	440	352	152	-	-	-	0.271
1976	876	286	187	23	-	25	0.308
1977	945	T ^b	T	T	T	T	0.260
1978	825	-	-	-	-	-	0.309

^aEstimates assuming similar fishing patterns and catch composition as the U.S.S.R. fleet.

^bT=Trace.

Table 1.2. Washington State landings (t) of Pacific ocean perch from the Vancouver Area (3B + 3C + 3D), north and south of the provisional Canada-U.S. boundary, by year, 1963-77.

Year	Total	North	South	% South
1963	3,767	2,142	1,625	43
1964	2,048	980	1,068	52
1965	2,961	1,694	1,267	43
1966	2,283	797	1,486	65
1967	783	386	396	51
1968	526	108	417	79
1969	573	155	418	73
1970	1,209	558	651	54
1971	718	123	595	83
1972	503	215	289	57
1973	342	83	259	76
1974	286	45	241	84
1975	431	86	346	80
1976	873	129	744	85
1977	929	25	904	97

Table 1.3. Reported "Pacific ocean perch" catch (t) by nation and CPUE (t/hr) for Canadian and U.S. vessels in Queen Charlotte Sound, 1956-77.

Year	Catch (t)				CPUE (t/hr)	
	Canada- U.S.A.	Japan	U.S.S.R. ^a	Total	Canada	U.S.A.
1956	1,236	-	-	1,236	-	-
1957	758	-	-	758	-	-
1958	933	-	-	933	-	-
1959	1,915	-	-	1,915	-	0.672
1960	1,680	-	-	1,680	-	0.577
1961	1,201	-	-	1,201	1.116	0.654
1962	1,838	-	-	1,838	1.034	0.661
1963	3,712	-	-	3,712	1.297	0.841
1964	3,507	-	-	3,507	0.939	0.731
1965	4,889	-	7,000	11,889	1.285	1.040
1966	8,254	few	18,000	27,054+	1.270	1.132
1967	5,745	3,196	17,800	26,741	0.884	0.800
1968	6,051	5,614	1,827	13,492	0.963	0.722
1969	6,628	6,268	55	12,951	0.743	0.656
1970	6,077	3,775	2	9,854	0.674	0.710
1971	4,165	702	few	4,867+	0.567	0.670
1972	5,561	2,281	0	7,842	0.941	0.710
1973	3,626	958	0	4,584	1.234	0.812
1974	3,618	7,983	0	11,601	0.961	0.610
1975	2,707	3,888	0	6,590	0.808	0.486
1976	1,967	1,182	0	3,046	0.848	0.361
1977	2,104	980	0	3,084	0.671	0.420
1978	1,336	0	0	1,336	0.948	0.705

^aAll U.S.S.R. statistics are estimated from surveillance and are in the process of revision.

Table 1.4. Reported "Pacific ocean perch" production off the west coast of the Queen Charlotte Islands (PMFC Area 5E), by nation, 1965-78.

Year	Catch (t)				Japan CPUE (t/hr)
	U.S.S.R. ^a	Japan	Canada	Total	
1965	24,740	-	-	24,740	-
1966	15,896	300	-	16,196	4.17
1967	2,847	5,216	-	8,163	3.71
1968	1,054	8,042	-	9,096	2.57
1969	159	4,169	-	4,328	2.46
1970	-	1,894	-	1,671	2.12
1971	-	3,033	-	3,033	2.62
1972	-	4,469	-	4,469	2.95
1973	-	3,514	-	3,514	2.40
1974	-	2,442	-	2,442	1.73
1975	-	1,833	-	1,833	1.11
1976	-	1,992	-	1,992	1.20
1977	-	1,270	1,551	2,821	0.91
1978	-	-	2,427	2,427	-

^aAll U.S.S.R. statistics are estimated from surveillance and are in the process of revision.

2. ROCKFISHES OTHER THAN PACIFIC OCEAN PERCH

2.1 Introduction

Pacific ocean perch has historically been the most valued of the rockfish species to both domestic and foreign fleets fishing in Canadian waters. Other rockfish species (Sebastes spp.; Sebastolobus spp.) have been exploited by U.S. vessels since the mid-1960s, due to their higher market acceptance in the U.S., and by foreign fleets since the later 1960s when Sebastes alutus stocks began to decline in areas of previous abundance. By contrast, Canadian fishermen did not begin directed fishing for these other rockfish species until the mid-1970s when markets for them began to develop. For both the U.S. and Canadian fisheries there has been very poor species and area resolution of catches and there is, therefore, very little historical information of use in the assessment of these stocks. This is a serious shortcoming with regard to current methods of stock analyses, where catches-at-age of a year-class over several years are fundamental to the estimation of mortality rates within the population. Since rockfish species are extremely slow-growing the absence of a historical record of the age composition of catches requires the invocation of a number of assumptions about stock parameters in order to conduct assessments. The number of these assumptions or their individual magnitudes will only be reduced as a historical record is acquired.

Rockfishes as a group are characterized by slow growth ($K = 0.05-0.15$), high age at first capture (6-10 yr) and at first maturity (9-13 yr), low natural mortality rates ($M = 0.12-0.20$) and high longevity (40-85 yr). These factors in combination suggest that rockfish stocks are low-volume production systems wherein annual yields must be less than 20% of the standing stock if stock levels are to be maintained at optimum levels.

The present report deals with rockfish species in three major categories: those species which can be directly fished by the fleet, in most areas (S. brevispinis, S. flavidus, S. paucispinis, S. pinniger, and S. reedi); those species which are relatively less abundant and are normally caught incidentally with other species, but do attain significant annual landings (100-500 t) (S. aleutianus, S. babcocki, S. entomelas, and S. proriger); and, those species which are consistently caught incidentally to other species and whose annual landings are relatively small (S. borealis, S. crameri, S. ruberrimus, and S. variegatus). There is an additional group of fish for which there is currently no market because of their small average size (S. diploproa, S. helvomaçulatus, S. zacentrus, and Sebastolobus alascanus).

2.2 Sebastes flavidus (Yellowtail rockfish, Greenies)

2.2.1 Summary of catch statistics

There has been a historical fishery by U.S. vessels in Canadian waters since the mid-1960s, however Canadian vessels did not begin directed

fishing for S. flavidus until after 1970, primarily due to marketing constraints. While U.S. catches by species and major statistical area have recently been obtained, species-specific effort is still unavailable.

The fishery for Sebastes flavidus is divided into four general areas which are roughly encompassed by PMFC Areas 3C, 3D, 5A-5B, and 5C-5D. Landings from other areas are minor and incidental in occurrence. The lack of significant landings of S. flavidus from between these four areas argues for individual area management. While no definite conclusions can be reached about genetically distinct stock units, there are sufficient geographic barriers (deep submarine canyons) between these exploited groups to justify some stock distinction, based upon the generally observed behaviour of shelf rockfish species. It is on this basis that the populations of S. flavidus in these four areas will be treated as separate stock units. In so doing, the inconclusive nature of available information is acknowledged and the current assignment of stock units may well be modified as better data are obtained.

2.2.1.1 Southwest coast of Vancouver Island (Area 3C)

Canadian landings of S. flavidus underwent a substantial decline during 1969-75 and were accompanied by a similar decline in CPUE of the U.S. fleet (which applied the majority of the fishing effort--Table 2.1). In 1976, however, many of the U.S. vessels began using a modified Norwegian trawl which had an increase in vertical opening of approximately 50% (to a total of ~9.5 m) over conventional trawls. This net would be expected to have a considerably greater catching power for species such as S. flavidus, which tend to school up over the bottom (they are also caught with midwater gear). In fact the U.S. catch and CPUE for S. flavidus did increase substantially during 1976 (600+ %) for the 3B-3C areas, over previous years. This increased catch and CPUE did not appear to be derived from recruitment of a strong, new year-class entering the fishery since the size/age composition of sampled landings did not change. These data imply that either the availability or the vulnerability of the species had increased. The former may be verified if CPUE for Canadian vessels, which had fished consistently with the same gear over the periods and areas in question, had increased commensurately with that of U.S. vessels. It was only in that area closest to the provisional U.S.-Canada boundary that any increase occurred and it was associated with only ten hours of effort. In 1977, however, the catch and CPUE of U.S. vessels fishing for S. flavidus had dropped by almost 50% while effort was almost identical. Canadian catch and CPUE which had increased dramatically in 1977, when Canadian vessels had fished more productive locations south of the boundary line, decreased to 1976 levels in 1978 when Canadians no longer fished these more productive locations. More importantly, the 25% qualified catch decreased 93% during 1977-1978 while the similar qualifications of effort and CPUE decreased 64% and 81%, respectively. The CPUE of U.S. vessels fishing for S. flavidus in the 3B-3C area during 1978 is not directly available due to the lack of species-specific effort, however overall shelf rockfish CPUE decreased for the U.S. fleet in 1978.

2.2.1.2 Condition of resource and assessment for 1980

The quantity of S. flavidus in the Canadian portion of Area 3C is evidently very small. The substantial increase in landings during 1977 was restricted to grounds south of the provisional boundary, where 78% of the catch originated. It should be noted that subsequent to the exclusion of Canadian vessels from these grounds in 1978, CPUE values have returned to previous levels and qualified (25%) CPUE values have dropped 81%.

There was a substantial decline in U.S. CPUE from 1969 through 1975 in the 3C-3B area. As noted in Section 2.2.1.1, many U.S. vessels switched to new gear sometime in 1976, which could well have resulted in the increased CPUE noted. It is difficult to provide objective assessment of the change in CPUE of the U.S. fishery since Canadian CPUE also increased in 1978, when one Canadian trawler began fishing in the traditional U.S. fishing areas. What is obvious, however, is that removals of up to 1,500 t/yr (1968-69) precipitated declines in CPUE despite subsequent decreases in effort. If a measure of instantaneous natural mortality (M) represents what might be the exploitable proportion of the population on a maximum sustainable basis then:

$$1,500 \text{ t} > M \times (\text{Equilibrium biomass of exploitable stock})$$

where equilibrium biomass = (0.5)(virgin biomass) as in Gulland (1970). Since the best available estimate of M is 0.2, the biomass of standing stock in 1968-69 must have been less than 15,000 t in the 3B-3C area (and smaller still in Area 3C alone).

There are two other estimates of the biomass of S. flavidus in the 3B-3C area. In 1977, the United States conducted a biomass survey of rockfishes in the California-Washington region using bottom trawls. For the U.S. segment of Areas 3B and 3C, the estimated biomass of S. flavidus was 11,480 t \pm 98%. Imposing the previous rationale with regard to sustainable yields, an estimated equilibrium yield (EY) from this biomass would be 2,296 t/yr. Canada has conducted hydroacoustic biomass estimates in Area 3C and part of Area 3B periodically during 1974-1976. The following table presents the estimated biomass of marketable S. flavidus obtained in these surveys:

Year/month	<u>S. flavidus</u> biomass ^a
1974 Aug.	14,279 t
Oct.	2,541 t
1975 Sept.	2,666 t
Nov.	42 t
1976 Nov.	1,696 t

^aIt should be noted that the precision of these estimates is reflective of the detail of the calculation used to generate them, rather than the accuracy of the estimate.

The 1974 estimate is an obvious anomaly, but it was noted that 1974 biomass estimates for all species surveyed were exceptionally high. No explanation of these high values is available but the surveyors did state that while checks had been performed, equipment malfunction could not be ruled out. The lack of other substantiating evidence of high abundance in 1974 (CPUE for the U.S. fleet was one of the lowest on record) would argue that the August, 1974 estimates were inaccurate. Mean estimate of the S. flavidus biomass in the 1975-76 period would then be 1,736 t for the 3C area, resulting in an EY of approximately 347 t.

A fourth estimator of population biomass and EY can be obtained through examination of the historical record of catch and CPUE using the Leslie-Davis (1939) method. In applying this method there are several conceptual assumptions which must be justified: (1) the data must apply to a unit stock in which there is equilibrium between annual recruitment and annual losses due to natural mortality; (2) the catchability of the stock, q , must be approximately constant over the time interval considered; and (3) the estimates of K_t must be reliable. Assumption (2) regarding catchability is suspect considering the aforementioned gear changes in 1976 and the fact that although landings of S. flavidus were recorded in 1967, the fishery by U.S. vessels did not begin in earnest until 1968. The catch analysis was, therefore, progressively resolved to take into consideration these constraints. In general, the errors noted would result in some over-estimation of N_0 , the initial population. The results of these examinations are presented below:

Catch data ^a	CPUE data ^b	r	N_0	EY
1967-1977	1967-1977	-0.399	9,877 t	990 t
1967-1977	1968-1977	-0.774	6,685 t	670 t
1967-1975	1967-1975	-0.863	5,321 t	530 t
1967-1975	1968-1975	-0.863	5,443 t	540 t

^aNorth American catch.

^bU.S. nominal S. flavidus CPUE.

Original population size is thus estimated to be in the range 9,877-5,321 t, although the low correlation coefficient for the highest value should be noted. One would intuitively have less confidence in this value since the poor correlation results from a single data point, generated prior to the development of the major fishery. The most probable values arising from this type of analysis then would yield N_0 in the range 6,685-5,443 t and concomitant EY values of 530-670 t/yr.

In summary, the following information is available for S. flavidus in Areas 3B-3C:

Year	Biomass estimate	Source	EY estimate
1966	6,685-5,321 t	Regression	530-670 t/yr
1968-69	<15,000	Catch trend	<1,500 t/yr
1974	2,541-14,279 ^a	Hydroacoustic survey	500-2,860 ^a t/yr
1975	42-2,666	Hydroacoustic survey	8-530 t/yr
1976	1,696	Hydroacoustic survey	340 t/yr
1977	11,480	Trawl survey	2,296 t/yr

^aQuestionable value.

For lack of secondary supporting evidence two figures of EY in these data appear extremely high, the higher 1974 estimate and the 1977 trawl survey estimate. It is also significant to note that following removal of 1,072 t of S. flavidus in 1976, U.S. CPUE fell 47% in 1977; a further indication that the sustainable yield from this stock at its current level of abundance is probably well below 1,000 t/yr. The 1975-76 hydroacoustic surveys infer EYs of 400-500 t (if the fishery had reduced virgin biomass by roughly one half) and considering the 1976-77 removals the lower figure is adopted as EY₈₀ here, i.e. 400 t for Areas 3B-3C, of which only a small segment (possibly 20%) applies to water within Canadian jurisdiction. It should be noted that U.S. scientists believe that this stock can support much higher levels of yield than are proposed here.

2.2.1.3 Recommendations

A TAC of 100 t is recommended for S. flavidus in the Canadian portion of Area 3C. The probable transboundary nature of the stock implies close cooperation with the United States in its management of that part of the stock lying within the U.S. zone.

2.2.2.1 Northwest coast of Vancouver Island (Area 3D)

Landings of S. flavidus by Canadian vessels from this area have always been small (<35 t annually -- Table 2.1), the fishery being largely composed of landings of lingcod and S. pinniger. Similarly, U.S. landings of S. flavidus from 3D have been low (<150 t/yr) however, their relative importance has increased in recent years possibly due to decreases in the catches of the predominant species, S. pinniger. This trend was reversed in 1978 when 98% of the catch was estimated to be S. pinniger.

The impact of the short-lived but large removals of S. flavidus and S. entomelas by the Polish trawl fleet in 1975 and 1976 is difficult to assess due to the effect of markets on domestic catches and the differences in fishing gears used by the domestic and foreign fleets. Species composition of the 1975 Polish catch was 6,700 t of S. flavidus, 6,125 t of S. entomelas and 48 t of other rockfish; fishing effort was 6,265 hr. In 1976, 2,339 t of S. flavidus, 1,364 t of S. entomelas, 211 t of S. pinniger and 17 t of other rockfish were caught by Polish vessels; fishing effort was 4,950 hr. Nominal CPUE of the Polish fleet thus fell some 59% in one year.

While the North American catches of S. flavidus and S. pinniger did drop in 1976, following the large 1975 Polish fishery, the catch of S. flavidus increased again in 1977 (when fishery restrictions were in effect). The catches of S. flavidus by Poland were made with midwater nets, whereas the North American fleet relies almost exclusively on bottom trawls. It may thus be possible that the initial lack of evident effects of the Polish fishery on domestic catches is a result of the exploitation of different segments of the population by the two fleets. The long-term effects of the Polish fishery may only be discernible if more domestic vessels begin using midwater gear in this area; however, the large decreases in nominal CPUE experienced by the Polish fleet infer a decrease in the abundance of S. flavidus.

2.2.2.2 Condition of resource and assessment for 1980

The S. flavidus stock currently exploited by domestic vessels in Area 3D is evidently small (a 1976 hydroacoustic survey indicated a biomass of 315 t) and catches are primarily incidental. Only 6% of the total effort expended during 1978 resulted in catches where S. flavidus was $\geq 25\%$ of the total catch. Qualified CPUE (25%) for 1978 Canadian catches increased almost 300% over 1977 (Table 2.2), although the total catch involved was small. Nominal CPUE has undergone no significant changes in recent years, rather has fluctuated without trend (catch-CPUE correlation, $r = 0.79$). Given the incidental nature of the domestic fishery but also considering the large Polish removals of 1975-76, it would appear unwise to allow the catch to exceed 200 t without review.

A partial biomass survey in 1978 suggested a yield of 100-200 t/yr available to bottom trawl gear. There was one instance of a large catch of S. flavidus with midwater gear (6+ t/hr) on that survey but since this catch rate was not even approached in other hauls it has not been assigned great significance.

2.2.2.3 Recommendation

Due to the incidental character of the S. flavidus fishery in Area 3D and considering the previous Polish removals, a TAC of 200 t is recommended together with the provision that any changes in the character of the fishery be closely monitored.

2.2.3.1 Queen Charlotte Sound (Areas 5A and 5B)

The two major areas into which Queen Charlotte Sound has been divided have been the traditional North American fishing areas for S. flavidus. Primary areas of catch are the southeast edge of Goose Island bank, the Cape Scott Spit, and the Cox Island-Cape Russell area. Peak landings occurred in 1973 and declined until 1976; CPUE also declined despite decreases in effort. In 1977 a reversal of the previous trend in CPUE began, with both U.S. and Canadian vessels experiencing modest increases in CPUE, and persisted into 1978.

Effort for S. flavidus by the U.S. fleet has been declining since 1973; the 1978 effort was the lowest on record because the U.S. fishery in Canadian waters was terminated in June of 1978. Canadian landings and CPUE have increased since 1977 and the 1978 catch and CPUE were the highest on record. Qualified CPUE (25%) has also increased since 1977.

2.2.3.2 Condition of the resource and assessment for 1980

While CPUE data indicate that the resource is not undergoing a decline sufficient to affect CPUE, it should be noted that the recent increases in CPUE are associated with the lowest effort on record. It is possible that the high CPUE values of 1978 were an artifact of this low effort. This is somewhat difficult to validate since the highest CPUE values are normally recorded in late summer and fall; the period during which the U.S. fleet was excluded in 1978. It is pertinent to note however, that while the Canadian fleet CPUE in the period July-November, 1978 was 30% higher than the same period for 1977, the CPUE for the January-June period in 1978 was 42% lower than that for 1977. CPUE values are only one indicator of stock abundance (and an imperfect one, at that) but the obvious influence of the decrease in total effort on the Canadian CPUE should not be ignored when assessing the resource. An additional factor is the influence of markets on the landings of the species, which tends to confound the understanding of observed trends.

The size composition of S. flavidus samples has not shifted to a smaller mean size as has been the case in Area 3C. Indeed, the size composition of the stock has been relatively constant in recent years. The fishery has been dominated by the 1960 and 1962 year-classes although the 1966 year-class is also relatively strong.

A secondary consideration, as in Area 3C, is the use of new types of gear in the fishery. Domestic vessels are experimenting with midwater and high-opening nets to which S. flavidus is susceptible. The fishery will need to be monitored to determine if, for example, midwater fishing exploits juveniles before they enter a bottom trawl fishery.

The most recent data available from the Canadian fishery (July 15) indicate that catch rates are lower in 1979 than in 1978 however, the major fishery for this species does not begin until the August-October period. CPUE values are approximately equal to those in 1977 when U.S. vessels were also participating in the fishery.

In summary, the changes in CPUE observed in this fishery over the past two years cannot be attributed to stock abundance changes alone because of the concomitant changes in fishing effort. For this reason a relatively cautious approach must be taken in 1979 and 1980, when total effort will increase due to the re-entry of the U.S. fleet to the fishery.

Aside from this analysis of catch statistics, hydroacoustic estimates of the biomass of S. flavidus in Queen Charlotte Sound are also available. Two surveys were conducted during 1978, one in January and one in October; during both surveys priority was given to diurnal estimation because of the observed diel behavioural differences observed in some

rockfish species. The October survey was judged to provide the most accurate data because it achieved the most complete area coverage. The January estimate was considered less reliable because it included coverage of a deep water scattering layer more diffuse in appearance than a typical fish school. While S. flavidus were obtained during sampling of this layer, their abundance was not proportional to the acoustical density of the layer and it was decided that inclusion of data from this layer would be unrealistic.

The October survey resulted in a diurnal biomass estimate for S. flavidus of 16,000 t and a nocturnal estimate of 17,800 t. Using an average biomass of 16,900 t suggests an EY₇₉ of approximately 3,380 t, if this stock level was approximately one-half the virgin population. The 1978 CPUE analysis of this stock suggested a TAC of 3,000 t, thus there was close agreement of two independent assessment techniques. Indeed, S. flavidus is one of the rockfishes which is most amenable to hydroacoustic estimation.

2.2.3.3 Recommendation

A TAC of 3,000 t is recommended for S. flavidus in Areas 5A-5B, but the fishery should be reviewed as the catch nears 2,500 t, particularly as regards exploitation by gear type.

2.2.4.1 Hecate Strait (Areas 5C and 5D)

S. flavidus has only recently attained any significance in landings from Hecate Strait, where it is now caught only by Canadian vessels. Prior to 1976, trawl landings averaged <40 t/yr. Effort for S. flavidus has increased considerably since 1976 (100+%) however, this species is caught primarily as an incidental to the pollock fishery. Qualified effort (25%) in 1978 was less than 15% of the total effort expended when S. flavidus was caught. Some directed fishing for this species began in 1979, in Area 5C. Qualified CPUE has remained relatively steady since 1976.

2.2.4.2 Condition of resource and assessment for 1980

S. flavidus remains largely an incidental fishery in Hecate Strait although directed effort in Area 5C is increasing somewhat. Despite increasing effort and catch, both the unqualified and the qualified (25%) CPUE have remained relatively stable since 1976, particularly in Area 5D where the majority of the catch originates.

Size and age composition of the stock have not altered significantly since 1976; the fishery is based primarily on the 1960 year-class with the 1965 and 1966 year-classes as secondary components. Age samples from the commercial fishery indicate that the species is approximately 8-10 yr old before it recruits to the fishery in this area. As yet, research samples are insufficient to determine at what age the fish may be recruited to the fishing grounds.

In view of this limited evidence, controlled growth of this fishery would appear possible but attention should be directed toward Area 5D and in particular to changes in statistics of the qualified fishery for evidence of increases in the directed fishery for this species.

2.2.4.3 Recommendation

A TAC of 450 t is recommended for S. flavidus in Areas 5C-5D, with the acknowledgment that this is based on and pertains primarily to Area 5D.

2.2.5.1 Condition of the resource and assessment for 1980 (Area 5E)

There is no fishery of significance for S. flavidus on the west coast of the Queen Charlotte Islands. There are, however, substantial concentrations of rockfishes in depths <200 m; in other areas, S. flavidus is present in such depths but generally where there is a wider shelf area. The lone sample of aged fish from Area 5E suggests no recent history of exploitation; dominant year-classes in increasing order of abundance are 1938, 1943, 1958, and 1964. The oldest year-classes are present in the Hecate Strait fishery but are absent from Areas 5A-5B and 3C, where the exploitation history of this species is longer.

In view of the rapidly evolving nature of the fishery in this area, particularly with regard to new gear types, a provisional TAC would be a desirable safeguard.

2.2.5.2 Recommendation

A provisional TAC of 200 t is recommended for S. flavidus in that part of Area 5E south of 54°00'N. North of 54°00'N a TAC of 400 t is recommended which includes all species of rockfish (Sections 1.4.2-1.4.4).

2.2.6.1 Foreign catches (coastwide)

Except as noted previously for the Polish fleet in Area 3D, the incidence of S. flavidus in foreign catches has been relatively minor. This has been largely a result of targetting on S. alutus in deep water; the overlap of depth range for these two species is very small. The incidence of S. flavidus in foreign catches is primarily an inferred conclusion because it was only subsequent to 1976 that accurate species composition data of rockfishes in foreign catches were obtained. The only significant quantities of S. flavidus landed in 1977 were from Sub-zone 5-2 (Area 3C) in the hake fishery. There were no records of S. flavidus catch by foreign (non-North American) vessels during 1977 in Sub-zones 5-5 or 5-4 (i.e. to seaward of Queen Charlotte Sound, Areas 5A and 5B, and off the Queen Charlotte Islands and Dixon Entrance, Area 5E).

2.3 Sebastes pinniger (Canary rockfish)

2.3.1 Summary of catch statistics

The exploitation of S. pinniger has been almost exclusively undertaken by North American trawlers, mainly because the depth distribution of the species places it well within territorial waters. North American landings, effort (where known) and CPUE for this species are presented by major area in Table 2.3). In lieu of more detailed information, the same segregation of stocks as was proposed for S. flavidus will be adopted here, i.e. 3C, 3D, 5A-5B, 5C-5D, and 5E.

2.3.1.1 Southwest coast of Vancouver Island (Area 3C)

Landings of S. pinniger from this area have always been minor except in 1977 when 120 t were recorded. Approximately one-half of this total was taken from south of the present Canada-U.S. boundary, so that catches from traditional Canadian fishing areas have not markedly changed. Lowered landings in the early 1970s may have been the result of market conditions rather than stock abundance changes, since the increased CPUE of more recent years has been associated with increased effort (Table 2.3).

United States catches averaged approximately 450 t/yr during 1967-71, but decreased in the early 1970s. Landings recovered in 1975 and 1976; 1977 catches were obtained under fishery restrictions, but CPUE fell some 54% with the same nominal effort being expended. In 1978, catches were again governed by an overall rockfish quota; CPUE increased dramatically but only with an accompanying dramatic decrease in effort. Catches were obtained under fishery restrictions (early closure upon attainment of the TAC for all rockfishes) and may not accurately reflect stock conditions.

2.3.1.2 Condition of resource and assessment for 1980

As was the case with S. flavidus, the majority of the landings in Area 3C originate south of the median line and the largest proportion of the stock thus comes under U.S. management control. Nonetheless, a total stock examination is required before delimiting a Canadian zone TAC.

The 1977 U.S. trawl survey in the U.S. segment of Areas 3B-3C estimated a biomass of 19,940 t \pm 168% of S. pinniger. The best estimate of M for the species is 0.2. Applying the rationale of $EY = M \times \text{Equilibrium Biomass}$ would then result in an estimated equilibrium yield of 2,000 t (if the fishery had not significantly reduced N_0) for the U.S. part of Areas 3B-3C. In contrast to this estimate is the decreasing CPUE trend noted in the early years of the fishery at a catch level substantially below that suggested by the biomass survey. It would thus be prudent to heed evidence provided by the fishery when assessing the validity of the 2,000 t TAC. These data infer that a catch level of ~600 t/yr was not sustainable.

Catch statistics of the fishery in Areas 3B-3C have showed a general decline in the CPUE of the U.S. fleet, which is responsible for the

majority of the fishery. Regression of CPUE on U.S. cumulative catch results in a virgin biomass estimate of 8,760 t from which a sustainable yield should be approximately 880 t. Such an analysis is not entirely satisfactory however, considering that the observed decreases in CPUE resulted from catches less than 500 t/yr. The primary shortcoming of the analysis is a poor estimation of cumulative catch and the subsequent error of population estimation, because rockfish catches were not always identified to species.

Biological data for S. pinniger in Area 3C are almost totally lacking as commercial samples were obtained only in 1967 and 1975. The size frequencies such as they are, suggest that the increased catches of 1975 may have resulted from the recruitment of a relatively stronger year-class to the fishery. This may only be a reflection of bathymetric size segregation, however, since the two samples were from markedly different depths.

Summarizing, available data suggest three EYs for S. pinniger in Areas 3B-3C: about 2,000 t as estimated from the 1977 biomass survey; 880 t from a regression analysis; and less than 600 t from a review of the trends within the fishery. Decreases in CPUE observed in the fishery argue that the first EY estimate is excessive. It is concluded that the EY estimated through regression is probably closer to the appropriate value but is still too high when viewed in light of observed trends of catch statistics. The most appropriate EY of present stock levels is thus estimated to be between 500-600 t/yr. As was the case with S. flavidus, only a segment of this yield would be obtainable from Canadian waters.

2.3.1.3 Recommendation

A TAC of 100 t is recommended for S. pinniger in the Canadian segment of Area 3C.

2.3.2.1 Northwest coast of Vancouver Island (Area 3D)

This area has traditionally produced the majority of landings by the North American fleet. Total landings peaked in 1970 and have declined erratically since then, with 1977 landings being the lowest on record, because of the aforementioned fishery restrictions. Canadian participation in this fishery has achieved significant levels only since 1976. The proportion of S. pinniger in the U.S. landings from Area 3D has undergone a progressive and substantial reduction since 1974, but rebounded in 1978 to the highest level on record.

The fishery in the 3D area was managed under quota in 1978 and U.S. vessels caught approximately 94% of the quota.

2.3.2.2 Condition of resource and assessment for 1980

In this area, which has consistently yielded a major portion of the S. pinniger production off B.C., changes have taken place in recent years which give rise to some concern about the health of the stock. In particular, the decline in the proportion of S. pinniger in U.S. landings of

"shelf" rockfish as well as the absolute decline in catch and nominal CPUE, concomitant with decreased effort, indicates the possibility of a decline in stock abundance. Over the same period however, Canadian catch and CPUE has been increasing; catch and CPUE declined in 1977 and 1978 while fishery restrictions were in effect. The U.S. fishery in the 3D area during 1978 produced a major change from the previous year in the CPUE of the U.S. fleet; CPUE, at 0.910 t/hr was more than ten times that of 1977.

Preliminary 1979 data show a continuation of the trend of decreasing qualified CPUE for the Canadian fleet. Qualified (25%) CPUEs for the 1977-79 period are 1.34, 0.80, and 0.51 t/hr, respectively. While the Canadian segment of the catch is generally smaller than that of the U.S., these decreasing CPUE values for the Canadian directed fishery are cause for some concern. Incomplete data from the U.S. fishery in 1979 indicate that 1978 catch rates have not been maintained and have returned to 1977 levels.

Biological data for S. pinniger in this area are minimal. The two samples from 1978 show approximately the same size composition as those from Queen Charlotte Sound and the west coast of the Queen Charlotte Islands, but are substantially different than those from Hecate Strait. No information is available from the Cape Cook ground, where the major North American fishery occurs.

Regression analysis of total catches and U.S. CPUE data predicts that the pre-1967 S. pinniger population in this area was approximately 5,200 t and a concomitant EY of about 500 t/yr. Landings have never been this high, except in 1978, yet there have been some indications of decreased stock abundance. The 1978 U.S. fishery does provide some contrasting evidence but since the level of estimated CPUE for this fleet in 1979 is approximately the same as in 1977, any conclusion of increased stock abundance appears unfounded. Indeed, a 1978 biomass survey which produced only partial coverage of the Cape Cook region (where the major fishery occurs) suggested a yield of about 200 t/yr.

2.3.2.3 Recommendation

A TAC of 500 t is recommended for S. pinniger in Area 3D. This value is below the most recent catch because of observed decreases in catch and CPUE.

2.3.3.1 Queen Charlotte Sound (Areas 5A and 5B)

Historical North American landings of S. pinniger from Queen Charlotte Sound reached a maximum of 944 t in 1968 and have never approached this level in recent years, despite levels of effort well in excess of that expended in 1968. Canadian landings have been increasing steadily since 1975 and reached a maximum in 1978. Preliminary 1979 data indicate that the catch will probably exceed the 1978 value for the Canadian fleet.

Changes in U.S. landings of S. pinniger are, in part, inversely correlated with those of S. flavidus in the same area. It is possible that some substitution of species occurs so that catch levels are maintained. While a total rockfish TAC was in effect during 1977, the actual TAC was

undersubscribed, i.e. the decreased U.S. catch of S. pinniger in 1977 was not a result of restriction of U.S. effort. The U.S. fishery in the Canadian zone was terminated in June of 1978 through a breakdown of the reciprocal fishing agreement.

2.3.3.2 Condition of the resource and assessment for 1980

While catches of S. pinniger in Queen Charlotte Sound have never regained the peak level of 1968 (943 t), there was no indication of changes in the stock until 1977 when Canadian and U.S. CPUE decreased. The decrease was moderate for the Canadian fleet but substantial (-84%) for the U.S. fleet. Catch and effort data of the 1978 fishery provide only a partial picture of the fishery since U.S. effort was terminated prior to the time in the year when the U.S. fleet traditionally applied the majority of its effort. Total effort decreased by 52% while Canadian unqualified CPUE increased by 88% and qualified (25%) CPUE increased by 47%. Preliminary 1978 U.S. data indicate that S. pinniger constituted less than 1% of the U.S. shelf rockfish catch during 1978. Thus although Canadian CPUE increased substantially in 1978 it did not increase disproportionately with the decrease in total effort. Indeed, if the preliminary U.S. data are borne out, then the observed increase of Canadian CPUE is totally an artifact of decreased effort and, considering the lack of a directed U.S. fishery for S. pinniger, may possibly conceal a decrease in abundance.

Some corroboration to the foregoing is provided by the preliminary data of the 1979 fishery. While unqualified CPUE of the Canadian fleet is up some 45%, that of the directed fishery (25% qualification) has decreased by 14%. U.S. nominal CPUE for S. pinniger is almost identical to that of 1977. In summary, the catch-effort statistics of the fishery for S. pinniger in Queen Charlotte Sound do not provide any conclusive evidence of increases in stock abundance, despite increased levels of CPUE. It is quite possible that stocks have decreased but the decreases are masked by compensatory changes in fishing effort.

Biological data for S. pinniger in Queen Charlotte Sound are minimal and restricted to 1978. Major production of the stock is presently centered on the 1952 and 1955 year-classes with secondary contributions from the year-classes of 1961 and 1962. An extremely strong 1952 year-class is typical of other rockfish species in this area, particularly S. alutus. That this year-class remains a major component of the S. pinniger stock while it is now inconsequential in the S. alutus stocks supports the view that S. pinniger has not been exploited as heavily as S. alutus.

2.3.3.3 Recommendation

A TAC of 500 t is recommended for S. pinniger in Areas 5A-5B in the aggregate. This fishery should be closely monitored for the persistence of catch rates observed in 1978 and 1979.

2.3.4.1 Hecate Strait (Areas 5C and 5D)

Landings of S. pinniger from Hecate Strait are primarily incidental to those of other species. Pre-1978 landings never exceeded 25 t/yr, but the fishery in south Hecate Strait (Area 5C) showed evidence of considerable development during 1978. Landings of approximately 100 t were nearly seven times those of 1977. Directed fishing was concentrated in the area of the Horseshoe Ground. Preliminary 1979 data indicate that directed fishing may not be maintainable, with only 35 t landed by mid-July.

2.3.4.2 Condition of resource and assessment for 1980

The incidental nature of the historical fishery for S. pinniger and the consequently small landings preclude detailed analysis. The increase in the directed fishery which occurred in 1978 can simply be noted as evidence that potential for a directed fishery exists.

Biological data on S. pinniger in this area are limited, but available samples provide such a striking contrast with those from all other areas that their implication should be considered. The size composition of the species in samples from Areas 3C, 3D, 5A-5B, and 5E all show major modes in the 51-55 cm range. By contrast, the 1978 samples from Hecate Strait exhibit major modes in the 41-43 cm range with almost no contribution from the larger sizes observed in other areas. In addition, the sex ratio of the Hecate Strait samples averages 55% males whereas that from Queen Charlotte Sound and Vancouver Island averages approximately 74% males. The presence of these smaller and younger (if growth in Hecate Strait is similar to other areas, these fish would be 12-13 yr old in 1978) fish with the absence of older fish, in an area where there has been no history of heavy exploitation, warrants closer examination. Consideration of these data strongly suggests that the south Hecate Strait area is the rearing area from whence populations in Queen Charlotte Sound, at least, are recruited. Obviously, further study is required to determine if this area is a sensitive one with regard to juvenile rockfishes. In the meantime exploitation should be approached cautiously.

2.2.4.3 Recommendation

A TAC of 150 t is recommended for S. pinniger in Areas 5C-5D.

2.3.5.1 West coast of Queen Charlotte Islands (Area 5E)

The catch of S. pinniger in this area is very small, incidental to directed fisheries for S. alutus and S. reedi. Catches are not expected to rise dramatically until the fishing fleet is able to target in shallow water areas of higher S. pinniger abundance.

2.3.5.2 Condition of the resource and assessment for 1980

The fishery for S. pinniger is primarily incidental to that for S. alutus and S. reedi. As noted previously, increase in landings of

S. pinniger may occur with development of a shallow (<180 m) water fishery either through location of areas suitable to trawling or exploitation with different gear types. Large concentrations of what are presumed to be rockfishes have been located in depths where S. pinniger is found in other areas. The biomass surveys in Area 5E have not sampled in depths where S. pinniger is normally found.

2.3.5.3 Recommendation

A TAC of 200 t is recommended for S. pinniger in that segment of Area 5E south of 54°00'N. North of 54°00'N a TAC of 400 t is recommended which includes all species of rockfish (Sections 1.4.2-1.4.4).

2.3.6.1 Coastwide foreign catches

S. pinniger is a very minor component of foreign catches, largely because fishing has occurred at depths below the range where S. pinniger is most abundant. In 1977, only the hake fishery in management Sub-zone 5-2 (Area 3C) produced enough S. pinniger (incidentally caught) to make up even 0.1% of the total catch.

2.4 Sebastes brevispinis (Silvergray rockfish)

2.4.1 Summary of catch statistics

As is the case with most rockfish species in Canadian waters, a directed fishery for S. brevispinis was initiated by U.S. vessels in the mid-1960s. Significant Canadian participation did not occur until the early 1970s. While historical landings by North American vessels were substantial in some areas, it is only in the most recent years that major increases in landings have occurred in most areas. Catch statistics by major areas are presented for the North American fleet in Table 2.4.

2.4.1.1 Southwest coast of Vancouver Island (Area 3C)

Aggregate North American landings were minor (<100 t/yr) until 1977 when 644 t were landed; 626 t by U.S. vessels operating in Areas 3B-3C as a whole. The majority of this catch was from south of the Canada-U.S. boundary region. Canadian catches of S. brevispinis in Area 3C have always been small and incidental to other species.

2.4.1.2 Condition of resource and assessment for 1980

It is extremely difficult to assess the condition of the stock of S. brevispinis in Areas 3B-3C, because there is essentially only two years of data for directed fishing and the majority of the landings came from waters under U.S. jurisdiction. Canadian landings in Canadian waters are very small and will probably remain so. The two years of U.S. data show

relatively high CPUE values and stocks may well be healthy. No biological data for S. brevispinis in this area have been obtained.

2.4.1.3 Recommendation

A TAC of 100 t for S. brevispinis in the Canadian segment of Area 3C is recommended.

2.4.2.1 Northwest coast of Vancouver Island (Area 3D)

U.S. landings of S. brevispinis from this area have been erratic and without evidence of trends. Peak landings occurred in 1969 (320.6 t) and have since fluctuated around the 250 t/yr level (Table 2.4). The 1977 catch by the U.S. fleet was only 18.4 t despite over 1,000 hr of nominal effort for shelf rockfish; the CPUE value of the U.S. fleet was also the lowest on record. While the U.S. data may show strong indications of stock changes the fishery restrictions in effect for part of 1977 (early closure upon attaining the TAC) may have had some effect on catches. The 1978 U.S. fishery showed a very small percentage of S. brevispinis in the shelf rockfish catch; preliminary 1979 data indicate that the species is much more prominent in the catch than in previous years.

Canadian catches have always been minor (usually <10 t/yr) and incidental to other species. While landings doubled in 1978, they were less than 21 t and provide little information of use in assessment.

2.4.2.2 Condition of resource and assessment for 1980

Total landings from Area 3D prior to 1977 show no signs of major changes in stock biomass. There is however, a direct correlation between nominal effort and CPUE. Such situations would normally suggest that the production system is close to maximal exploitation, however the interpretation here is complicated by the fact that species-specific effort for U.S. catches is unavailable. The observed changes may thus be simply an artifact of directed fishing for other shelf rockfish species. Unfortunately, this problem must remain largely unresolved until more details of the U.S. fishery are available. The substantial drop in CPUE for S. brevispinis in the area from 1976 to 1977 is an example of the foregoing since it is evident that the U.S. fleet targetted primarily on S. brevispinis during 1976 and on S. pinniger in 1977. The preliminary data from 1979 indicate that S. brevispinis is again one of the major catch components, with the consequent increase in CPUE. It is evident that CPUE based on nominal (i.e. all effort for shelf rockfishes) effort is an extremely insensitive indicator of stock changes when species composition of catches has high variance.

While Canadian CPUE (species-specific) increased markedly in 1977, the amount of effort is small. The subsequent 1978 fishery was considerably larger, with a concomitantly lower CPUE; both qualified catch and CPUE were substantially reduced during 1977-1978. Canadian effort for S. brevispinis in this area in 1979 has returned to pre-1978 levels, as has CPUE.

The exploitation of S. brevispinis is of special concern because its growth rate is extremely low relative to those species it is caught with (S. flavidus, S. paucispinis); estimates of k , the von Bertalanffy growth completion rate, obtained for Canadian waters in 1978 are 0.09 for S. brevispinis vs. 0.17 for S. flavidus and 0.15 for S. paucispinis. The successful optimization of yield from S. brevispinis is therefore critically dependent upon the degree of intermixing with other, faster-growing species. The lack of species-specific effort data from the U.S. fleet assumes major significance in light of the shifting of effort among these species. For this reason a provisional catch limit which will allow the fishery to continue in a controlled manner would be advisable.

The 1978 biomass survey of part of Area 3D suggests a yield of approximately 200 t although the survey did not attain full coverage of the area.

2.4.2.3 Recommendation

A TAC of 200 t for S. brevispinis in Area 3D is recommended. While it is below historical catches, a cautious approach is warranted by recent trends in CPUE, particularly with regard to the problems of interpreting U.S. data.

2.4.3.1 Queen Charlotte Sound (Areas 5A and 5B)

Queen Charlotte Sound has been the area of highest annual production of S. brevispinis by the North American fleet. The fishery was primarily conducted by U.S. vessels until 1976 when Canadian markets for this species became stronger. Peak U.S. landings of 1,164 t occurred in 1969 and have never returned to that level, but rather, have fluctuated around 300 t/yr (Table 2.4). An increase occurred in 1976 which was not sustained through 1977. The 1978 fishery recorded less than 1% S. brevispinis in the catch. Preliminary 1979 data indicate that the species is slightly over 10% of the total rockfish catch.

Canadian landings have increased steadily since 1975, with the 1978 landings being the highest on record. The 1979 fishery does not indicate this level of catch will be maintained.

2.4.3.2 Condition of resource and assessment for 1980

The stock of S. brevispinis in the Queen Charlotte Sound region has undergone the heaviest exploitation. Data from the U.S. fishery indicates some inverse correlation between nominal fishing effort and CPUE. The peak landings of 1969 were followed by decreased CPUE, despite decreased effort in 1970. Thereafter, the CPUE fluctuated inversely with effort by the U.S. fleet. Interpretation is complicated by a lack of species-specific effort by the U.S. fleet.

Canadian CPUE has fluctuated around the level of 0.080 t/hr until 1978 when it rose to 0.178 t/hr. The 1978 increase may be in part owing to the decrease in total fishing pressure with the exclusion of the U.S. fleet

in mid-June. Qualified (25%) catch and CPUE for Canadian vessels also increased in 1978, over those of 1977. Preliminary 1979 data show decreases in both unqualified and qualified CPUE however, the declines are modest and will possibly be offset by those of the major fishery beginning in August. This situation should be monitored closely for indications of further declines.

Catch statistics indicate that the S. brevispinis stock in Queen Charlotte Sound may be close to maximal exploitation. Biological data from this fishery are limited; age composition of the catch is dominated by the 1958 year-class with little evidence of stronger incoming year-classes.

If we assume the same rationale regarding EY as was previously used and if $M = 0.1$, then the average yield for 1967-77 of 580 t/yr implies a virgin biomass of approximately 11,600 t. This may be a somewhat conservative estimate due to the effects of averaging yields, however it is probably not excessively so since peak yields in this area were followed by decreases in nominal CPUE. Recent increases in CPUE need to be verified by a fishery applying similar effort as in previous years.

In summary, the stock of S. brevispinis in Queen Charlotte Sound may be maximally exploited. Average yield of past years has been approximately 580 t/yr and a catch limit of about this magnitude would seem advisable.

2.4.3.3 Recommendation

A TAC of 600 t for S. brevispinis from Areas 5A-5B is recommended for 1980.

2.4.4.1 Hecate Strait (Areas 5C and 5D)

Canadian landings from Hecate Strait were mainly incidental to other fisheries until 1976 when more directed fishing began to occur. Prior to 1976 landings averaged less than 30 t/yr. 1977 and 1978 catches were almost identical and CPUE was directly proportional to fishing effort. Preliminary 1979 data show a substantial reduction in catch and CPUE, however the fishery is not generally prosecuted until the August-October period.

2.4.4.2 Condition of resource and assessment for 1980

The fishery for S. brevispinis in Hecate Strait is a relatively recent one in terms of directed fishing effort. While 1971 and 1972 saw catch rates of about 0.20 t/hr, landings were still below 100 t/yr and subsequent years did not produce similar yields. In 1976, the fishery appeared to develop, with a seven-fold increase in species effort and an order of magnitude increase in CPUE. 1977 and 1978 data indicate that catch statistics are almost entirely dependent on the degree to which the fleet can or will target on this species. As yet, there is no evidence of a detrimental effect of the fishery on the stock.

Hecate Strait is one of the very few areas where even small amounts of historical biological data are available for rockfishes. Two size frequency samples for the White Rocks Ground in 1972 show similar frequency distributions with the major size mode at 55-57 cm. Both distributions are characterized by a relatively narrow range. A similar distribution is evident in samples taken in 1977 from the same areas although the data suggest that a slightly stronger year-class may be recruiting to the fishery. All samples appear to be multi-modal with a single major mode. The 1978 samples, by contrast show a relatively stronger minor mode and in one case (White Rocks 88-95 m, 27/7/78) shows a major mode at 44 cm. Age compositions of these samples show an extremely broad range of ages with significant contributions from the 1948, 1954, 1958, 1961, and 1962 year-classes. The species appears to begin recruiting to the fishery at about age 12. The 1960 and 1962 year-classes should be closely monitored for changes in relative abundance which are disproportionate to natural mortality.

In the absence of any indications of lowered stock abundance, a catch limit larger than the free-fishery catch of recent years would permit development of the fishery under somewhat controlled conditions.

2.4.4.3 Recommendation

A TAC of 300 t for S. brevispinis in Areas 5C-5D is recommended.

2.4.5.1 West coast of the Queen Charlotte Islands (Area 5E)

S. brevispinis landings from the west coast of the Queen Charlotte Islands have primarily been incidental to directed fisheries for S. alutus and S. reedi. As such, fishery statistics are extremely insensitive indicators of stock trends. While qualified (25%) catches are small, qualified CPUE has increased since the inception of the fishery (Table 2.5). As with S. flavidus and S. pinniger, the dominant fishery in the area is not prosecuted at depths where S. brevispinis is found abundantly in other locations.

2.4.5.2 Condition of resource and assessment for 1980

The limited amount of information available on S. brevispinis in Area 5E does not indicate any stock problems created by the currently developing fishery. Indeed, the major portion of the stock would be expected to be slightly shallower than the range of the current fishery. Biological samples taken in 1978 tend to support this, at least in terms of the size of fish encountered at various depths; although there may be some confounding effects of location.

The 1978 and 1979 biomass surveys could not sample in depths where this species is found in highest abundance, however catch rates were inversely proportional with depth in all regions. Highest catch rates were obtained at the shallowest depth sampled.

The extrapolated data presented on foreign catches off the Queen Charlotte Islands (Table 2.6) indicate that a yield of 276 t/yr was probably sustained from the northern segment of Area 5E. It is probable that a yield in excess of this value would be possible for the entire area, although developments of new fisheries would necessitate careful monitoring. In setting a catch limit, the low growth rate of S. brevispinis does counsel a certain caution.

2.4.5.3 Recommendations

A TAC of 350 t is recommended for S. brevispinis in that part of Area 5E south of 54°00'N. This is a provisional value which will be reviewed if a fishery is initiated in shallower water. North of 54°00'N, a TAC of 400 t is recommended which includes all species of rockfish (Sections 1.4.2-1.4.4).

2.4.6.1 Coastwide foreign catches

The catch of S. brevispinis by foreign vessels is very difficult to determine because of the inadequate species identification in reports by foreign nations. In 1977, the percentage of S. brevispinis in the Japanese trawl fishery in Area 5E (Management Sub-zone 5-5) was estimated to be 8.3% of the total rockfish catch, or approximately 166 t. Off Queen Charlotte Sound, the estimated catch was approximately 17 t. It is not entirely appropriate to apply these percentages to the historical reports of "Other rockfish" by foreign nations for two reasons: (a) the areas of fishing by foreign fleets are believed to have changed over time in response to depletions of target species in traditional areas of abundance; and (b) the species composition of the category "Other rockfish" is not consistent among or within nations. The only nation for which detailed area breakdown of catches where S. brevispinis would be caught is Japan. A suggested historical incidence of this species in Japanese catches off the Queen Charlotte Islands and Queen Charlotte Sound is contained in Tables 2.6 and 2.7, respectively. Catches of S. brevispinis might thus have averaged 275 t/yr in Sub-zone 5-5 and 87 t/yr in Sub-zone 5-4. This species is not normally encountered in the hake fishery off Vancouver Island and since no observations have been made of trawl fisheries for other species in this area, it is not possible to estimate S. brevispinis incidence.

2.5 Sebastes reedi (Yellowmouth rockfish)

2.5.1 Summary of catch statistics

The fishery for S. reedi in Canadian waters has been a relatively minor component of total rockfish landings by North American trawlers, except for occasional large catches in Queen Charlotte Sound, until 1977. With the development of a rockfish fishery in Area 5E, more attention has been focused on this species. There are only two areas of significant catches of S. reedi (Areas 5A-5B, and 5E).

2.5.1.1 Recommendation (Areas of minor importance)

A nominal TAC of 50 t is recommended for S. reedi in each of Areas 3C, 3D, and 5C-5D.

2.5.2.1 Queen Charlotte Sound (Areas 5A and 5B)

Landings of S. reedi from Queen Charlotte Sound have been erratic although catch rates have generally been high (Table 2.8). While a certain amount of the species is caught incidentally in the S. alutus fishery, the major portion of the stock appears to lie over rougher bottom areas than S. alutus, which accounts for the inconsistent directed effort for it. The area around Triangle Island at the mouth of Goose Island Gully is the area where major catches have occurred, mainly with the use of midwater gear. There was also some development of a S. reedi fishery in Mitchell's Gully in 1978. While catches were lower in 1978, CPUE was relatively similar. Preliminary 1979 data indicate lower landings of S. reedi and almost all resulting from incidental catches.

2.5.2.2 Condition of the resource and assessment for 1980

Landings of S. reedi from Queen Charlotte Sound by the Canadian fleet have been somewhat erratic. No estimates of U.S. landings are available by area, but they might logically be expected to average approximately 250 t/yr from 1973-77. By far the major impact on the stock of S. reedi in and off Queen Charlotte Sound has been made by non-North American trawlers. Average removals of S. reedi during 1971-77 by Japan were estimated to be over 1,800 t/yr. Historical landings may have been as high as 2,700 t although the fishery for S. alutus may not have encountered as much S. reedi when the target species was more abundant.

In view of the fact that both the North American nominal CPUE for S. reedi and the foreign CPUE for "ocean perch" have been decreasing relatively steadily, there is a strong possibility that stock biomass is also decreasing. In addition, there are other indications of lowered stock abundance in Areas 5A-5B. All of the landings of S. reedi in Queen Charlotte Sound during 1977 came from Area 5A and 99% of these were included in the qualified catch (331.3 t) and CPUE (1.46 t/hr). By contrast, in 1978 90% of the catch came from Area 5B and almost all of that (89%) was included in the qualified catch. CPUE was approximately the same although fishing effort was down substantially from the previous year. Preliminary 1979 data indicate lower catch rates and the majority of the catch originating in Area 5B. While CPUE values are lower the lack of any qualified catch in Area 5B implies that no directed fishery has occurred. Historical data such as they are, suggest that localized depletions may have occurred.

Biological samples from the area are limited to size frequencies and one year of age frequency from commercial catches. The fishery is prosecuted on relatively few age-groups (17, 18, 16, and 20 in 1978 by order of abundance); fish appear to begin recruiting to the fishery at age 12. While a narrow spectrum of ages in the exploited stock may not be highly

desirable in rockfishes, it should be noted that the size frequency associated with the 1978 age-composition was similar to that exhibited in this area in 1966. It is possible therefore that the present age composition is primarily a function of the natural process of recruitment to the fishable stock rather than of exploitation history. The all-nation decrease in CPUE recorded or implied for S. reedi in Areas 5A-5B taken with the inference of dislocation of fishing effort from areas of relatively high production, suggests that historical levels of catch (ca 1,800-2,700 t) are not sustainable from the present biomass.

The October 1978 hydroacoustic biomass survey to Queen Charlotte Sound produced an estimate of 2,000 t of S. reedi off Triangle Is. While such a biomass might suggest an equilibrium yield of approximately 300 t, the history of the fishery for this species, with its large removals must be considered when recommending a TAC.

2.5.2.3 Recommendation

A TAC of 250 t for S. reedi in Areas 5A-5B is recommended, of which the limit is 200 t for waters outside the fishery closing line.

2.5.3.1 West coast of the Queen Charlotte Islands (Area 5E)

The fishery in this area developed in very late 1976. Catches of S. reedi in 1977 were 1,257 t and represented almost one-half of the rockfish landings from the area (Table 2.8). Landings dropped 23% from 1977-78 in spite of considerable diversification of the fishery. Landings continued to drop in 1979 and the three major fishing areas were closed in July 1979 out of concern for the impact of such large removals on subsequent yields.

2.5.3.2 Condition of the resource and assessment for 1980

Stock assessment off the west coast of the Queen Charlotte Islands was conducted in two ways: (i) analysis of the statistics of the commercial fishery; and (ii) biomass surveys using commercial vessels and gear.

In a previous analysis it was noted that the CPUE for S. reedi in Area 5E had fallen by 22% during 1977-78 with almost identical effort. The maintenance of CPUE was largely a result of diversification of the fishery to new grounds in 1978. The decrease in CPUE for the same fishing areas during the two years was 27%. Qualified (25%) catch dropped 41% along with a drop of 40% in qualified effort, while the qualified CPUE remained the same (Table 2.9). If CPUE is proportional to stock abundance then the 1977 removals were somewhat in excess of what the stock might sustain. Preliminary 1979 data indicate decreases in both the unqualified and qualified CPUE for S. reedi, 20% and 25%, respectively.

Regression analysis of the Canadian commercial fishery data suggests a pre-1976 biomass of S. reedi in Area 5E of approximately 5,700 t. If the biomass were to be treated as a virgin population then the EY might be approximately 430 t/yr. It is probable, however, that some of this stock had been previously fished by foreign fleets but whether the virgin biomass was significantly reduced is unknown. In view of this, CPUE analysis suggests that the EY of S. reedi in Area 5E would lie in the 430-855 t/yr range.

Two biomass surveys using commercial data have been conducted in this area. The first survey (1978) was designed to identify concentrations of fish and provide gross biomass estimates. The second survey (1979) utilized the information from the first survey to more accurately design the sampling pattern and thereby minimize the errors inherent in a swept-area biomass calculation. This second survey estimated the biomass of S. reedi at the three major fishing locations as 7,880 t. Confidence limits for this estimate have yet to be accurately determined (largely because the application of normal theory is not appropriate to this catch rate distribution) however, they may be as high as 40-50% for some areas. If this estimate were to be treated as a desirable standing stock then the EY might be as high as 1,180 t/yr. The exact EY of S. reedi on this area is dependent to some degree upon the relationship between present biomass and the theoretical maximum biomass, B_{∞} , for the area, since present theory holds that maximum production from the stock would occur at a stock level equal to $B_{\infty}/2$.

Combining the results of these two assessment methods suggests either that the biomass survey overestimated the abundance of S. reedi or that there were significant removals of the species by foreign fleets prior to 1976. The latter is impossible to determine but may be true; the former is possible but close agreement between 1978 and 1979 estimates, even given the better design in 1979, lends some confidence to the figures. A guiding consideration, however, should always be the extremely sensitive nature of rockfish species to overexploitation. For this reason the recommended yield of this species should consider the results of both of these analyses. In addition, since S. reedi is fished jointly with S. alutus the TAC must also consider the conservation needs of that species.

2.5.3.3 Recommendations

A TAC of 800 t for S. reedi in that segment of Area 5E south of 54°00'N is recommended. For that segment north of 54°00'N the recommended TAC is 400 t which includes all species of rockfish (Sections 1.4.2-1.4.4).

2.5.4.1 Foreign fisheries off the west coast of the Queen Charlotte Islands (Area 5E)

Historical catches of S. reedi by foreign fleets are very difficult to estimate because of both the general problems of species segregation in foreign data and the very pragmatic problem of the inability of untrained people (including fishermen) to distinguish the species from S. alutus. Applying 1977 species compositions reported by observers to historical catches suggests an average yield of 332 t/yr from the Queen

Charlotte Islands area and 1,859 t/yr from the Queen Charlotte Sound area, by Japan, over the period 1971-77 (Tables 2.6, 2.7, respectively). It is likely that there have always been substantial catches of S. reedi as it will have been identified as S. alutus in catches.

2.6 Sebastes paucispinis (Bocaccio)

S. paucispinis has always been a minor species in the North American fishery, with landings normally being less than 550 t for Canadian waters as a whole. Market acceptance of this species appears to be higher for the U.S. fleet since Canadian vessels are generally restricted by fish companies as to the quantity they may land per boat trip. The reason for this is apparently that the high incidence of nematode parasites in the flesh of the fish require additional processing and quality control. Most of the catch comes from Area 3D (off Vancouver Island) and Areas 5A-5B (Queen Charlotte Sound) (Table 2.10). Landings of this species by foreign nations have never been of great significance, if 1977 observer reports are representative.

2.6.1.1 Southwest coast of Vancouver Island and northern Washington (Areas 3B and 3C)

Landings of S. paucispinis are very small in this region, with maximum annual total being <65 t. Catches are primarily incidental to other directed fisheries such as that for lingcod. Landings by U.S. vessels have decreased in recent years whereas those by Canadian vessels have increased.

2.6.1.2 Condition of the resource and assessment for 1980

The near total absence of directed fishing for S. paucispinis and the very low level of its incidence in other directed fisheries render assessment attempts almost futile. There are two biological samples available; one from Area 5E and one from Area 5A, both for 1978. Nonetheless, available information will be examined for evidence of any anomalous situations.

Nominal CPUE of U.S. catches has been remarkably constant over the 1967-77 period; not surprising when the incidental nature of the fishery is considered. Canadian catches increased up to 1977 but are minimal in 1978, probably because of the closure of the fishery in mid-June. Canadian CPUE has also been remarkably stable.

2.6.1.3 Recommendation

A TAC of 50 t is recommended for S. paucispinis in the Canadian segment of Area 3C.

2.6.2.1 Northwest coast of Vancouver Island (Area 3D)

There has been a traditional fishery by U.S. vessels for S. paucispinis in this area, although not a directed fishery. Landings averaged less than 100 t/yr over the 1967-76 period with peaks occurring in 1970 and 1976. Canadian landings remain very minor in the area, never exceeding 20 t/yr.

2.6.2.2 Condition of resource and assessment for 1980

While some fluctuations have occurred in recent years, the nominal CPUE of U.S. vessels in the 3D area has fluctuated around 0.040 t/hr. It is notable that the highest CPUE values are associated with the highest catches, typical of non-target fisheries. If a limit were to be placed on the catch of S. paucispinis for the 3D region, it should be at a level of highest historical catch.

2.6.2.3 Recommendation

A TAC of 200 t is recommended for S. paucispinis in Area 3D.

2.6.3.1 Queen Charlotte Sound (Areas 5A and 5B)

Queen Charlotte Sound is the major area of production for this species by North American vessels. Peak landings by U.S. vessels occurred in 1969 (657 t) and have approached that level only once in the succeeding decade. Prior to the onset of fishery restrictions in 1977, the U.S. catch of S. paucispinis averaged approximately 280 t; over the same period the Canadian catch averaged about 32 t/yr, although it has been increasing steadily in the most recent 3 years. 1978 Canadian landings were 133 t, the highest on record.

2.6.3.2 Condition of resource and assessment for 1980

In spite of the wide variance in landings of S. paucispinis there are no strong indications of changes in stock biomass due to the fishery. While CPUE has varied it displays no strong, consistent correlations with fishing effort. Qualified CPUE of the Canadian fleet continues to rise. The single sample from Area 5A shows a rather broad frequency distribution suggesting that the fishery may be based on several successive year-classes. Such a situation is generally felt to be a healthy one from a stock point of view because it infers relatively consistent recruitment and potential stability of the resource base. Catch limits if any should be at about the average level of removals in past years, and raised if the fishery continues to appear healthy.

2.6.3.3 Recommendation

A TAC of 300 t for S. paucispinis in Areas 5A-5B is recommended.

2.6.4.1 Hecate Strait (Areas 5C and 5D)

The Hecate Strait region has produced minor quantities of S. paucispinis as incidental catches to other fisheries. The peak catch of 92 t in 1974 is considerably above both recent and previous catches. 1978 landings were 54 t and were unique in that the species effort was considerably above the species effort for historical catches.

2.6.4.2 Condition of resource and assessment for 1980

From what information is available there is no sign that the stock is in danger. If a catch limit is necessary, it should be at least as high as the best catch year on record.

2.6.4.3 Recommendation

A TAC of 100 t for S. paucispinis in Areas 5C-5D is recommended.

2.6.5.1 West coast of the Queen Charlotte Islands (Area 5E)

Landings of S. paucispinis in this area are an extremely small catch (0.1%), incidental to other directed rockfish fisheries.

2.6.5.2 Recommendation

A TAC of 50 t for S. paucispinis in that segment of 5E south of 54°00'N is recommended. North of 54°00'N a TAC of 400 t is recommended which includes all species of rockfish (Sections 1.4.2-1.4.4).

2.7 Sebastes entomelas (Widow rockfish)

2.7.1 Summary of catch statistics

The North American fishery for S. entomelas is a rather recent development. Canadian landings had never risen above 10 t for the coast as a whole until 1977 (Table 2.11), when there was a major increase in the landings from Areas 3C and 5A-5B as well as first records of landings from Hecate Strait and the west coast of the Queen Charlotte Islands. Landings further increased in the latter area and in Queen Charlotte Sound during 1978. Complete information on the species composition of shelf rockfish catches by U.S. trawlers is not available, but S. entomelas is normally ranked as a minor species in this group.

Fraidenburg et al. (1977) estimated that foreign catches of S. entomelas were extremely small in the INPFC Charlotte and Vancouver Areas, never exceeding 60 t/yr during 1967-75. It was in 1975 however, that the Polish trawl fleet reported 6,125 t of S. entomelas in Area 3D⁵. The Polish fleet returned in 1976 and removed an additional 3,900 t, of which 1,364 t was S. entomelas.

2.7.2 Condition of resource and assessment for 1980

The relatively recent origin of the fishery for S. entomelas in B.C. waters, except in Area 3D, and the fact that landings in 1977 and 1978 were quite small would indicate that there are no stock problems with the species. Unqualified CPUE rose over 1977 values in all areas where a fishery continued in 1978.

The fishery in Area 3C was curtailed by restrictions imposed in May 1978 and there was therefore very little Canadian effort in 1978. Landings of S. entomelas from Area 3D are notable by their almost total absence. This is at once both logical and puzzling; the former because the large Polish removals may have severely depleted the resource and the latter because there are still catches of S. flavidus in the area despite the Polish fishery and the two species would normally be caught together. Available information suggests that the growth and mortality rates of the two species are not greatly different and therefore it would not be expected that one species would be exploited to the point of reduction while the other was not.

For the time being there seem to be no stock problems and hence no foundation for restrictions on the fishery. However, should catch limits be deemed desirable they should be set at levels which at least will not discourage fishing and hence prevent the gathering of much needed additional information.

2.7.3 Recommendations

A summary of the recommended TACs for S. entomelas is as follows:

⁵It should be noted that the identification of S. entomelas in Polish catches was never confirmed by North American scientists, although Polish biologists reportedly were aboard at least some of the 6 vessels which operated in Area 3D. They initially identified the species as S. ciliatus, but the identification was altered to S. entomelas by S. J. Westrheim, for reason that S. ciliatus is an inhabitant of northern waters with a southern limit of Hecate Strait.

Area	TAC
3C (Canadian)	100 t
3D	50 t
5A-5B	250 t
5C-5D	50 t
5E (S. of 54°N)	100 t

2.8 Sebastes proriger (Redstripe rockfish)

2.8.1 Summary of catch statistics

S. proriger has only recently become a marketable species in Canada and significant fisheries are restricted to Queen Charlotte Sound (mainly Area 5A) and the west coast of the Queen Charlotte Islands (Area 5E). There are minor landings off the west coast of Vancouver Island and in Hecate Strait (Table 2.12). Almost all of the S. proriger landed are taken incidentally to fisheries for S. alutus. As such, it would be difficult to establish a TAC unique for this species since it might seriously compromise the optimization of a more abundant resource. It is also apparent from an examination of available data, that little can be said about the condition of the resource.

The major component of the fishery for S. proriger is presumed to have been removals by foreign nations. Tables 2.6 and 2.7 present estimated removals by Japan during 1971-77 for Sub-zones 5-5 and 5-4, respectively, based upon an assumed species composition of total rockfish catches. Average removals from Sub-zone 5-5 (i.e. Area 5E) during 1971-77 were 432 t/yr while the comparable figure off Queen Charlotte Sound (Areas 5A and 5B) was 1,219 t/yr.

2.8.2.1 West coast of Vancouver Island (Areas 3C and 3D)

Hydroacoustic biomass estimates are available for S. proriger off the west coast of Vancouver Island for the period 1974-76. Using an M value of 0.1 to calculate EY, the following results are obtained, assuming no substantial reduction of N_0 :

Area	Year/Month	Estimated biomass (t)	Estimated EY (t/yr)
3C	1974 - Aug.	7,481	750
	- Oct.	10,099	1,010
	1975 - Sept.	791	80
	- Nov.	193	20
	1976 - Nov.	2,282	230
3D	1976 - Nov.	997	100

The 1974 estimate again appears anomalous relative to other years. The reservations about these 1974 data have been noted earlier (Section 2.2). While the later biomass estimates may or may not be very accurate, there are certain pragmatic constraints regarding establishing catch limits at these levels. The stock of S. alutus off Vancouver Island is known to be in a depressed condition and since the catching of S. proriger could not be accomplished without an unacceptably high incidental catch of S. alutus, catch should either be prohibited or set at a very low level.

2.8.2.2 Recommendation

A TAC of 50 t each is recommended for S. proriger in the Canadian segment of Area 3C and in Area 3D.

2.8.3.1 Queen Charlotte Sound (Areas 5A and 5B)

Catch statistics from this area show a steadily declining CPUE for S. proriger landed by the Canadian fleet. This decline could be attributed in large measure, to the removals by foreign fleets as estimated in Table 2.7. Regression analysis suggests that virgin biomass might have been as high as 9,700 t. If growth is as slow as it appears in this species, the natural mortality (M) may be as low as 0.1, in which case EY would be about 490 t. However, the yield to a North American fishery would have to be less, since the regression analysis is based on Japanese catches, which, according to observers contain substantial numbers of small fish which would not be acceptable on the North American market. The 1978 hydroacoustic biomass survey of Queen Charlotte Sound resulted in an estimate of 13,900 t of S. proriger, however 10,900 t of this total was from areas not fished by the domestic or foreign fleets (Cox Is.-Cape Russell areas). Thus the biomass of the traditionally fished stock may be as low as 3,000 t, some 2,000 t below the optimum level. If the latter is true, rehabilitation of the stock is called for and yields should be less than 490 t/yr. In any event, the catch should be geared to provide optimal protection for the potentially more valuable resource of S. alutus which cohabits grounds frequented by S. proriger.

2.8.3.2 Recommendations

A TAC of 75 t is recommended for S. proriger in Areas 5A-5B and an additional 150 t outside the Fishery Closing Line. For Areas 5C-5D, a TAC of 50 t is recommended.

2.8.4.1 West coast of the Queen Charlotte Islands (Area 5E)

The present fishery in Area 5E is distinct from the historical foreign fishery and should be dealt with individually. Both catch and CPUE have increased steadily within the fishery, and in contrast to other species. The 1979 biomass survey estimated that the biomass of S. proriger in the three major fishing areas could be as high as 2,300 t. It is notable that catch rate was inversely correlated with depth; the lone haul made in

shallow water where sizeable quantities of fish are seen was comprised primarily of S. proriger. The biomass estimate indicates EY of at least 200 t, however the shortcomings of the survey with regard to the normal habitat of the species are acknowledged.

2.8.4.2 Recommendations

A TAC of 250 t is recommended for S. proriger in that segment of Area 5E south of 54°00'N; north of 54°00'N a TAC of 400 t is recommended which includes all species of rockfish (Sections 1.4.2-1.4.4).

2.9 Sebastes aleutianus (Rougheye rockfish)

2.9.1 Summary of catch statistics

The fishery for S. aleutianus has always been a relatively minor one in Canadian waters. The only region of significant landings has been Area 5E, since the development of the rockfish fishery in this area (Table 2.13). Small annual landings (<15 t) have occurred in other areas as incidentals.

Landings of S. aleutianus by foreign fleets in Area 5E may have been well in excess of 200 t/yr if 1977 observer estimates are representative. Table 2.6 presents estimated Japanese landings in Area 5E from 1971-77. The estimated average yield of S. aleutianus thus obtained is 389 t/yr.

2.9.2 West coast of the Queen Charlotte Islands (Area 5E)

Assessment of the condition of the S. aleutianus stock off the west coast of the Queen Charlotte Islands can progress little beyond a narrative account. The present fishery is geographically distinct from the previous foreign fishery which accounted for the major removals from the area. Effective management of this species may not be possible in isolation since it is generally caught incidentally with S. alutus and S. reedi. There are, however, instances of vessels conducting directed fishing for this species in deeper (>360 m) water. It is difficult to determine whether the stock could maintain removals on the order of 389 t/yr because species-specific effort is not available for foreign catches. The CPUE of S. aleutianus in the Canadian fishery rose in 1979, but the incidental nature of the fishery for this species may preclude effective control of its harvest without reducing yield from the major fishery. If catch limits must be identified, they should be set at a level no less than current removals.

2.9.3 Recommendations

A TAC of 150 t is recommended for S. aleutianus in that segment of Area 5E south of 54°00'N; north of 54°00'N a TAC of 400 t is recommended which includes all species of rockfish (Sections 1.4.2-1.4.4).

2.10 Sebastes babcocki (Redbanded rockfish)

2.10.1 Summary of catch statistics

The Canadian fishery for S. babcocki has always been a minor incidental fishery with S. alutus and also incidental in the line fishery for halibut two decades ago. U.S. trawlers land the species as an incidental with slope rockfish catches, and it is usually designated as a trace or minor species. Individual species breakdown for U.S. slope rockfish catches are not available, however statistics of the Canadian fishery are presented in Table 2.14. U.S. vessels would be expected to obtain a similar percentage of S. babcocki in their S. alutus fishery.

There were no records of S. babcocki in the 1977 foreign trawl fishery. This may indicate that the species does not occur in the offshore deep water fishery.

2.10.2 Condition of resource and assessment for 1980

In almost all areas of capture, CPUE for S. babcocki increased in 1977, 1978, and 1979. Available biological samples (3) from Queen Charlotte Sound indicate a relatively broad size frequency base to the resource. Since there are no indications of stock problems with the species, catch limits if any, should be no less than present removals.

2.10.3 Recommendations

The following TACs are recommended for S. babcocki in 1980:

Area	TAC
3C (Canadian)	20 t
3D	20 t
5A-5B	200 t
5C-5D	75 t
5E (South of 54°00'N)	25 t

2.11 Other rockfish species

There are several other rockfish species occurring in trawl catches from B.C. waters which will not be dealt with on an individual species basis at this time. In general, these species are either uncommon or are too small for a marketable product. For species which are low in abundance, such as S. borealis and S. elongatus, the basic problem is that their abundance in trawl catches is so low that it is almost impossible to gain any insight into their population dynamics through examination of catch

statistics.⁶ Data so produced are not sufficiently precise, nor may they ever be, to detect population changes; understanding of such changes will be gained only through research programs designed to estimate the vital parameters of their populations. The very low incidence of these species in trawl catches would indicate that their effective management is precluded. The most likely prognosis for these rather slow-growing species is that they will become reduced, if not eliminated, in those areas where they co-exist with more abundant and faster-growing species. A mechanism for the avoidance of this is not evident, given the current species focus of the trawl fishery.

There are several other rockfish species which are normally too small for market acceptance; among this group are S. diploproa, S. zacentrus, and Sebastolobus alascanus. While some occur in abundance in particular areas, it is difficult to obtain information about them because they are normally discarded at sea and cannot be sampled from landings. Consequently, data on populations of these species and their dynamics can only be obtained via research vessel activities. Further, it is also difficult to assess the impact of a fishery on these species because fishing mortality rates cannot be realistically estimated without catch data and information on the quantity discarded.

ADDENDUM

The rockfish stocks in the area of Canadian waters adjacent to Queen Charlotte Sound, seaward of the fishery closing line from Cape St. James to Triangle Island, are presented here as an addendum for several reasons. Chief among these reasons is that the area represents a logical management unit and it merits attention as such. While some biological constraints to this approach do exist, they concern primarily one species and will be dealt with later.

The historical foreign fishery for rockfishes off Queen Charlotte Sound is thought to have severely reduced their biomass. The section of this document dealing with Sebastes alutus has chronicled this decline. Indeed, the 1977 discovery of the true species composition of rockfish catches on Japanese trawlers in the area implies declines in many other rockfishes beside S. alutus. The two species of major concern in this area are S. alutus and S. reedi; the yields from other species will be almost exclusively determined by those of these two major species, since they are caught concurrently.

It is believed that a deeper-water group of S. alutus exists off Queen Charlotte Sound and that this group does not take part in the observed seasonal bathymetric migration displayed by the main body of fish, exploited by domestic trawlers inside Queen Charlotte Sound. This deep-water group of

⁶S. ruberrimus is uncommon on trawling grounds but appears to be common in sheltered inshore inlets and channels, as well as untrawlable offshore areas. It is often taken on sportfish jigs and in the past at least was a common incidental species in the handline fishery for lingcod.

fish is genetically indistinct (protein isozymes) from the main body of the stock. The S. alutus returns to the Japanese fishery when it was excluded from fishing the main body of the stock imply that the size of the deep-water group is not large. In view of this it is recommended that no more than 200 t be removed from this deep-water group. In addition, it will be necessary to limit the time period over which this TAC may be fished to June-September inclusive, to avoid overlap with the main body of the stock.

For S. reedi, the 250 t identified for Queen Charlotte Sound earlier in the document can be roughly partitioned into components inside and outside the fishery closing line, based on historical distribution of the fishery for it. The domestic fishery has been prosecuted as a directed fishery only off Triangle Island and almost exclusively outside the closing line. Approximately 200 t of the 250 t TAC previously recommended could be designated as available outside the closing line. The remaining 50 t takes on a somewhat "softer" character since landings from inside Queen Charlotte Sound have been erratic.

With regard to other rockfish species, the catch levels recommended are reflective of observed percentages in landings of the two previous species.

Recommendation

In summary, the following TACs are recommended for the area of Queen Charlotte Sound (Areas 5A-5B) seaward of the fishery closing line:

Species	TAC ^a
<u>Sebastes alutus</u>	200 t
<u>S. reedi</u>	200 t
<u>S. proriger</u>	150 t
<u>S. diploproa</u>	15 t
<u>S. zacentrus</u>	75 t
<u>S. crameri</u>	20 t
<u>Sebastolobus alascanus</u>	50 t
Total	710 t

^aFishing restricted to the period June-September, inclusive.

Table 2.1. Interviewed catch (t), effort (hr) and CPUE (t/hr) of Sebastes flavidus by Canada and United States, by area, 1967-79.

Year & Nation	Area											
	3B-3C			3D			5A-5B			5C-5D		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1967 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	121.7	4,579	0.027	79.6	1,344	0.059	872.5	9,313	0.094	-	-	-
1968 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	1,081.7	7,551	0.143	16.0	1,381	0.012	281.4	8,488	0.033	-	-	-
1969 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	1,575.8	8,619	0.183	113.3	2,172	0.052	2,129.8	13,557	0.157	-	-	-
1970 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	379.9	3,637	0.104	142.1	2,978	0.048	2,568.0	9,264	0.277	-	-	-
1971 Can.	9.7	100	0.097	4.8	38	0.126	209.8	966	0.217	50.5	201	0.251
U.S.	398.0	4,934	0.081	91.2	1,825	0.050	1,805.6	7,137	0.253	-	-	-
1972 Can.	11.3	437	0.026	-	-	-	678.2	2,414	0.281	25.5	108	0.236
U.S.	416.3	4,823	0.086	115.6	1,691	0.068	2,349.4	9,224	0.254	-	-	-
1973 Can.	13.8	247	0.056	-	-	-	519.2	1,387	0.374	0.5	42	0.012
U.S.	227.3	4,182	0.054	17.3	1,613	0.011	2,837.7	9,625	0.295	-	-	-
1974 Can.	16.8	631	0.027	0.3	11	0.027	153.4	1,188	0.129	47.1	242	0.195
U.S.	123.5	5,165	0.024	111.3	1,849	0.060	924.1	8,797	0.105	-	-	-
1975 Can.	5.6	217	0.026	0.6	14	0.043	383.4	1,760	0.218	53.3	303	0.176
U.S.	124.9	10,101	0.012	89.7	2,034	0.044	379.3	5,179	0.073	-	-	-
1976 Can.	47.7	931	0.051	25.4	141	0.180	627.6	4,360	0.144	178.9	1,002	0.179
U.S.	1,024.3	12,408	0.083	3.0	1,550	0.002	341.5	4,620	0.074	-	-	-
1977 Can.	238.6	1,858	0.128	8.0	53	0.151	1,012.1	4,744	0.213	295.2	2,713	0.109
U.S.	542.3	12,464	0.044	99.4	1,037	0.096	507.1	5,165	0.098	-	-	-
1978 Can.	42.6	741	0.058	35.7	254	0.141	1,644.3	5,045	0.326	356.5	2,493	0.143
U.S.	647.8	5,033	0.129	-	-	-	484.1	927	0.522	-	-	-
1979 ^a Can.	13.6	367	0.037	4.8	38	0.128	243.2	1,265	0.192	176.9	1,293	0.137

^aPreliminary data (to July 15).

Table 2.2. Canadian qualified (25%) catch (t), effort (hr) and CPUE (t/hr) of major rockfish species (other than Pacific ocean perch) from Areas 3C, 3D, 5A and 5B in 1977, 1978 and 1979.

Species	Area 3C								
	1979 ^a			1978			1977		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
<u>S. aleutianus</u>	-	-	-	-	-	-	-	-	-
<u>S. babcocki</u>	-	-	-	-	-	-	-	-	-
<u>S. brevispinis</u>	-	-	-	-	-	-	7.75	5.00	1.55
<u>S. entomelas</u>	-	-	-	-	-	-	13.29	11.50	1.16
<u>S. flavidus</u>	0.32	4.00	0.08	12.84	29.50	0.44	188.89	82.50	2.29
<u>S. paucispinis</u>	-	-	-	-	-	-	-	-	-
<u>S. pinniger</u>	3.63	35.00	0.10	1.91	9.25	0.21	37.88	162.50	0.23
<u>S. proriger</u>	-	-	-	-	-	-	0.03	1.00	0.03
<u>S. reedi</u>	-	-	-	0.26	1.00	0.26	-	-	-

Species	Area 3D								
	1979 ^a			1978			1977		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
<u>S. aleutianus</u>	1.36	2.67	0.51	-	-	-	-	-	-
<u>S. babcocki</u>	-	-	-	0.32	0.50	0.64	-	-	-
<u>S. brevispinis</u>	1.59	9.25	0.17	1.27	7.75	0.16	9.45	23.25	0.41
<u>S. entomelas</u>	-	-	-	-	-	-	-	-	-
<u>S. flavidus</u>	2.13	8.00	0.27	14.64	15.58	0.94	6.85	28.50	0.24
<u>S. paucispinis</u>	9.53	9.83	0.97	5.14	38.33	0.13	0.46	2.75	0.17
<u>S. pinniger</u>	41.28	80.75	0.51	37.77	47.42	0.80	89.59	66.75	1.34
<u>S. proriger</u>	-	-	-	-	-	-	-	-	-
<u>S. reedi</u>	-	-	-	-	-	-	-	-	-

Table 2.2 (cont'd).

Species	Area 5A								
	1979 ^a			1978			1977		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
<u>S. aleutianus</u>	-	-	-	-	-	-	-	-	-
<u>S. babcocki</u>	3.63	6.00	0.60	14.25	9.50	1.50	-	-	-
<u>S. brevispinis</u>	48.90	154.70	0.32	285.60	603.22	0.47	56.49	115.75	0.49
<u>S. entomelas</u>	-	-	-	-	-	-	10.20	7.00	1.46
<u>S. flavidus</u>	107.09	239.00	0.45	321.85	774.25	0.42	251.04	1,114.50	0.23
<u>S. paucispinis</u>	-	-	-	34.12	59.60	0.57	10.41	31.00	0.34
<u>S. pinniger</u>	19.16	46.50	0.41	67.91	163.75	0.41	9.62	29.25	0.33
<u>S. proriger</u>	1.59	2.50	0.64	3.79	5.00	0.76	35.89	84.75	0.42
<u>S. reedi</u>	5.22	7.50	0.70	10.86	16.00	0.68	331.29	226.25	1.46

Species	Area 5B								
	1979 ^a			1978			1977		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
<u>S. aleutianus</u>	-	-	-	-	-	-	-	-	-
<u>S. babcocki</u>	-	-	-	31.81	27.00	1.18	3.25	8.50	0.38
<u>S. brevispinis</u>	70.08	148.67	0.47	144.22	329.58	0.44	62.57	176.75	0.35
<u>S. entomelas</u>	3.24	17.50	0.19	117.32	134.50	0.87	26.38	53.00	0.50
<u>S. flavidus</u>	77.72	235.51	0.33	1,106.75	1,769.45	0.63	620.02	1,557.75	0.40
<u>S. paucispinis</u>	51.26	121.25	0.42	3.32	18.00	0.18	5.15	22.50	0.23
<u>S. pinniger</u>	129.28	370.92	0.35	32.81	78.22	0.42	45.23	164.25	0.28
<u>S. proriger</u>	-	-	-	4.68	30.50	0.15	-	-	-
<u>S. reedi</u>	-	-	-	84.65	45.20	1.87	-	-	-

^apreliminary data (to July 15).

Table 2.3. Catch (t), effort (hr) and CPUE (t/hr) of Sebastes pinniger by Canada and United States, by area, 1967-79.

Year & Nation	Area											
	3B-3C			3D			5A-5B			5C-5D		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1967 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	342.1	4,579	0.075	352.0	1,344	0.262	226.4	9,313	0.024	-	-	-
1968 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	472.8	7,551	0.063	494.9	1,381	0.358	943.5	8,488	0.111	-	-	-
1969 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	495.8	8,619	0.058	557.3	2,172	0.257	455.6	13,557	0.034	-	-	-
1970 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	511.8	3,637	0.141	727.9	2,978	0.244	171.8	9,264	0.019	-	-	-
1971 Can.	51.7	355	0.146	13.6	48	0.283	18.0	365	0.049	24.7	310	0.080
U.S.	466.0	4,934	0.094	573.3	1,825	0.314	167.0	7,137	0.023	-	-	-
1972 Can.	0.2	38	0.005	-	-	-	0.4	48	0.008	1.9	77	0.025
U.S.	168.8	4,823	0.035	198.5	1,691	0.117	45.9	9,224	0.005	-	-	-
1973 Can.	-	-	-	-	-	-	29.1	116	0.251	8.1	50	0.162
U.S.	179.0	4,182	0.043	473.7	1,613	0.294	267.8	9,625	0.028	-	-	-
1974 Can.	9.9	333	0.030	3.8	59	0.064	2.5	78	0.032	-	1	-
U.S.	169.5	5,165	0.033	586.0	1,849	0.317	466.2	8,797	0.053	-	-	-
1975 Can.	6.7	178	0.038	7.0	10	0.700	21.9	390	0.056	3.2	102	0.031
U.S.	549.8	10,101	0.054	442.3	2,034	0.217	279.9	5,179	0.054	-	-	-
1976 Can.	51.8	627	0.083	137.6	157	0.876	102.6	1,538	0.067	7.5	273	0.027
U.S.	644.2	12,408	0.052	170.4	1,550	0.110	459.4	4,620	0.099	-	-	-
1977 Can.	119.8	1,766	0.068	97.0	135	0.719	123.4	2,358	0.052	15.4	412	0.037
U.S.	302.8	12,464	0.024	85.4	1,037	0.082	84.1	5,165	0.016	-	-	-
1978 Can.	14.5	254	0.057	54.1	181	0.300	262.6	2,692	0.098	101.4	701	0.145
U.S.	299.0	5,033	0.059	829.1	910	0.910	-	-	-	-	-	-
1979 ^a Can.	15.8	356	0.044	42.9	125	0.345	204.5	1,408	0.145	34.6	228	0.152

^apreliminary data (to July 15).

Table 2.4. Catch (t), effort (hr) and CPUE (t/hr) of Sebastes brevispinis by Canada and United States, by area, 1967-79.

Year & Nation	Area											
	3B-3C			3D			5A-5B			5C-5D		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1967 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	43.1	4,579	0.009	148.5	1,344	0.110	348.5	9,313	0.037	-	-	-
1968 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	24.7	7,551	0.003	161.4	1,381	0.117	799.9	8,488	0.094	-	-	-
1969 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	5.8	8,619	0.001	320.6	2,172	0.148	1,164.1	13,557	0.086	-	-	-
1970 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	38.5	3,637	0.011	297.9	2,978	0.100	269.4	9,264	0.029	-	-	-
1971 Can.	2.0	3	0.667	2.6	46	0.057	17.9	322	0.056	34.5	229	0.151
U.S.	50.6	4,934	0.010	133.9	1,825	0.073	689.0	7,137	0.097	-	-	-
1972 Can.	-	-	-	0.3	38	0.008	53.0	629	0.084	61.0	232	0.263
U.S.	12.8	4,823	0.003	371.3	1,691	0.220	350.7	9,224	0.038	-	-	-
1973 Can.	0.2	38	0.005	-	-	-	37.5	293	0.128	9.9	147	0.067
U.S.	-	4,182	-	205.9	1,613	0.128	198.4	9,625	0.021	-	-	-
1974 Can.	-	-	-	1.4	12	0.117	45.0	414	0.109	12.9	64	0.202
U.S.	-	5,165	-	217.9	1,849	0.118	336.2	8,797	0.038	-	-	-
1975 Can.	0.5	35	0.014	3.2	9	0.356	30.7	480	0.064	11.2	191	0.059
U.S.	98.1	10,101	0.010	65.9	2,034	0.032	286.2	5,179	0.055	-	-	-
1976 Can.	4.6	9	0.511	0.1	4	0.025	164.4	1,606	0.102	121.3	1,429	0.085
U.S.	52.5	12,408	0.004	254.1	1,550	0.164	496.6	4,620	0.107	-	-	-
1977 Can.	18.0	476	0.038	10.3	40	0.258	197.7	2,463	0.080	233.8	2,059	0.114
U.S.	626.4	12,464	0.050	18.4	1,037	0.018	209.7	5,165	0.041	-	-	-
1978 Can.	1.0	48	0.021	20.8	236	0.088	723.6	4,072	0.178	232.4	1,392	0.167
U.S.	564.7	5,033	0.112	16.9	910	0.019	-	-	-	-	-	-
1979 ^a Can.	-	-	-	3.9	20	0.193	178.8	1,225	0.146	21.0	655	0.032

^apreliminary data (to July 15).

Table 2.5. Canadian qualified (25%) catch (t), effort (hr) and CPUE (t/hr) of major rockfish species (other than Pacific ocean perch) from Areas 5C, 5D in 1977, 1978, and 1979.

Species	Area 5C								
	1979 ^a			1978			1977		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
<u>S. aleutianus</u>	-	-	-	-	-	-	-	-	-
<u>S. babcocki</u>	-	-	-	12.27	11.00	0.21	-	-	-
<u>S. brevispinis</u>	2.72	12.00	0.23	61.99	86.90	0.71	23.54	69.20	0.34
<u>S. entomelas</u>	-	-	-	-	-	-	-	-	-
<u>S. flavidus</u>	-	-	-	15.57	20.70	0.75	-	-	-
<u>S. paucispinis</u>	-	-	-	1.43	14.00	0.10	0.23	2.00	0.11
<u>S. pinniger</u>	18.19	20.70	0.88	65.28	74.88	0.87	3.42	2.00	1.71
<u>S. proriger</u>	-	-	-	0.81	4.00	0.20	-	-	-
<u>S. reedi</u>	-	-	-	-	-	-	-	-	-

Species	Area 5D								
	1979 ^a			1978			1977		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
<u>S. aleutianus</u>	2.65	6.00	0.44	-	-	-	-	-	-
<u>S. babcocki</u>	1.13	4.00	0.28	3.58	5.70	0.63	1.09	6.00	0.18
<u>S. brevispinis</u>	0.26	8.50	0.03	109.90	162.90	0.67	112.14	377.70	0.30
<u>S. entomelas</u>	-	-	-	-	-	-	1.72	2.00	0.86
<u>S. flavidus</u>	87.50	226.57	0.39	97.70	316.30	0.31	89.37	220.75	0.40
<u>S. paucispinis</u>	3.86	15.00	0.26	14.80	48.50	0.31	19.04	33.50	0.57
<u>S. pinniger</u>	1.81	8.00	0.23	2.00	5.50	0.37	2.38	8.00	0.30
<u>S. proriger</u>	-	-	-	-	-	-	-	-	-
<u>S. reedi</u>	-	-	-	-	-	-	3.75	2.50	1.50

^aPreliminary data (to July 15).

Table 2.6. Estimates of Japanese catches (t) of selected rockfish species, 52°N-54°30'N, (Area 5E or Management Sub-zone 5-5).

Year	Total rockfish	<u>S. brevispinis</u> ^a	<u>S. reedia</u> ^a	<u>S. proriger</u> ^a	<u>S. aleutianus</u> ^a
1971	3,113	258	311	405	364
1972	4,559	378	456	593	533
1973	4,208	349	421	547	492
1974	2,883	239	288	375	337
1975	2,954	245	295	384	346
1976	3,538	294	354	460	414
1977	~2,000	166	200	260	234

^aExtrapolated using observed % in 1977 rockfish catch.

Table 2.7. Estimates of Japanese catches (t) of selected rockfish species, 50°30'N-52°N, (Areas 5A and 5B or Management Sub-zone 5-4).

Year	Total rockfish	<u>S. brevispinis</u> ^a	<u>S. reedia</u> ^a	<u>S. proriger</u> ^a
1971	349	6	135	92
1972	2,643	48	1,020	700
1973	5,653	102	2,182	1,498
1974	14,240	256	5,497	3,374
1975	6,490	117	2,505	1,720
1976	3,364	61	1,299	891
1977	~970	17	374	257

^aExtrapolated using observed % in 1977 rockfish catch.

Table 2.8. Canadian catch (t), effort (hr), and CPUE (t/hr) of Sebastes reedi, by area, 1971-79.

Year	Area											
	3C			5A-5B			5C-5D			5E		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1971	-	-	-	5.4	32	0.169	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	176.7	38	4.650	-	-	-	-	-	-
1974	-	-	-	78.9	23	3.430	-	-	-	-	-	-
1975	0.5	3	0.167	1.1	35	0.031	-	-	-	-	-	-
1976	-	-	-	12.3	10	1.230	-	-	-	-	-	-
1977	-	-	-	335.9	466	0.721	3.8	3	1.267	1,256.7	583	2.156
1978	0.3	1	0.300	108.5	164	0.660	-	-	-	973.4	579	1.682
1979 ^a	-	-	-	34.5	101	0.340	-	-	-	350.8	260	1.349

^aPreliminary data (to July 15).

Table 2.9. Canadian qualified (25%) catch (t), effort (hr) and CPUE (t/hr) of major rockfish species (other than Pacific ocean perch) from Area 5E in 1977, 1978, and 1979.

Species	Area 5E								
	1979 ^a			1978			1977		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
<u>S. aleutianus</u>	83.48	86.90	0.96	100.89	111.20	0.91	74.69	66.00	1.13
<u>S. babcocki</u>	-	-	-	-	-	-	-	-	-
<u>S. brevispinis</u>	28.43	39.67	0.72	52.82	103.70	0.51	-	-	-
<u>S. entomelas</u>	-	-	-	1.28	6.70	0.19	-	-	-
<u>S. flavidus</u>	-	-	-	-	-	-	1.38	10.00	0.14
<u>S. paucispinis</u>	-	-	-	0.08	14.60	0.01	-	-	-
<u>S. pinniger</u>	-	-	-	5.14	1.00	5.14	0.18	1.00	0.18
<u>S. proriger</u>	13.78	17.83	0.77	96.45	41.90	2.30	58.04	79.33	0.73
<u>S. reedi</u>	287.53	143.43	2.00	727.61	274.57	2.65	1,243.30	458.20	2.71

^aPreliminary data (to July 15).

Table 2.10. Catch (t), effort (hr) and CPUE (t/hr) of Sebastes paucispinis by Canada and United States, by area, 1967-79.

Year & Nation	Area											
	3B-3C			3D			5A-5B			5C-5D		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1967 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	3.2	4,579	0.001	51.8	1,344	0.039	170.9	9,313	0.018	-	-	-
1968 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	15.9	7,551	0.002	34.2	1,381	0.025	52.7	8,488	0.006	-	-	-
1969 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	8.7	8,619	0.001	96.5	2,172	0.044	657.4	13,557	0.048	-	-	-
1970 Can.	-	-	-	-	-	-	-	-	-	-	-	-
U.S.	63.1	3,637	0.017	117.7	2,978	0.040	78.4	9,264	0.008	-	-	-
1971 Can.	0.5	38	0.013	11.6	291	0.040	23.8	637	0.037	2.2	245	0.009
U.S.	19.5	4,934	0.004	18.1	1,825	0.010	119.9	7,137	0.017	-	-	-
1972 Can.	1.3	32	0.041	5.8	172	0.034	17.9	126	0.142	26.0	128	0.203
U.S.	19.6	4,823	0.004	72.7	1,691	0.043	287.5	9,224	0.031	-	-	-
1973 Can.	2.9	80	0.036	13.2	115	0.115	38.8	347	0.112	19.0	222	0.086
U.S.	15.2	4,182	0.004	69.9	1,613	0.043	582.3	9,625	0.060	-	-	-
1974 Can.	4.4	115	0.038	9.5	91	0.104	81.3	719	0.113	92.0	673	0.137
U.S.	-	5,165	-	25.7	1,849	0.014	378.7	8,797	0.043	-	-	-
1975 Can.	0.7	14	0.050	0.5	4	0.125	4.6	81	0.057	10.1	208	0.049
U.S.	-	10,101	-	18.7	2,034	0.009	303.4	5,179	0.059	-	-	-
1976 Can.	3.9	45	0.087	8.4	109	0.077	28.3	741	0.038	25.5	525	0.049
U.S.	18.6	12,408	0.001	165.1	1,550	0.107	201.7	4,620	0.044	-	-	-
1977 Can.	29.0	712	0.041	10.1	118	0.086	41.9	1,161	0.036	59.7	858	0.070
U.S.	8.9	12,464	0.001	4.9	1,037	0.005	119.6	5,165	0.023	-	-	-
1978 Can.	3.8	129	0.029	19.2	245	0.078	133.3	2,039	0.065	53.6	1,558	0.034
U.S.	-	-	-	-	-	-	-	-	-	-	-	-
1979 ^a Can.	1.2	68	0.017	11.1	65	0.170	91.5	1,013	0.090	18.7	482	0.039

^apreliminary data (to July 15).

Table 2.11. Catch (t), effort (hr) and CPUE (t/hr) of Sebastes entomelas by Canada and United States, by area, 1967-79.

Year	Area														
	3C			3D			5A-5B			5C-5D			5E		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1972	0.1	11	0.009	-	-	-	-	-	-	-	-	-	-	-	-
1973	1.5	27	0.057	-	-	-	0.3	11	0.025	-	-	-	-	-	-
1974	2.3	68	0.034	-	-	-	2.7	13	0.210	-	-	-	-	-	-
1975	0.1	16	0.009	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	52.9	167	0.317	-	-	-	86.3	869	0.099	3.5	26	0.135	12.3	136	0.090
1978	-	-	-	1.5	3.0	0.556	143.5	736	0.195	-	-	-	56.1	437	0.128
1979 ^a	0.3	49	0.006	-	-	-	3.8	47	0.082	-	-	-	6.9	123	0.056

^aPreliminary data (to July 15).

Table 2.12. Canadian catch (t), effort (hr) and CPUE (t/hr) of Sebastes proriger, by area, 1975-79.

Year	Area														
	3C			3D			5A-5B			5C-5D			5E		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1975	-	-	-	-	-	-	12.9	35	0.369	-	-	-	-	-	-
1976	-	-	-	-	-	-	11.6	46	0.253	-	-	-	-	-	-
1977	0.7	53	0.013	-	-	-	49.4	356	0.139	0.9	25	0.036	156.0	454	0.344
1978	0.4	1	0.380	6.4	35	0.182	19.7	423	0.046	2.6	15	0.176	228.8	392	0.583
1979 ^a	-	-	-	0.2	3	0.086	3.7	120	0.030	0.2	7	0.034	71.6	167	0.430

^aPreliminary data (to July 15).

Table 2.13. Canadian catch (t), effort (hr) and CPUE (t/hr) of Sebastes aleutianus, 1971-79.

Year	Area														
	3C			3D			5A-5B			5C-5D			5E		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1971	4.8	134	0.036	3.7	21	0.176	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	8.2	48	0.170	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	14.4	63	0.229	-	-	-	-	-	-
1977	-	-	-	-	-	-	0.3	29	0.012	0.4	56	0.007	76.3	135	0.565
1978	-	-	-	-	-	-	0.02	0.5	0.040	-	-	-	134.0	390	0.344
1979 ^a	-	-	-	1.4	3	0.509	-	-	-	4.0	24	0.167	114.3	231	0.495

^aPreliminary data (to July 15).

Table 2.14. Canadian catch (t), effort (hr) and CPUE (t/hr) of Sebastes babcocki, by area, 1971-79.

Year	Area											
	3B-3C			5A-5B			5C-5D			5E		
	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE	catch	effort	CPUE
1971	-	-	-	13.5	179	0.075	11.9	195	0.061	-	-	-
1972	-	-	-	-	-	-	4.2	118	0.036	-	-	-
1973	-	-	-	3.8	51	0.075	2.7	60	0.045	-	-	-
1974	-	-	-	5.3	68	0.078	0.8	55	0.015	-	-	-
1975	-	-	-	29.4	205	0.143	3.6	112	0.032	-	-	-
1976	1.0	6	0.167	64.1	563	0.114	14.4	568	0.025	-	-	-
1977	0.3	60	0.005	20.2	602	0.034	12.8	498	0.026	2.3	32	0.072
1978	0.8	40	0.020	72.6	438	0.166	29.6	354	0.084	5.1	211	0.024
1979 ^a	-	-	-	4.3	15	0.293	7.4	178	0.041	1.2	48	0.025

^aPreliminary data (to July 15).

3. SABLEFISH STOCK ASSESSMENT

3.1 Introduction

Canadian sablefish (Anoplopoma fimbria) landings (Table 3.1) prior to 1978 were relatively minor compared to other groundfish landings. The average total catch from 1968 until 1978 was 678 t/yr compared to an average of 21,306 t/yr for all groundfish species. In 1978, market conditions appeared to stimulate an increased interest in the sablefish fishery and although trawl landings were reduced, trap landings increased from 215 t in 1977 to 635 t in 1978 (Table 3.2). Catches in 1979 are expected to reach 2,000 t as a result of new vessels entering the fishery and increased effort by vessels previously in the fishery.

While there has been a large number of vessels landing sablefish in the past, few longline or trawl vessels have landed more than 3 t per year. During 1973-1978 no longline vessel landed more than 30 t per year and in 1978 only 3 of 76 longline vessels landed more than 3 t (Table 3.2). However in 1979, 11 of 116 longline vessels reporting sablefish landings have landed more than 3 t as of August 31 and the largest landing for one vessel was 51 t. Trap vessels also increased to 16 in 1979 from 10 in 1978. Although the total of 183 vessels participating in the fishery in 1979 is not a substantial increase over previous years, effort has shown an increase.

In 1980, as a consequence of restrictions on Canadian participation in the halibut fishery in United States waters, it is anticipated that the number of vessels landing sablefish may exceed 20 trap vessels and the total number of vessels landing sablefish may exceed 200. Because of this anticipated increased effort and because important biological problems remain unsolved, a conservative approach to management of sablefish stocks is recommended at this time.

3.2 Catch statistics

3.2.1 Japan and other nations

3.2.1.1 Discards

In 1977, 1978, and 1979 (as of August 31) Canadian observers monitored catches on 25 Japanese longline vessels. No discards of sablefish were observed in 1977 and 1978. In 1979, discards of approximately 1% of the total catch of sablefish were reported on one vessel and approximately 0.1% on a second vessel. While the discard rate may be increasing, discards can be considered to be negligible prior to mid-1979.

3.2.1.2 Catch

The Japanese longline fishery represents the most extensive set of sablefish catch data for the Canadian west coast fishery zone. This fishery started in 1968 with a total catch of 1,454 t. Catches increased to 4,919 t in 1970 but dropped to 2,721 t in 1971 and except for 1975 have remained below 3,500 t (Table 3.3; Fig. 3.1). Since 1977, Canada has established annual all-nation quotas for the sablefish fishery and the effect of the quotas on the Japanese CPUE is unknown. Catches by other nations (Table 3.1) were less than 600 t except catches of 1,263 t and 2,335 t by the Republic of Korea, for 1975 and 1976, respectively.

3.2.1.3 Fishing locations

In 1977 and 1978 Japanese longline vessels provided detailed fishing locations (Figs. 3.2; 3.3). The accuracy of these positions was confirmed by Canadian observers and surveillance operations. During these two years, Japanese effort was dispersed throughout the Canadian zone outside of Canadian territorial waters (22 km; 12 naut mi) in the depth range of 270-310 m (150-450 fm). Since 1968, the beginning of the longline fishery, the Japanese have recorded their fishing effort in blocks bounded by 1° longitude and 1/2° latitude (Table 3.4, Fig. 3.4). Although these data are grouped into larger areas than the data available for 1977 and 1978 (Figs. 3.2, 3.3), the pattern of fishing from 1968 to 1976 appears similar to that observed in 1977 and 1978. Off the west coast of the Queen Charlotte Islands (Sub-zone 5-5), 51% of the fishing effort from 1968 until 1978 occurred in block 033540 (Table 3.5). Similarly in Queen Charlotte Sound (Sub-zone 5-4), 41% of the effort since 1971 (excluding 1973) has occurred in block 030513 (Table 3.6). The catches within these blocks appear high, however effort is actually confined to a small number of blocks in Sub-zones 5-5 and 5-4 where a suitable depth range occurs outside of the Canadian territorial waters (Table 3.4). Off Vancouver Island (Sub-zones 5-3, 5-2, 5-1), effort has not been concentrated in any particular block (Table 3.7). There is little doubt, that since 1968, Japanese effort has been distributed throughout the Canadian zone outside of Canadian territorial waters with slightly higher effort in one or two areas.

3.2.1.4 CPUE

Catch-per-unit-effort for the Japanese longline fishery is defined as catch in metric tons per 10 hachi (t/10 hachi). One hachi of longline gear is approximately 100 m long and contains an average of 40 hooks but the number of hooks may vary between 33 and 53 (information from observers aboard longliners in 1977, 1978, and 1979). Since the Japanese freeze a dressed product their estimate of total catch was obtained by multiplying the dressed product weight by 1.333, a recovery rate of 75%. However, calculations made by Canadian observers indicated that the recovery rate is closer to 65%; that is the dressed, head-off weight should be multiplied by 1.538. Reported total catches would therefore be lower than actual total catches by approximately 15%. Of course, if these conversion factors have not changed since the beginning of the fishery, CPUE data will not be affected. Catch statistics reported in Tables 3.1, 3.3, 3.4, 3.5, 3.6, and

3.7 have not been adjusted upward by 15% as it is unknown at this time, when or if a change in the conversion factor was made. However, the stock assessments in this document use both adjusted and unadjusted catch statistics.

The use of 10-hachi units to measure fishing effort could misrepresent effort if longer "soak-time" times are used. Soak-time is the period of time, usually in hours, that the gear is left in the water and is actually fishing. The use of boat-days, the number of calendar days spent fishing, might reduce the dependence on soak-time, however, a boat-day unit ignores the problem of increased efficiency by setting more hachi per day. Since the possibility of setting more hachi per day is thought to have a greater effect than longer "soak-time", effort calculated as 10-hachi units is thought to be more accurate. The CPUE using boat-days has been calculated for the whole coast for comparison (Fig. 3.1).

The Japanese catches (Table 3.3; Fig. 3.1) show an initial decline from 1968 to 1971 in CPUE from 0.261 t per 10-hachi to 0.162 t per 10-hachi. CPUE then remained relatively steady from 1972 to 1976 ranging from 0.194 to 0.210 t per 10-hachi. During 1977, CPUE dropped by 24% to 0.147 t per 10-hachi and 1978 CPUE was only slightly higher at 0.156 t per 10-hachi. (If a correction for the 1977 and 1978 catches for the discrepancy in recovery rates is made, the drop in CPUE in 1977 is only 13% to 0.169 t per 10-hachi.)

A similar pattern of change in CPUE is seen in Queen Charlotte Islands-Dixon Entrance area, Sub-zone 5-5, (Table 3.5; Fig. 3.5), where CPUE declined from 1968 to 1971 from 0.289 t per 10-hachi to 0.180 t per 10-hachi. During 1972-75, CPUE was relatively consistent varying between 0.194 t per 10-hachi and 0.202 t per 10-hachi. A drop in CPUE in 1976 to 0.184 t per 10-hachi precedes the drop in 1977 to 0.140 t per 10-hachi. However, there was an increase in CPUE in 1978 to 0.162 t per 10-hachi.

The pattern of catch and effort in Queen Charlotte Sound, Sub-zone 5-4, and off Vancouver Island, Sub-zones 5-1, 5-2, and 5-3 was different from Sub-zone 5-5 (Table 3.6, 3.7; Fig. 3.5). CPUE is almost as high between the years 1972 and 1976 as the initial high CPUEs in 1969 and 1970. However, there were low CPUEs in 1971 and in 1977. The increase in CPUE in 1978 from the low of 1977 is less pronounced in these areas than in the Queen Charlotte Islands-Dixon Entrance area.

3.2.2 Canada

3.2.2.1 Discards

Many reports of small blackcod discards by the groundfish fleet have been recorded from 1977 to the end of August 1979 (Table 3.8). In 1978, reports of large amounts of small blackcod discards were also received from salmon seiners in July and August. In May 1978, the mean length of the blackcod discards was 32.5 cm indicating these fish were part of the 1977 year-class. In May 1979, the length frequency in Area 3C showed two modes, the same year-class (1977) as seen in 1978 had a mean length of 44 cm and a

new 1978 year-class with a mean length of ~35 cm. However, most of the discards appear to be from a strong 1977 year-class.

If we assume that these fish would enter the fishery at about 55 cm or 5 years-of-age, we can calculate the loss to the fishery by calculating first the instantaneous rate of growth, G , for the age-group (note that recent information indicates 55-cm fish may not be age-5 in all areas).

$$\frac{W_t}{W_o} = e^{Gt}$$

when W_t = weight at age of recruitment
 W_o = weight at age of discard
 t = time in years

Knowing G , and obtaining an estimate of M from Low et al. (1976) we can then calculate the expected biomass of each age class at the time of recruitment.

$$\frac{B_t}{B_o} = e^{(G-M)t}$$

when B_t = biomass at age of recruitment
 B_o = biomass at age of discard
 t = time in years
 M = instantaneous rate of natural mortality (assuming no fishing mortality at these ages)

If we use a calculated length-weight relationship for blackcod of

$$W = 8 \times 10^{-6} L^{3.0673}$$

we obtain a weight of 0.35 kg for 32.5-cm blackcod of age 1, 0.88 kg for 44-cm blackcod of age 2, and 1.74 kg for 55-cm blackcod at age of recruitment. These figures result in instantaneous rates of growth of 0.40 and 0.23 for age 1 and 2, respectively, which can be substituted into the formula to calculate the expected biomass of the discards if they had not been caught.

The reported discards in 1978 of age-1 blackcod, 357 t, represents a potential biomass of 733 t at the time of recruitment. If we consider that all the fish in 1979 were age-2 fish (actually an unknown percentage were age one), the reported discards of 1,647 t to the end of August represents a potential biomass of 1,698 t.

The biomass at time of recruitment would have been reduced by both instantaneous natural mortality ($M = 0.22$) and instantaneous fishing mortality ($F = 0.36$). F was estimated by multiplying q (catchability coefficient) and f_{opt} (optimum fishing effort) (Table 3.9).

The potential biomass from reported 1978 and 1979 discards would therefore represent an approximate yield of 1,000 t to the sablefish fishery in 1982.

3.2.2.2 CPUE

It is difficult to estimate CPUE for the Canadian fishery because fishing logs were not collected on a formal basis until 1978 and trip reports were not obtained routinely prior to 1978. Information in Table 3.10 prior to 1978 was obtained directly from fishermen's personal logs. The data are not sufficient to permit a stock analysis but may be useful in future years assuming CPUE can be standardized for the two types of traps currently in use. Information by major areas is scanty and because of seasonal variation in catch it is difficult to interpret. One area off the west coast of the Queen Charlotte Islands probably was not fished by the Japanese as most of the accessible bottom is within 22 km (12 mi) of the coast. The Canadian fishery that developed here in 1973 is probably exploiting relatively unutilized stocks and an accurate account of this fishery may provide a better appreciation of the response of sablefish stocks to exploitation.

3.3 Stocks

Prior to recent tagging studies by Canada and the United States, all sablefish were thought to be part of one North Pacific stock. While some still retain this view, the preliminary results of Canadian tagging studies indicate that in Canadian waters there is very little movement of adults from the release area. Of the 21,462 fish tagged during 1977 and 1978, 1,010 have been recovered as of December 30, 1978 and 88% of the recoveries were made within 50 km of the release area. Only 3% were recovered at distances greater than 200 km. However, we do not know the source or method of recruitment of the adults into any particular fishing area and it is possible that juvenile sablefish migrate considerable distances.

Sablefish found off the southwest coast of Vancouver Island tend to be smaller than sablefish caught off the Queen Charlotte Islands (Fig. 3.6). At first it was thought that these smaller fish (50-60 cm) were young fish, but if the recently developed method for determining the age of sablefish is valid, some of these fish range in age from 4-30 yr and are as old as the larger fish found in both areas.

The absence of substantial movement and the presence of fish with different rates of growth may indicate that discrete stocks of adult sablefish exist in areas such as off the southwest coast of Vancouver Island, in Queen Charlotte Sound, on the west coast of the Queen Charlotte Islands as well as in major inlets and on seamounts. It is also possible that major recruitment to these stocks is from outside any particular area. Thus there is concern that excessive effort in the absence of compensating recruitment in any one area may result in the depletion of the stock to a level that cannot be fished economically by Canadian fishermen. However, until better information is available to permit a decision to be made about the presence of discrete stocks, the assessment of allowable catch will be made for the entire coast. If it appears that sablefish fisheries in 1980 expend excessive effort in one particular area, then it will be necessary in 1981 to set quotas by smaller areas as a precautionary measure.

3.4 Stock assessments

American scientists in 1979 used two methods to fit the sablefish catch and effort data from the Japanese longline fishery to a general production model. They indicate from tagging observations that there may be a number of biological stock units. However, defining these stocks was considered to be difficult so an analysis by geographical regions was used. Their results for the longline fishery off Canada produced a MSY of 5,155 t/yr using the method of Fox (1970) and a MSY of 5,800 t/yr using the method of Rivard and Bledsoe (1973, personal communication).

In a document entitled "Re-calculations of the longline effort and stock assessment of blackcod in the North Pacific" provided by Japanese scientists in May 1978, the Gulland (1961) linear model was again used to relate estimated total effort (= total catch/longline CPUE) to longline CPUE in terms of catch-per-hachi and resulted in an estimate of $MSY = 26,000$ t/yr for Canadian waters. However, the source of statistics for total catch was not given and the data used are very different from either the total Japanese catch or the all-nation catch (Table 3.1). Moreover, in the Japanese analysis longline CPUE for 1968 was used to derive total effort figures for 1966 and 1967 when no Japanese longline fishery existed off Canada. This approach is very questionable and seems particularly unwise since the total Japanese catch during 1966 and 1967 was only 6% and 42%, respectively, of the total all-nation catch in 1968. Since Gulland's model assumes that fishing effort during previous years is the major factor determining present abundance, the relatively small removals during 1966 and 1967 do not merit consideration.

When little is known of the population parameters of a stock, methods of stock assessment are limited to an analysis of catch and effort data. Two methods are used in this study to estimate maximum sustainable yield. The first method is the same method used by U.S. and Japanese scientists and involves a regression of CPUE on the average fishing effort over a number of preceding years (K) which ideally should be equal to the average length of time an individual of a year-class is vulnerable to the fishery (Gulland 1961); the second is a dynamic, stochastic version of the Schaefer model (Schnute 1977).

Ages determined from the surface of otoliths indicate that sablefish remain in the fishery for an average of 5 or 6 years. Using Gulland's (1961) linear regression model (Table 3.11; Figs. 3.7, 3.8) the best fit ($r = 0.9$) producing a MSY of 3,900 t/yr was obtained for $K = 5$ and CPUE expressed as catch-per-boat-day. Estimates of MSY using catch-per-10-hachi and catch-per-boat-day range between 3,200 and 4,100 t/yr. If the Canadian estimates of Japanese catch based on lower dressed recovery percentages are used for 1977 and 1978 a MSY range of 3,400-3,500 t/yr for catch-per-boat-day and catch-per-10-hachi is obtained.

Results generated by the modified Schaefer model produced an estimate of MSY of 5,200 t/yr (Table 3.9; Fig. 3.9) using the 1977 and 1978 CPUE values corrected for the discrepancy in recovery rates.

An estimated total effort for all-nation catches for the whole coast was calculated by applying the Japanese longline CPUE to all other catches of sablefish (i.e. catches by different gear types). The results of the Gulland's linear regression model using this estimated total effort in both 10-hachi and boat-day units are presented in Table 3.12; Fig. 3.10.

The fit in all cases is good ($r = 0.8-0.9$) but is best with $K = 6$ and CPUE expressed in t/boat-day. The MSY in this case is 4,600 t/yr (Table 3.12).

Ages determined from otolith sections indicate that sablefish in the fishery range in age from approximately 3 to 35 yr. Each year-class could remain in the fishery for an average of approximately 16 yr. Neither method of age determination has been validated, but the section method does appear to be more accurate. If $K = 16$, then the use of the Gulland model is suspect since the fishery has not been in operation for more than 12 yr. (For a Gulland analysis with $K = 16$, it is necessary to have at least 18 yr of catch data to produce a regression line.) If the section ages are valid then Gulland's method may not be of use in assessing stocks at this time. If the ages are correct we may still be in a "fishing up" phase in some areas such as off the west coast of the Queen Charlotte Islands.

In summary, the MSY estimated using the all-nation catches for the total zone was 4,600 t/yr. If we use only the Japanese data the MSY was estimated at 3,900 t/yr. However, these estimates may be quite different from the "actual" MSY if the ages determined from otolith sections are correct. Even if we do accept these estimates, fishing at a MSY level is generally considered to be dangerous so that current fishery practice is to fish below the MSY. It is, therefore, recommended that the quota remain at 3,500 t. If major changes are seen in the population's age composition, size composition or apparent biomass, then the quota will obviously have to be adjusted. Until the ageing, recruitment and stock assessment problems are resolved, we recommend that the setting of the quota for sablefish be approached very carefully and a "conservative" estimate be used. This approach should not result in a serious loss of production since adult sablefish are relatively old slow-growing fish by either ageing method and natural mortality rates will be low.

3.5 Other aspects of the fishery

3.5.1 Lost gear

At present we do not have an estimate of how many traps are lost annually. Reports from fishermen suggest that the loss of traps is important, particularly since it has been demonstrated that they continue to fish for periods of up to several months -- probably longer. As an example, one fisherman reported having picked up 5 strings of traps apparently lost within the last year and most traps were still fishing. A survey of sablefish fishermen produced a unanimous response that a regulation was necessary. However, we have no final solution to the problem of preventing the entrapment of sablefish by lost gear. It is proposed that in 1980 studies be conducted so that a regulation will be in effect by January 1, 1981.

3.5.2 Discards

In last year's stock assessment document it was recommended that a minimum size limit be established for sablefish. This problem has been

amplified in the last couple of years with the emergence of the strong 1977 year-class. As a result of the large numbers of small sablefish being caught by trawlers and the lack of a minimum size limit, some fishermen have been developing markets for these small sablefish. The fishery is beginning to retain small sablefish which until recently have always been discarded as unmarketable. In some cases these small fish are used only for reduction. Depending on which areas these small fish recruit to there could be considerable impact on the fishery by the removal of these fish. It makes little sense to allow a fishery for juvenile sablefish when we are experiencing explosive growth in the fishery for adult sablefish. Therefore it is again recommended that minimum size regulations be implemented.

3.6 Recommendations

1. The recommended TAC for sablefish for all areas is 3,500 t.
2. Sablefish 55 cm in fork length and smaller must be discarded.
3. Regulations requiring trap gear to have escape devices should be in effect by January 1, 1981. This is a serious problem and since it has taken more than a year to implement a minimum size regulation (that is still not in effect) action should be initiated immediately to require stricter controls to reduce gear loss and prevent lost gear from continuing to fish.
4. Policies with respect to fleet size should be finalized during 1980.

Table 3.1. Sablefish catch (t) by nation (all fishing gears) in British Columbia waters, 1964-78.

Calendar year	Canada ^a	USA ^b	Japan ^c	USSR ^b	R.O.K. ^b	Total
1964	398	83	-	-	-	481
1965	455	92	-	-	-	547
1966	635	95	174	-	-	904
1967	393	65	1,189	-	-	1,647
1968	465	65	2,271	-	-	2,801
1969	312	43	4,712	-	-	5,067
1970	257	104	5,119	-	-	5,480
1971	314	161	3,012	-	-	3,487
1972	1,086	582	4,172	-	-	5,840
1973	938	82	2,950	-	-	3,976
1974	482	70	3,866	65	129	4,612
1975	892	126	4,460	0	1,263	6,741
1976	771	217	3,379	0	2,335	6,702
1977	1,088	345 ^e	3,001 ^d	0	168 ^d	4,602
1978	831	319	2,091 ^d	-	-	3,241

^aCan. Dept. Fish., B. C. Catch Statistics (1965-78) and Fish. Res. Board Canada, Catch and effort statistics of the B. C. trawl fishery, 1967-1978).

^bKetchen (1977).

^cINPFC statistical bulletins including unpublished data for 1975 and 1976.

^dFishing log books from foreign vessels.

^ePMFC data series.

Table 3.2. Canadian Sablefish landings (t), 1973-79.

Year	Gear	Total number of vessels	Total landings t (dressed) ^a	Round (dressed × 1.5)	Vessel landings greater than 3 t	
					Number of vessels (% of total)	Landings (t) (% of total)
1973	longline	75	90.4	135.6	11(14.7)	101.0(74.4)
	trawl	39	62.8	94.2	8(20.5)	68.7(73.0)
	trap	14	497.1	745.6	9(64.3)	741.3(99.4)
1974	longline	49	35.6	53.4	5(10.2)	29.1(54.5)
	trawl	49	84.6	126.9	9(18.4)	110.7(87.3)
	trap	7	217.7	326.5	5(71.4)	322.6(98.8)
1975	longline	68	111.9	167.8	16(23.5)	135.9(81.0)
	trawl	50	201.2	301.8	17(34.0)	284.6(94.3)
	trap	9	314.8	472.2	6(66.7)	470.7(99.7)
1976	longline	63	65.7	98.5	8(12.7)	66.6(67.6)
	trawl	68	261.8	392.7	20(29.4)	374.1(95.3)
	trap ^b	7	163.9	245.8	5(71.4)	245.0(99.6)
1977	longline	80	53.1	79.6	6(7.5)	45.8(57.4)
	trawl	68	512.6	768.9	25(36.8)	750.8(97.6)
	trap	10	143.1	214.6	6(60.0)	210.3(98.0)
1978	longline	76	38.8	58.2	3(3.9)	27.0(46.4)
	trawl	66	92.5	138.8	13(19.7)	114.4(82.5)
	trap	10	423.1	634.6	7(70.0)	631.6(99.5)
1979 ^c (Aug 31)	longline	116	72.7	109.0	11(9.5)	102.0(66.5)
	trawl	51	46.2	69.3	9(17.6)	83.1(79.8)
	trap	16	513.0	769.5	10(62.5)	438.8(98.3)

^aFisheries management 1090 West Pender Street, Vancouver, all figures dressed weight. British Columbia catch statistics (sales slips).

^bThis data does not correspond to that stated in Table 3.10. Detailed information on the missing data is not available at this time.

^cPreliminary data.

Table 3.3. Sablefish catch (t) and effort (10-hachi) statistics for Japanese longline fishery in Canadian waters (48°00'-54°30'N lat.), 1968-78.

Calendar year	Catch (t)	Effort (10-hachi)	CPUE (t/10-hachi)
1968 ^a	1,454	5,573	0.261
1969	4,224	22,412	0.207
1970	4,919	22,886	0.215
1971	2,721	16,774	0.162
1972	3,491	16,831	0.207
1973	2,585	12,367	0.209
1974	3,527	16,765	0.210
1975	4,433	22,807	0.194
1976	3,209	16,519	0.194
1977 ^b	2,982	20,260	0.147
1978	2,091	13,396 ^c	0.162
1968-78 average	3,240	16,781	0.197

^a1968-76 statistics from U.S. National Marine Fisheries Service computer printouts.

^b1977 and 1978 statistics from fishing log books.

^cEffort estimated for one longliner (no log book available).

Table 3.4. Japanese longline catch (t) and effort (10-hachi) for 1° longitude × 1/2° latitude blocks (Fig. 3-4).

Sub-zone	Block no.	1968		1969		1970		1971		1972		1973	
		Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
5-1,5-2,5-3	025480	70	21	797	149	110	18	84	18	320	48	124	27
	025483	-	-	-	-	-	-	-	-	-	-	-	-
	026480	-	-	470	100	40	7	72	11	360	49	289	64
	026483	-	-	818	150	250	58	1,264	200	760	159	943	211
	026490	-	-	550	108	79	28	-	-	40	10	244	55
	027473	-	-	-	-	-	-	-	-	50	7	-	-
	027480	-	-	-	-	16	2	-	-	100	19	-	-
	027483	-	-	-	-	-	-	-	-	200	28	-	-
	027490	65	19	1,850	413	949	178	925	131	515	133	693	158
	027493	466	102	4,367	796	1,016	192	1,284	173	826	191	544	100
	028490	-	-	76	19	85	16	-	-	-	-	-	-
	028493	66	15	50	14	-	-	-	-	336	69	-	-
	028500	486	82	1,000	201	1,858	455	361	47	289	63	732	172
	029483	-	-	-	-	-	-	-	-	50	7	-	-
	029493	-	-	-	-	160	24	-	-	-	-	-	-
	029500	-	-	85	19	338	82	162	14	198	43	53	10
5-4	028503	78	16	85	15	798	177	84	9	-	-	-	-
	028510	-	-	53	8	49	10	-	-	-	-	-	-
	029503	37	4	1,001	203	1,059	191	212	28	320	65	872	178
	029510	189	22	1,055	197	1,145	236	1,203	146	495	97	714	162
	029513	-	-	250	63	-	-	-	-	-	-	-	-
	030503	-	-	-	-	112	15	-	-	243	56	-	-
	030510	68	14	1,051	246	3,988	886	856	108	285	65	305	66
	030513	60	7	205	33	3,305	741	1,843	338	1,140	295	224	44
	031513	34	10	-	-	300	54	260	26	20	7	41	10
	033510	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.4 cont'd

Sub-zone	Block no.	1968		1969		1970		1971		1972		1973	
		Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
5-5	031520	-	-	145	34	247	49	129	24	-	-	33	8
	032520	70	18	235	35	360	87	40	4	-	-	-	-
	032523	40	10	-	-	80	11	42	9	40	4	-	-
	032530	-	-	39	4	92	17	-	-	-	-	-	-
	032540	-	-	-	-	-	-	-	-	-	-	-	-
	033520	-	-	30	8	47	13	-	-	-	-	-	-
	033523	-	-	-	-	207	55	-	-	-	-	-	-
	033530	593	165	627	162	632	113	347	62	498	91	91	25
	033533	247	56	1,329	268	1,553	282	1,798	324	1,772	388	1,718	350
	033540	1,532	478	2,218	580	2,971	708	4,484	786	5,996	1,221	3,731	752
	034530	-	-	-	-	-	-	-	-	-	-	40	5
	034533	926	304	110	18	110	23	-	-	100	13	78	13
	034540	546	111	1,202	232	930	191	1,324	263	1,843	358	675	131
	035530	-	-	-	-	-	-	-	-	-	-	40	8
	035533	-	-	-	-	-	-	-	-	-	-	103	19
	036530	-	-	145	25	-	-	-	-	-	-	-	-
	036533	-	-	20	1	-	-	-	-	-	-	-	-
	030523	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.4 cont'd

Sub-zone	Block no.	1974		1975		1976		1977		1978	
		Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
5-1,5-2,5-3	025480	1,893	411	611	100	75	13	540	74	336	41
	025483	-	-	39	8	-	-	-	-	-	-
	026480	542	115	288	55	391	74	499	87	166	18
	026483	1,404	318	1,644	338	401	72	1,942	308	1,145	176
	026490	158	36	317	56	119	26	359	56	286	54
	027473	-	-	-	-	-	-	-	-	-	-
	027480	42	9	-	-	-	-	-	-	-	-
	027483	35	8	75	16	263	43	-	-	-	-
	027490	880	186	1,903	371	712	130	1,118	156	505	81
	027493	1,541	336	826	161	1,048	193	1,925	263	1,445	238
	028490	-	-	-	-	-	-	-	-	-	-
	028493	75	17	274	50	38	6	-	-	-	-
	028500	529	114	817	158	1,295	267	1,649	262	569	93
	029483	-	-	-	-	-	-	-	-	-	-
	029493	-	-	-	-	-	-	-	-	40	10
	029500	36	6	32	66	-	-	40	12	-	-
5-4	028503	-	-	114	23	203	35	507	80	50	5
	028510	-	-	-	-	-	-	-	-	40	8
	029503	1,098	224	1,221	235	1,164	230	1,331	183	742	101
	029510	1,055	235	2,015	402	313	56	1,807	260	1,720	284
	029513	-	-	-	-	-	-	-	-	-	-
	030503	-	-	-	-	-	-	-	-	50	5
	030510	395	85	1,825	346	307	64	471	73	366	60
	030513	1,172	268	2,051	405	3,382	741	2,761	423	1,954	304
	031513	35	8	171	33	-	-	120	19	-	-
	033510	-	-	-	-	-	-	45	7	-	-

Table 3.4 cont'd

Sub-zone	Block no.	1974		1975		1976		1977		1978	
		Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
5-5	031520	-	-	147	26	-	-	38	3	-	-
	032520	-	-	-	-	-	-	-	-	-	-
	032523	-	-	101	17	-	-	-	-	-	-
	032530	-	-	-	-	-	-	-	-	-	-
	032540	-	-	-	-	-	-	-	-	-	-
	033520	-	-	-	-	-	-	-	-	42	5
	033523	-	-	-	-	-	-	-	-	-	-
	033530	93	23	573	105	461	90	474	60	439	73
	033533	1,709	334	2,242	440	1,992	394	2,024	305	935	144
	033540	3,559	694	4,759	935	4,098	717	2,743	377	1,363	219
	034530	-	-	-	-	-	-	-	-	-	-
	034533	40	9	78	15	-	-	-	-	-	-
	034540	276	53	344	65	269	52	-	-	-	-
	035530	-	-	-	-	-	-	126	15	-	-
	035533	78	14	-	-	-	-	-	-	-	-
	036530	-	-	-	-	-	-	-	-	-	-
	036533	-	-	-	-	-	-	-	-	-	-
	030523	-	-	-	-	-	-	39	4	-	-

Table 3.5. Sablefish catch (t) and effort (10-hachi) statistics for Japanese longline fishery in the Queen Charlotte Islands-Dixon Entrance area, Sub-zone 5-5 (52°00'-54°30'N lat.), 1968-78.

Year ^a	Total for Sub-zone 5-5			Block with the largest catch (033540)		
	Catch (t)	Effort (10-hachi)	CPUE (t/10-hachi)	Catch (t)	Effort (10-hachi)	CPUE (t/10-hachi)
1968 ^b	1,142	3,954	.289	478	1,532	.312
1969	1,490	6,650	.224	580	2,128	.273
1970	1,549	7,229	.214	708	2,971	.238
1971	1,472	8,164	.180	786	4,484	.175
1972	2,080	10,284	.202	1,221	5,996	.204
1973	1,327	6,589	.201	752	3,731	.202
1974	1,151	5,875	.196	694	3,559	.195
1975	1,610	8,284	.194	935	4,759	.196
1976	1,259	6,850	.184	717	4,098	.175
1977 ^c	737	5,246	.140	377	2,743	.138
1978	555	3,424 ^d	.162	219 ^e	1,363 ^e	.161

^aCalendar year.

^b1968-76 data from U.S. Nat. Marine Fish. Serv. computer printouts.

^c1977 and 1978 data from Japanese log books.

^dOne log book unavailable, therefore, effort estimated.

^eCatch and effort in this block probably higher -- missing information from one log book.

Table 3.6. Sablefish catch (t) and effort (10-hachi) statistics for Japanese longline fishery adjacent to Queen Charlotte Sound, Sub-zone 5-4 (50°30'-52°00'N lat.), 1968-78.

Year ^a	Total for Sub-zone 5-4			Block with the largest catch					
	Catch (t)	Effort (10-hachi)	CPUE (t/10-hachi)	Catch (t)				Effort (10-hachi)	CPUE (t/10-hachi)
				029510	029503	030510	030513		
1968 ^b	73	466	.157	22	-	-	-	189	.116
1969	765	3,700	.207	-	-	246	-	1,051	.234
1970	2,310	10,756	.215	-	-	886	-	3,988	.222
1971	655	4,458	.147	-	-	-	338	1,843	.183
1972	585	2,503	.234	-	-	-	295	1,140	.259
1973	460	2,156	.213	-	178	-	-	872	.204
1974	820	3,755	.218	-	-	-	268	1,172	.229
1975	1,444	7,397	.195	-	-	-	405	2,051	.197
1976	1,126	5,327	.211	-	-	-	741	3,382	.219
1977 ^c	1,081	7,342	.147	-	-	-	423	2,761	.153
1978	765	4,924	.155	-	-	-	304	1,954	.155

^aCalendar year.

^b1968-76 data from U.S. Nat. Marine Fish. Serv. computer printouts.

^c1977 and 1978 data from Japanese log books.

Table 3.7. Sablefish catch (t) and effort (10-hachi) statistics for Japanese longline fishery in the Vancouver Island Area, Sub-zones 5-1, 5-2 and 5-3 (48°00'-50°30'N. lat.), 1968-78.

Year ^a	Total for Sub-zones 5-1,2,3			Block with the largest catch						
	Catch (t)	Effort (10-hachi)	CPUE	Catch (t)					Effort (10-hachi)	CPUE
				028500	027493	027490	026483	025480		
1968 ^b	239	1,153	.207	-	102	-	-	-	466	.219
1969	1,969	10,062	.196	-	796	-	-	-	4,367	.182
1970	1,060	4,901	.216	455	-	-	-	-	1,858	.245
1971	594	4,152	.143	-	-	-	200	-	1,264	.158
1972	826	4,044	.204	-	191	-	-	-	826	.231
1973	798	3,622	.220	-	-	-	211	-	943	.224
1974	1,556	7,135	.218	-	-	-	-	411	1,893	.217
1975	1,379	7,126	.194	-	-	371	-	-	1,903	.195
1976	824	4,342	.190	267	-	-	-	-	1,295	.206
1977 ^c	1,164	7,672	.152	-	-	-	308	-	1,942	.158
1978	771	5,048 ^d	.162	-	238 ^e	-	-	-	1,445 ^e	.165

^aCalendar year.

^b1968-76 data from U.S. Nat. Marine Fish. Serv. computer printouts.

^c1977 and 1978 data from Japanese log books.

^dOne log book unavailable, therefore, effort estimated.

^eCatch and effort in this block probably higher--missing information from one log book.

Table 3.8. Reported Canadian sablefish discards (t), 1977-79.

Year	Area								Total
	4B	3C	3D	5A	5B	5C	5D	5E	
1977	-	-	2.7	-	-	-	9.1	-	11.8
1978	6.8	63.8	-	86.1	101.8	8.6	89.9	.4	357.5
1979 ^a	2.2	348.7	15.5	136.6	276.5	162.6	703.2	2.3	1,647.5

^aUntil Aug 31.

Table 3.9. Results obtained by fitting a dynamic stochastic stock production model (Schnute 1977) to sablefish catch statistics for Japanese longline fishery in Canadian waters (48°00'-54°30'N lat.).

Parameters estimated	1968-78 ^a
<u>Biological parameters</u>	
Natural growth rate (r)	.7299
Carrying capacity (K) (t)	28,564
<u>Fishing parameters</u>	
Catchability coefficient (q) (x10-hachi ⁻¹)	8.118x10 ⁻⁶
MSY (t/yr)	5,200
Biomass at MSY (t)	14,300
Optimum fishing effort (f _{opt}) (x10-hachi)	45,000
CPUE at f _{opt} (t/10-hachi)	0.116
<u>Variance parameters</u>	
σ	0.163
Failure Index ^b	0.888

^a1977 and 1978 CPUE corrected for discrepancy between observed recovery rates and recovery rate used by Japanese to calculate total catch weight from processed weight.

^bThe failure index is a rough gauge of the model's overall success in predicting present catches from past year's data. Although a value of 1.0 indicates a very poor fit, values less than 0.9 are generally deemed reasonable.

Table 3.10. Canadian sablefish trap fishery statistics -- Canadian rectangular collapsible traps and Korean conical traps, 1971-79.

Year	Total catch (t)	Monitored catch (t)		Monitored Effort (no. of traps)		CPUE (kg/trap)	
		Canadian traps	Korean traps	Canadian traps	Korean traps	Canadian traps	Korean traps
1971	? ^a	15	-	397	-	38	-
1972	? ^a	34 ^b	-	552	-	61	-
1973	732	133	-	2,556	-	52	-
1974	318	124 ^b	-	1,993	-	62	-
1975	458	79	-	2,185	-	36	-
1976	334	132 ^b	-	2,379	-	55	-
1977	215	101 ^b	-	1,916	-	53	-
1978	635	132	369	2,287	20,060	58	18
1979 ^c	735	132	527	2,829	31,204	47	17

^aCatch by trap not separated in catch statistics.

^bEstimated total.

^cTotals until Aug. 28.

Table 3.11. Sablefish CPUE (t/10-hachi and t/boat-day) and average fishing effort (10-hachi, boat-day) for Japanese longline fishery in Canadian waters, 1972-78.

Calendar year	10-hachi units ^a			Boat-days ^b		
	CPUE (t/10-hachi)	Effort ^c		CPUE (t/boat-day)	Effort	
		K=5	K=6		K=5	K=6
1972	0.207	16,495	-	9.29	387	-
1973	0.209	17,854	15,807	9.07	415	370
1974	0.210	17,124	17,672	7.94	408	424
1975	0.194	17,108	18,072	7.42	419	440
1976	0.194	17,057	17,010	7.48	433	422
1977	0.147(0.169) ^e	17,744	17,592	5.74 (6.60) ^e	457	444
1978	0.156(0.179)	17,949	17,019	6.20 ^f (7.13)	468	437

Parameter estimates from Gulland's (1961) linear regression model ^d					
	K=5	K=6		K=5	K=6
a	0.691(0.460) ^e	0.322(0.304) ^e		25.8(20.3) ^e	23.1(19.8) ^e
b	2.90x10 ⁻⁵ (1.53x10 ⁻⁵)	7.99x10 ⁻⁶ (6.51x10 ⁻⁶)		.0427(.0292)	.0373(.0289)
r	-0.593(-0.515)	-0.235(-0.318)		-0.907(-0.827)	-0.848(-0.939)
MSY (t/yr)	4,100(3,500)	3,200(3,500)		3,900(3,500)	3,600(3,400)
f _{opt} (10-hachi)	11,900(15,000)	20,200(23,300)	f _{opt} (boat-days/yr)	302(348)	310(343)

^aCompiled for Canadian waters (48°00'-54°30') from U.S. NMFS computer printout SM 762.

^bData for INPFC Areas Charlotte and Vancouver (47°30'-54°30') presented by Japanese delegation at Nanaimo, B.C., May 1978. Anon.

^cEffort averaged over previous K years.

^d $Y/f = a - bf$ where Y/f = CPUE, f = average effort over previous K yr.

$MSY = a^2/4b$

$f_{opt} = \text{optimum fishing effort} = a/2b$.

^eFigures in parentheses refer to calculations made using 1977 and 1978 CPUE corrected for discrepancy between observed recovery rates and recovery rate used by Japanese to calculate total catch weight from processed weight (see text).

^fFrom Japanese log books.

Table 3.12. Sablefish CPUE (t/10-hachi, t/boat-day) for Japanese longline fishery and all-nation catch (t) and calculated effort (10-hachi, boat-day) in Canadian waters (48°00'-54°30'N lat.), 1968-78.

Calendar year	All-nation catch (t) ^a	10-hachi units ^b				Boat-days ^c			
		Japanese longline CPUE (t/10-hachi)	Effort ^d			Japanese longline CPUE (t/boat-day)	Effort ^d		
			K=1	K=5	K=6		K=1	K=5	K=6
1968	2,801	0.261	10,732	-	-	10.05	279	-	-
1969	5,067	0.207	24,478	-	-	8.47	598	-	-
1970	5,480	0.215	25,488	-	-	9.04	606	-	-
1971	3,487	0.162	21,525	-	-	7.42	470	-	-
1972	5,840	0.207	28,213	22,087	-	9.29	629	516	-
1973	3,976	0.209	19,024	23,746	21,577	9.07	438	548	503
1974	4,612	0.210	21,962	23,242	23,448	7.94	581	545	554
1975	6,741	0.194	34,747	25,094	25,160	7.42	908	605	605
1976	6,702	0.194	34,546	27,698	26,670	7.48	896	690	654
1977	4,602	0.147	31,306	28,317	28,300	5.74	802	725	709
1978	3,241	0.156	20,776	28,667	27,060	6.20 ^e	523	742	692

Parameter estimates from Gulland's (1961) linear regression model^f

	K=5	K=6	K=5	K=6
a	.402	.420	15.7	16.1
b	8.35x10 ⁻⁶	9.26x10 ⁻⁶	.0129	.0142
r	-0.858	-0.858	-0.910	-0.955
MSY (t/yr)	4,800	4,800	4,800	4,600
f _{opt} (10-hachi)	24,100	22,700	609	567
			f _{opt} (boat-days/yr)	

^aTable 3.1.

^bCompiled for Canadian waters (48°00'-54°30') from U.S. Nat. Marine Fish. Serv. computer printout.

^cData for INPFC Areas Charlotte and Vancouver (47°30'-54°30') presented by Japanese delegation at Nanaimo, B. C. May 1978. Anon.

^dTotal effort = all-nation catch/Japanese longline CPUE.

^e1978 figure from Japanese log books.

^fY/f=a-bf where Y/f=CPUE, f=average effort over previous K yr; MSY=a²/4b; f_{opt}=optimum fishing effort=a/2b.

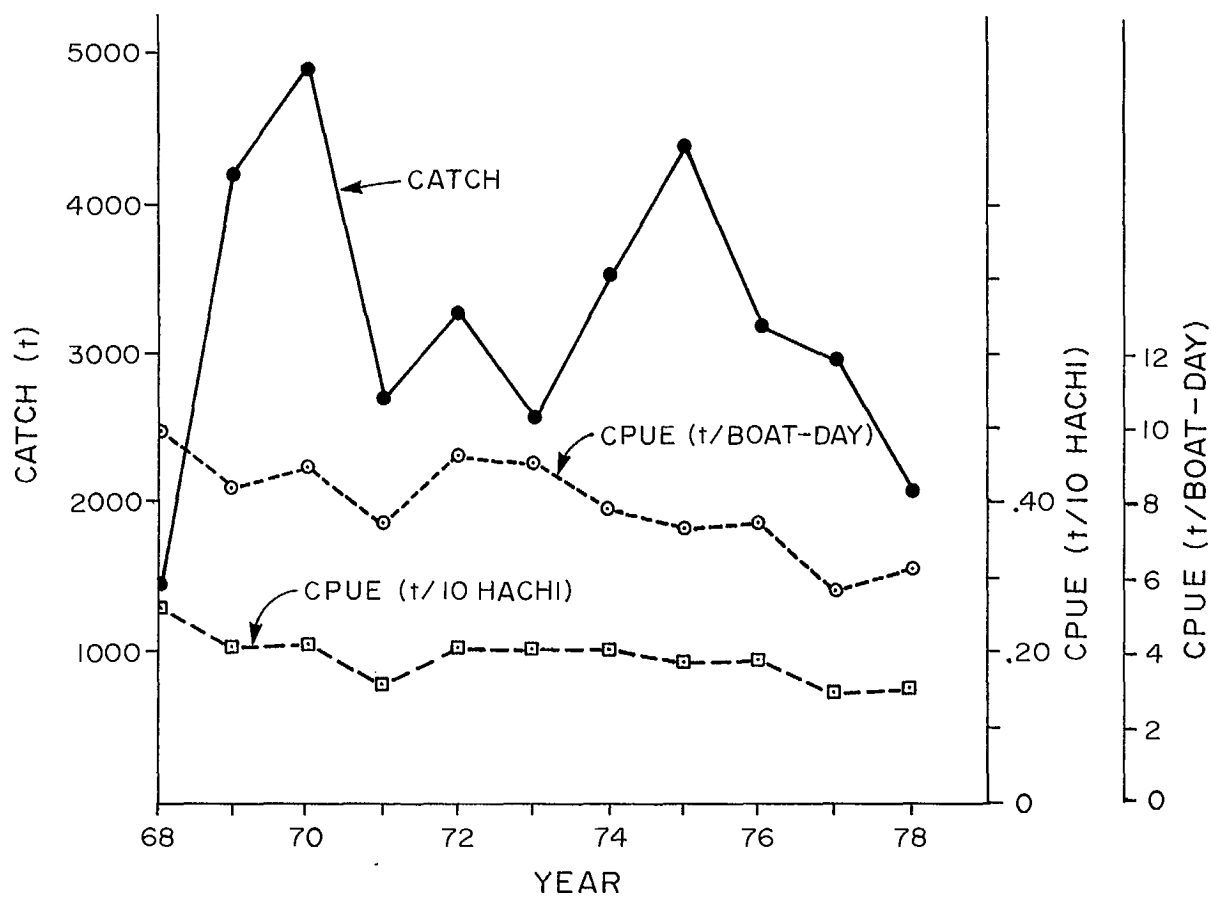


Fig. 3.1. Trends in catch and CPUE for Japanese longline fishery for sablefish in Canadian waters (48°00'-54°30'N Lat.) 1968-1978.

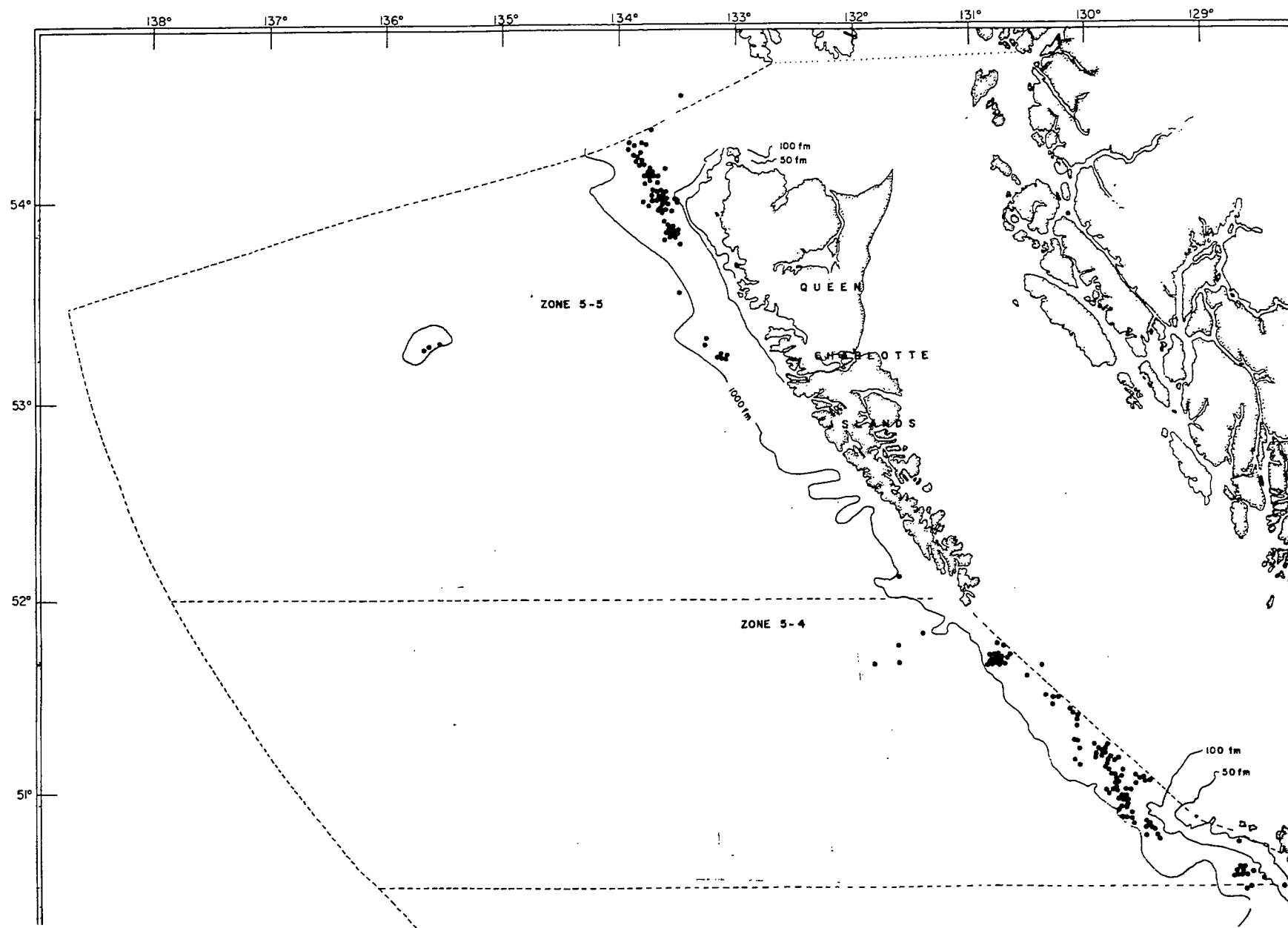


Fig. 3.2 Mid-day positions of Japanese longliners fishing for sablefish in Sub-zones 5-5 and 5-4 during 1977. One dot represents one mid-day position.

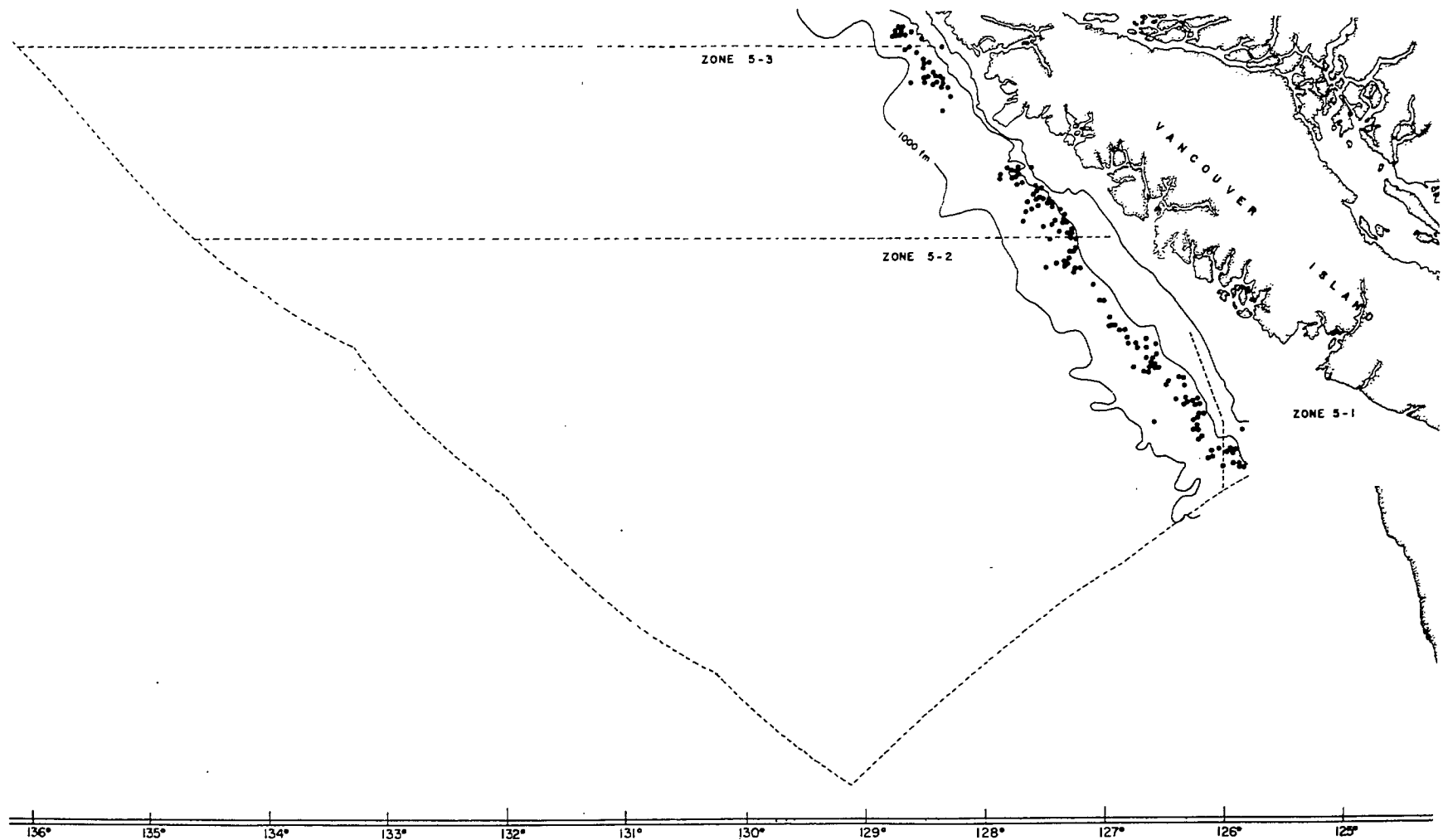


Fig. 3.2 (cont'd). Mid-day positions in Sub-zones 5-3, 5-2, and 5-1 during 1977. One dot represents one mid-day position.

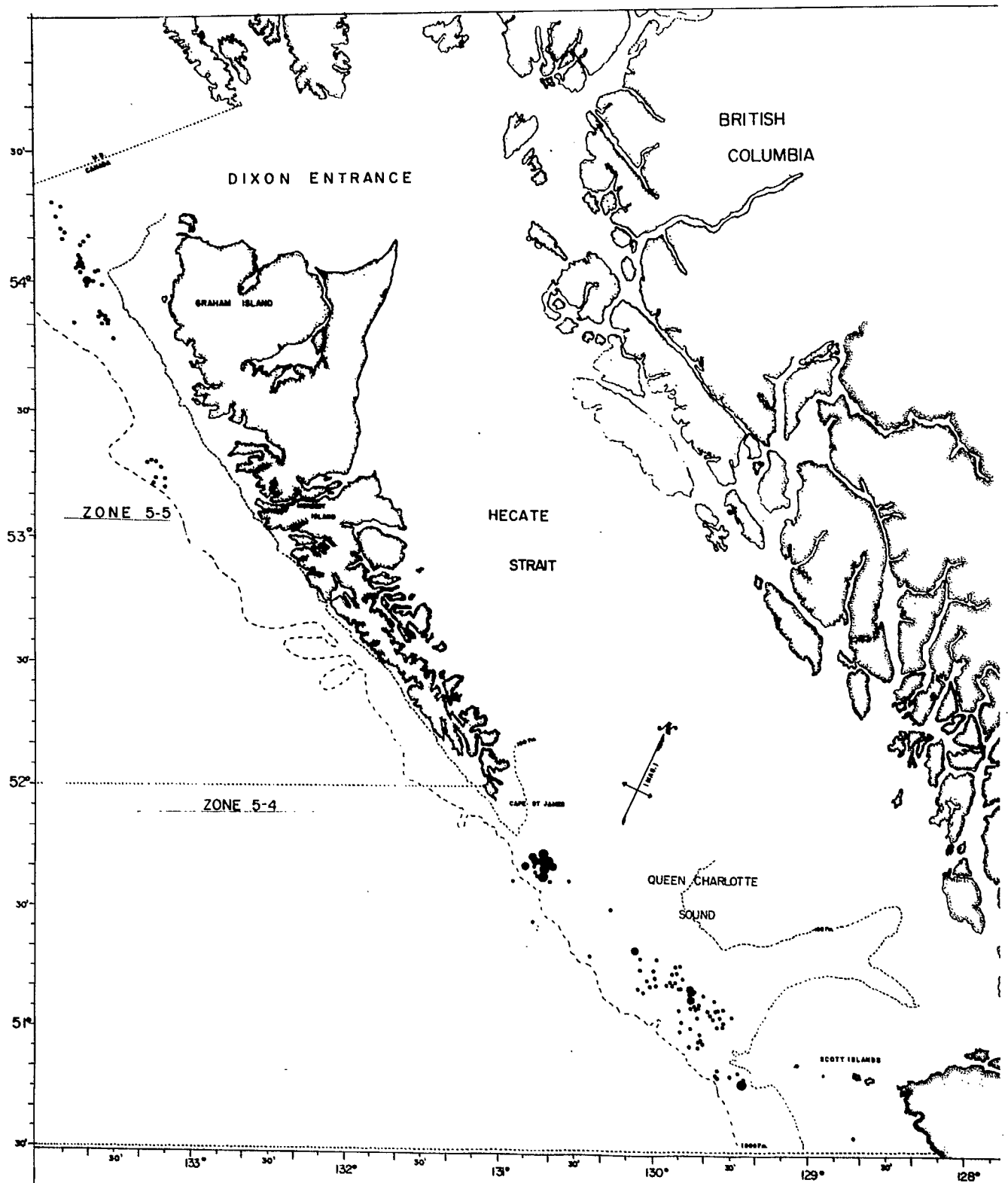


Fig. 3.3. Mid-day positions of Japanese longliners fishing for sablefish in Sub-zones 5-5 and 5-4 during 1978. Small dot represents one mid-day position; large dot represents more than one mid-day position.

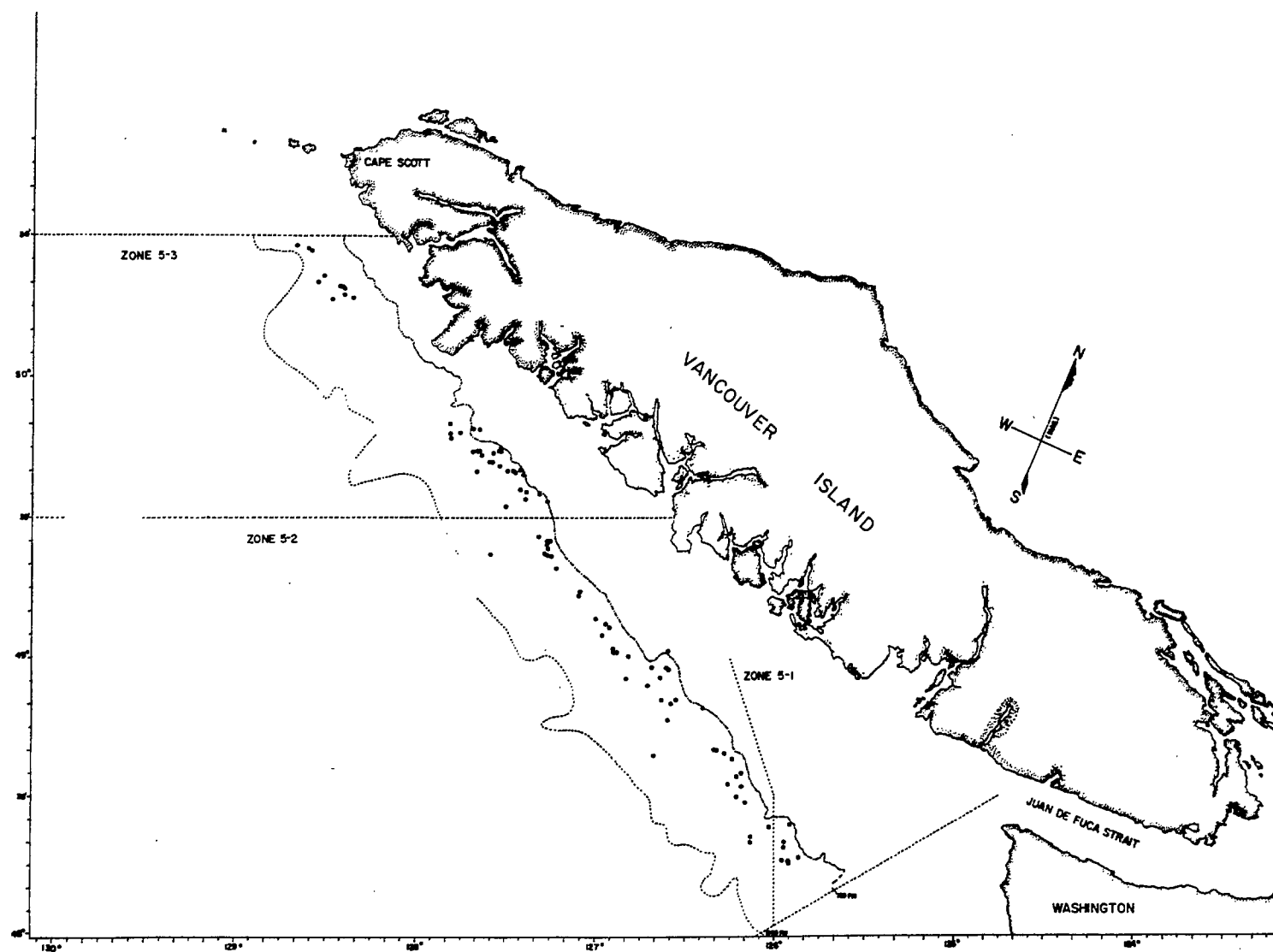


Fig. 3.3 (cont'd). Mid-day positions of Japanese longliners fishing for sablefish in Sub-zones 5-3, 5-2 and 5-1 during 1978. Small dot represents one mid-day position.

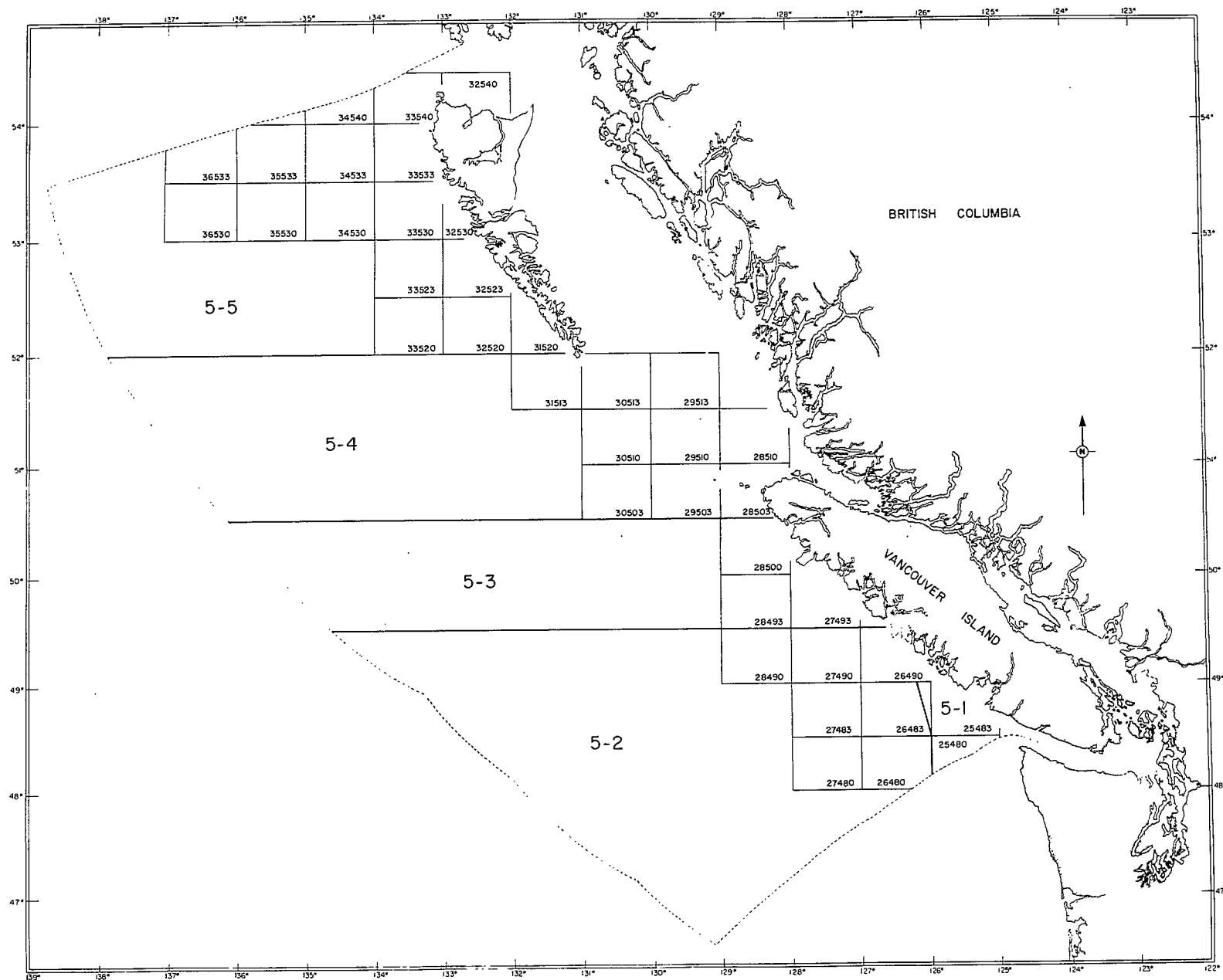


Fig. 3.4. Locations of blocks referred to in Japanese catch and effort records. Numbers refer to the longitude and latitude of the southeast corner of each block.

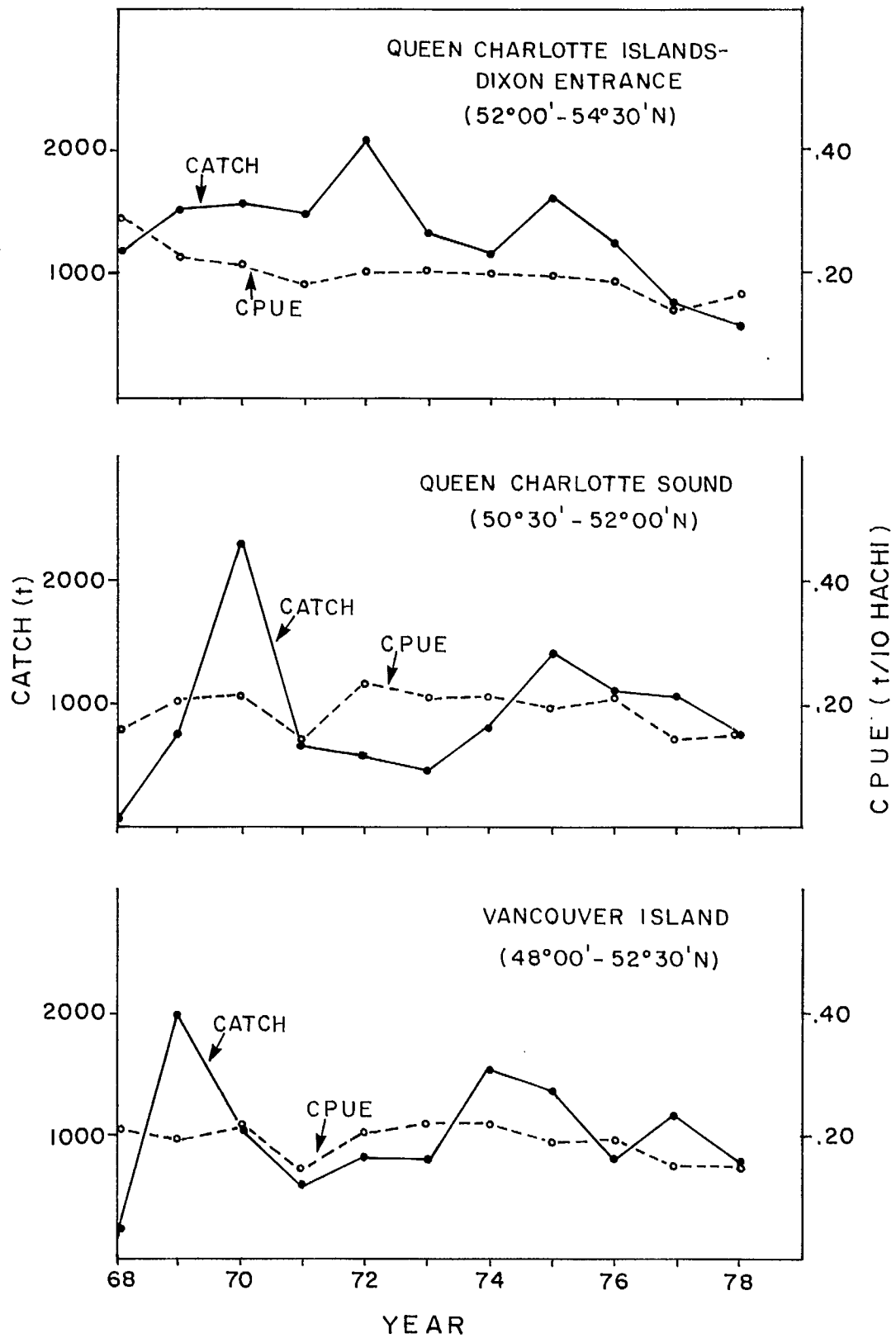


Fig. 3.5. Trends in catch (t) and CPUE (t/10-hachi) for Japanese longline fishery for sablefish by zone, 1968-1978.

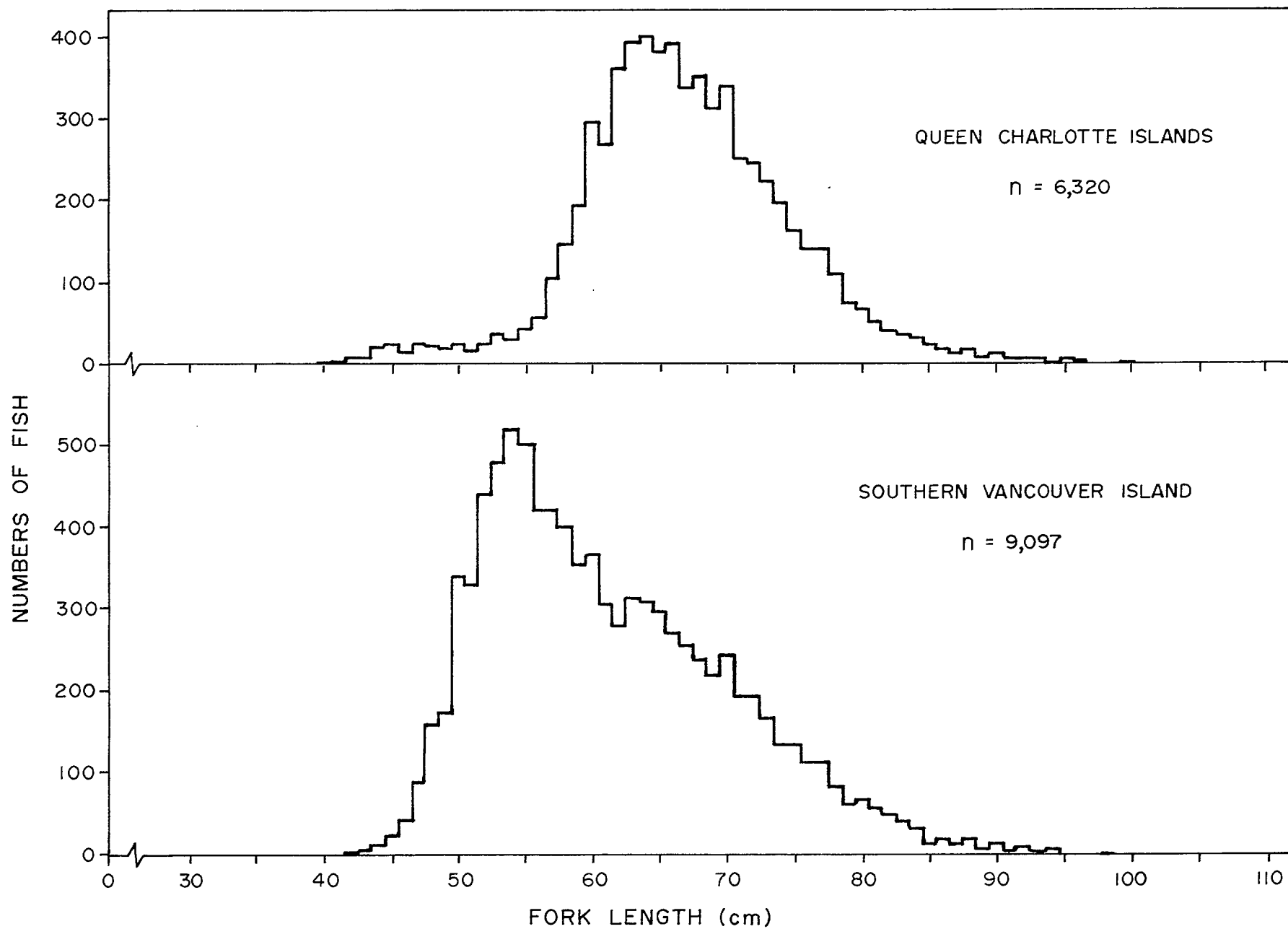


Fig. 3.6. Length frequency distributions of trap-caught sablefish from the west coasts of the Queen Charlotte Islands (May 1979) and southern Vancouver Island (June 1979).

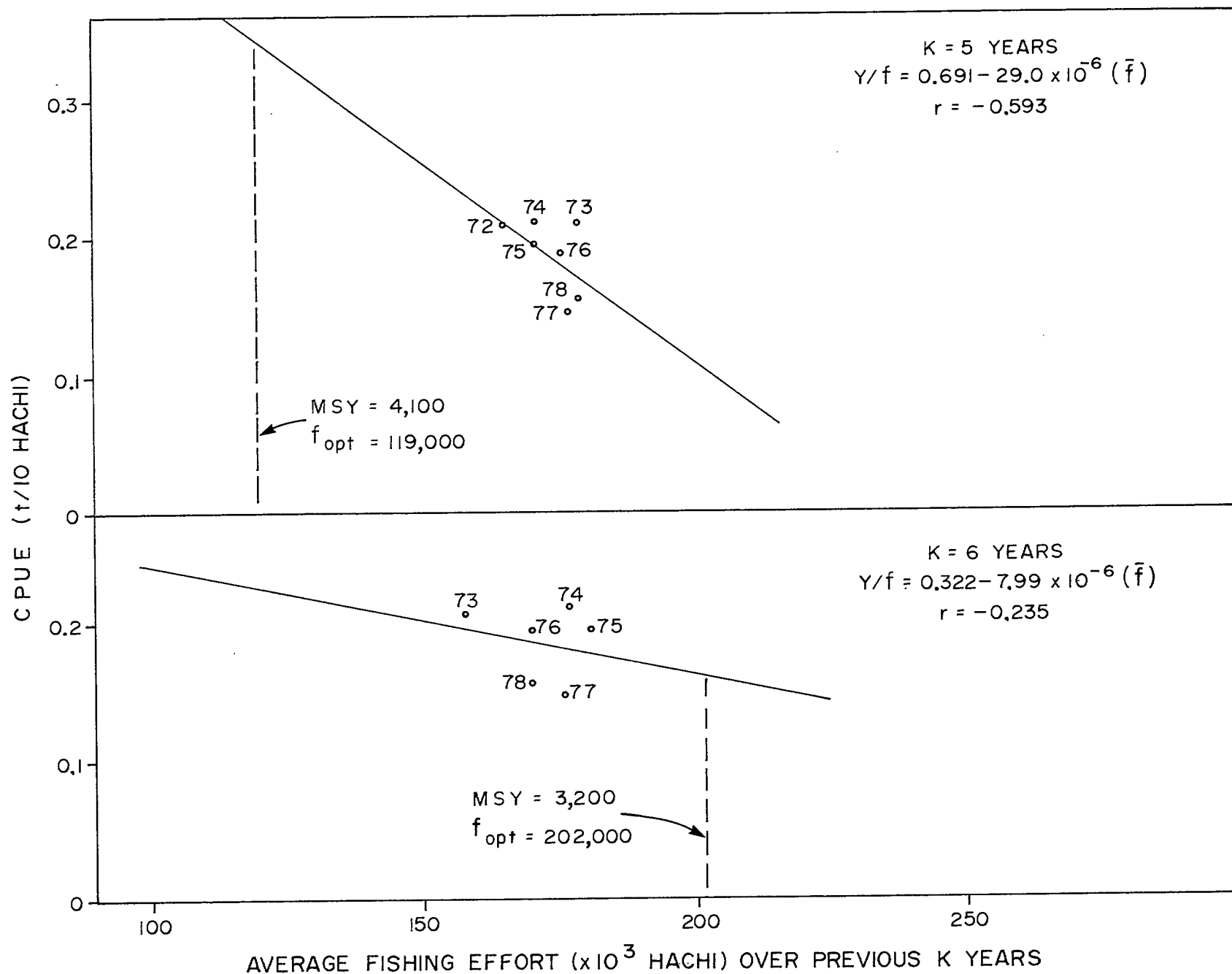


Fig. 3.7. Relationship between sablefish CPUE and fishing effort expressed in hachi averaged over previous 5 and 6 years respectively for Japanese longline fishery in Canadian waters (48°00'-54°30'N Lat.) -- Gulland (1961) linear regression model.

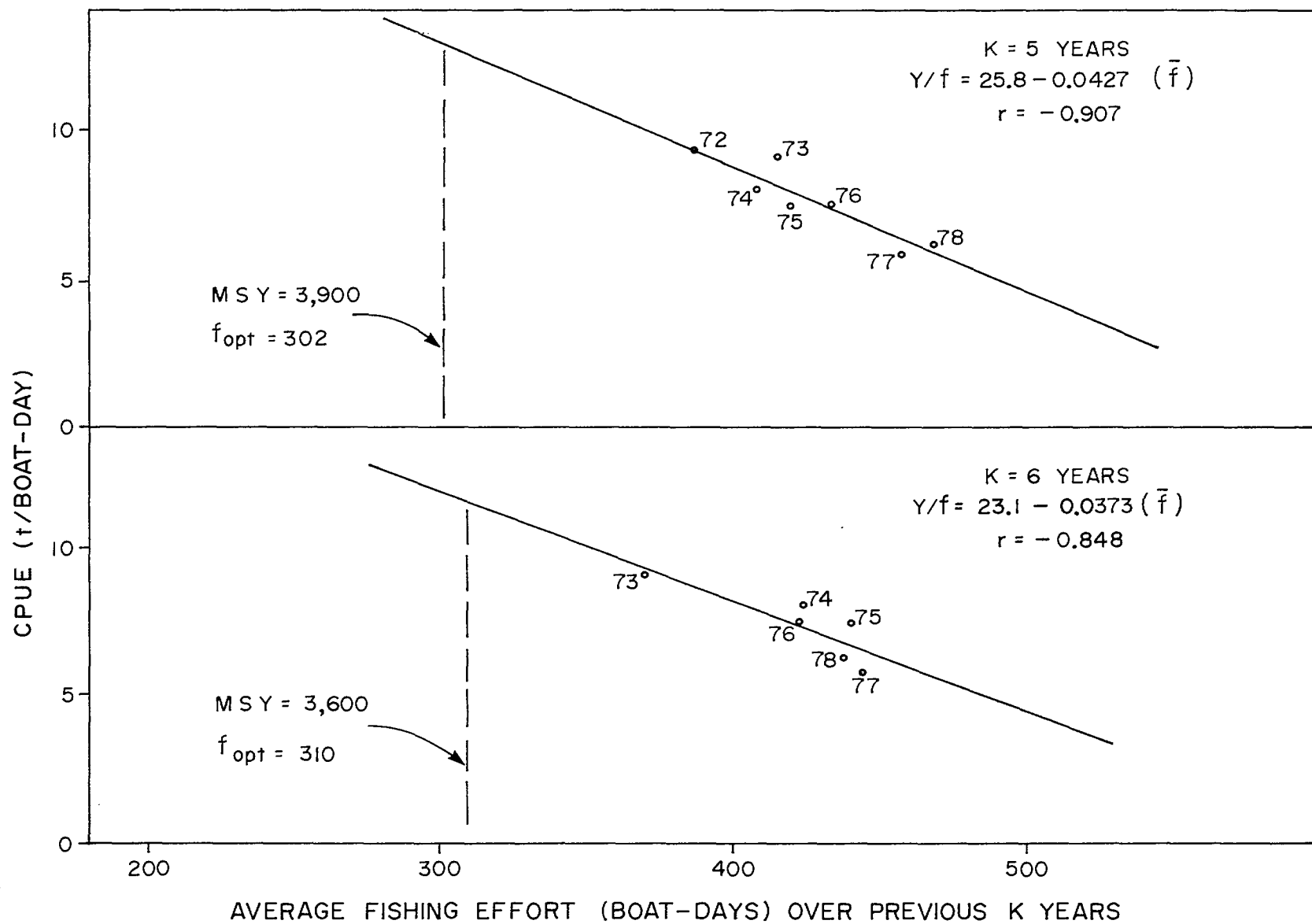


Fig. 3.8. Relationship between sablefish CPUE and fishing effort expressed in boat-days averaged over previous 5 and 6 years respectively for Japanese longline fishery in the Charlotte and Vancouver INPFC area (47°30'-54°30'N Lat.) -- Gulland's (1961) linear regression model.

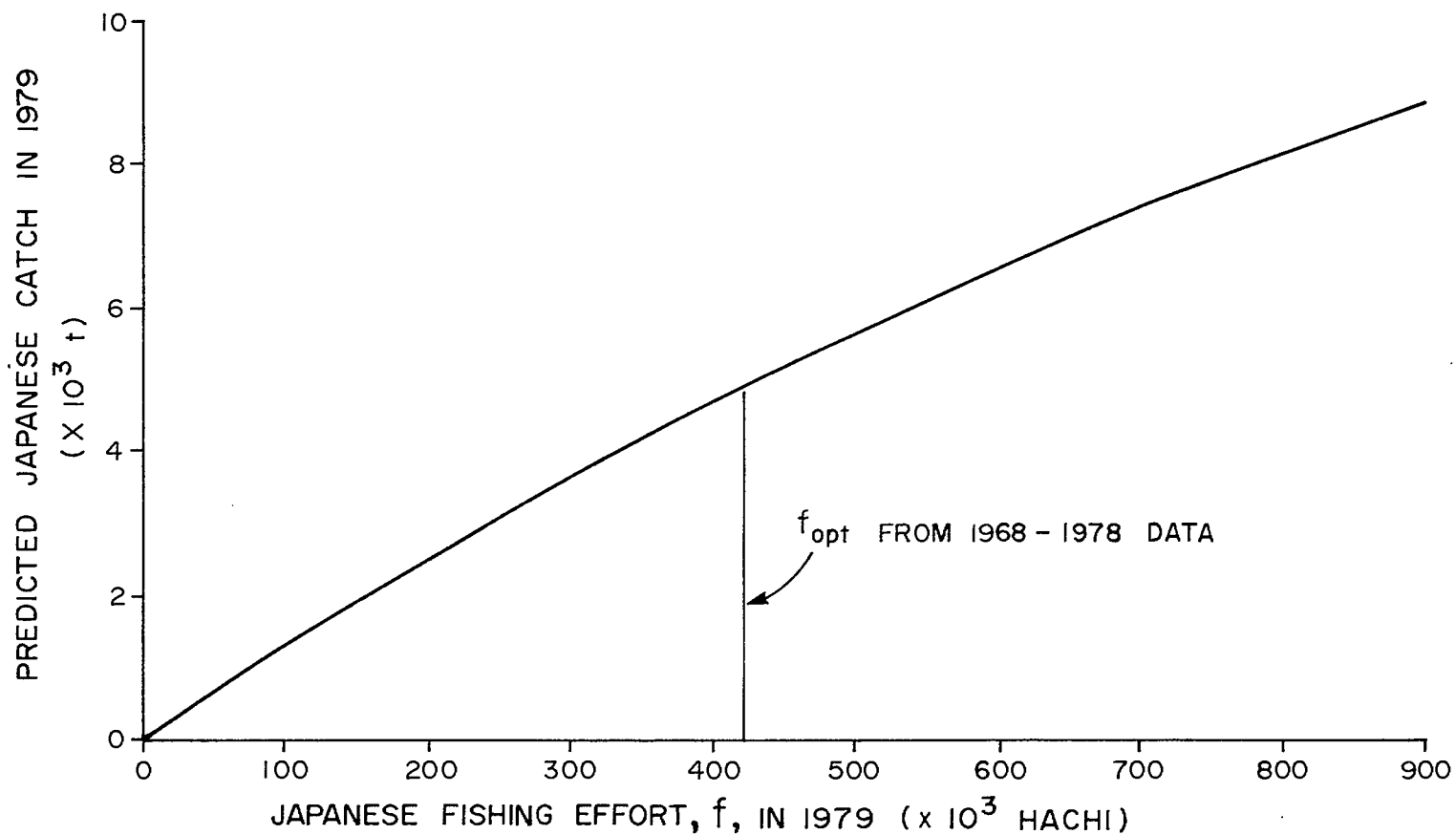


Fig. 3.9. Projected 1979 sablefish catch for given levels of effort by the Japanese longline fleet in Canadian waters based on 1968-1978 CPUE data and estimates of population parameters from the dynamic, stochastic stock production model (Schnute 1977). 1977 and 1978 CPUE are corrected for discrepancy in recovery weights.

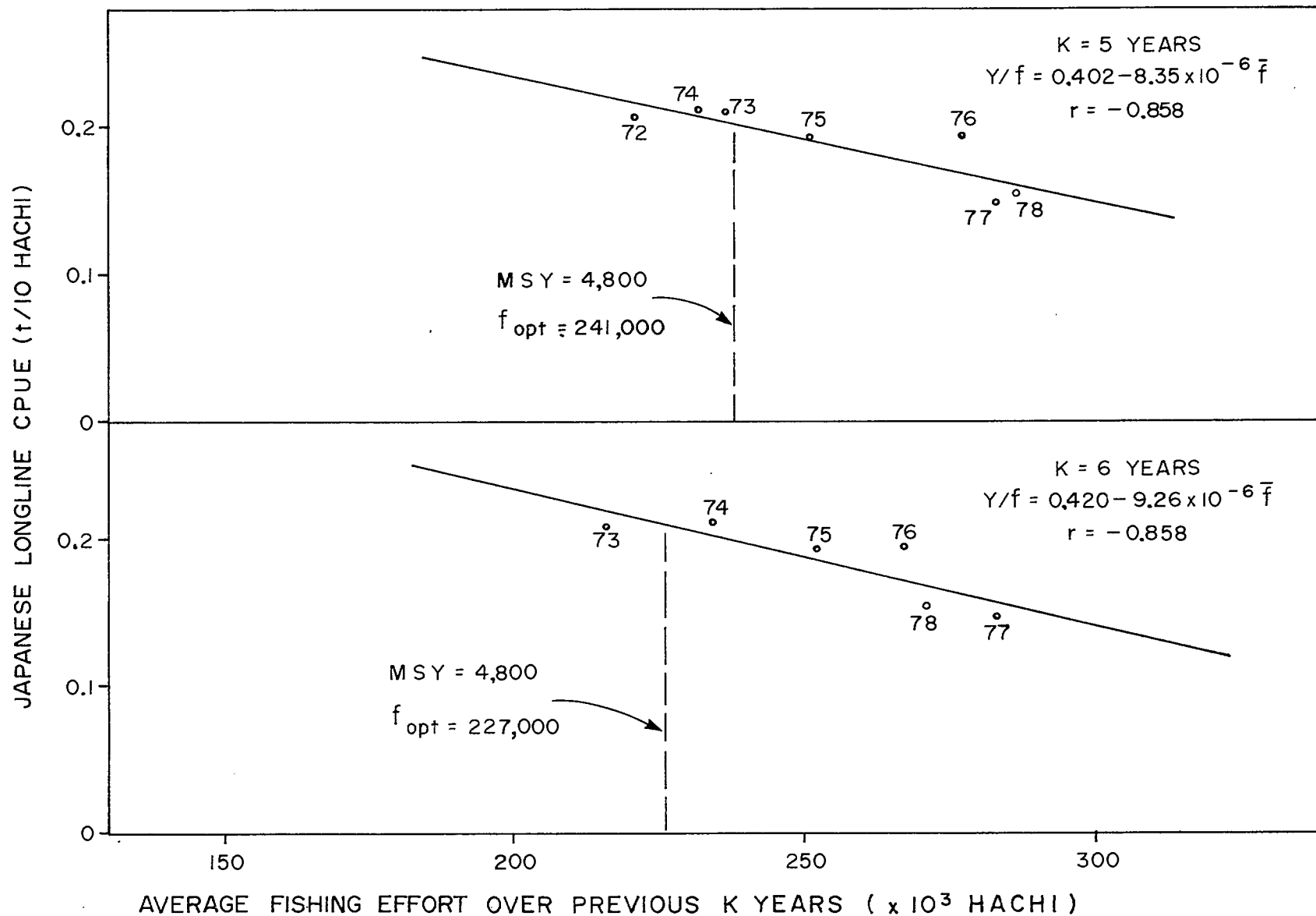


Fig. 3.10. Relationship between sablefish CPUE for Japanese longline fishery and estimated fishing effort by all nations in Canadian waters (48°00'-54°30'N Lat.) averaged over 5 and 6 years respectively -- Gulland's (1961) linear regression model.

4. PACIFIC COD STOCK ASSESSMENT

4.1 Introduction

Pacific cod (*Gadus macrocephalus*) is the most important species, based on quantities landed, in the Canada-United States trawl fishery off British Columbia. No other foreign nation participates in this fishery. Trawl fisheries exist in all regions of British Columbia except the west coast of Queen Charlotte Islands (Area 5E) (Fig. 1). Principal production regions are Hecate Strait (Areas 5C and 5D) and West Vancouver Island (Areas 3C and 3D), where annual Canada-U.S. landings during 1950-78 ranged from 1,814-9,072, and 907-5,443 t, respectively (Fig. 4.1). Secondary production regions are Queen Charlotte Sound (Areas 5A and 5B) and Georgia Strait (Area 4B) where 1950-78 landings ranged from 454-2,722 and 907-1,168 t, respectively. In all regions, landings fluctuated substantially, and somewhat cyclically.

Pacific cod in British Columbia waters exhibit rapid growth and a short life (Ketchen 1967). They recruit to the fishery at age 2+ and cease to be commercially abundant at age 5+ or less. The individual regional fisheries largely depend upon one or two year-classes in any one year. Hence, the large fluctuations in landings reflect the highly variable abundance of individual year-classes. Total mortality rate is high, and natural mortality rate comprises a large proportion, possibly of the order of 55-65% per annum (Ketchen 1964). To date, no evidence is available to demonstrate that the fishery is the major factor in determining year-class abundance, except possibly in Area 3C.

Regional stock delineation has been roughly achieved by tagging studies conducted by Canadian and United States scientists in waters of Hecate Strait, Georgia Strait, Puget Sound, southwest Vancouver Island, and northwest Washington State. Migration of cod among regions has been negligible in most cases. Percentages of recaptures reported from outside the tagging region were: 0.3% for Area 5C and 5D; 9.2% for Area 4B; 2.3% for Area 4A; 2.1% (Canadian) and 14.3% (U.S.) for Area 3C; 11.9% for Area 3B; and 42.9% for Area 3A. The 1979 report contains the details (Ketchen, ed. 1980).

The purpose of this report is to review the available statistical and biological information on Pacific cod in British Columbia waters, and to assess the condition and yield of the regional stocks off southwest Vancouver Island (Area 3C), Georgia Strait (Area 4B), Queen Charlotte Sound (Areas 5A and 5B), and in Hecate Strait (Areas 5C and 5D).

4.2 Georgia Strait and vicinity (Area 4B)

Pacific cod was the most important species in the foodfish trawl landings from the Canadian portion of Georgia Strait and vicinity (Area 4B) (Fig. 4.1), and accounted for 37% of the total groundfish production during 1960-72 (Forrester and Smith 1974). In second place was English sole (13%). For Area 4B, October-September has been established as the fishing year because of numerous time-area closures in effect throughout most of the

area, and traditional tendency for the fleet to concentrate its efforts during October-March when the fish congregate for spawning (Forrester and Ketchen 1963).

Localized stocks of Pacific cod have been delineated by tagging experiments conducted during 1954-62 in the important production locations -- Northwest Gulf (Minor Statistical Area 14), Nanoose Bay (MSA 17N), Gulf Islands (MSA 17S and 18), and Juan de Fuca Strait (MSA 19 and 20) (Fig. 4.1). Little inter-MSA migration was noted for tagged cod, except those tagged at Nanoose Bay. Detailed results were reported in the 1979 report (Ketchen ed. 1980).

4.2.1 Statistics and mortality rates

During 1960-78, October-September trawl landings of Pacific cod from Area 4B ranged from 326-1,444 t, with peak landings in 1963-64, 1966-67, 1970-71, 1975-76, and 1977-78 (Table 4.1). Mean annual landing was 632 t. Principal production locations were Minor Statistical Areas 18 (35%), 19 (21%), and 17 (19%). In all minor statistical areas annual landings fluctuated substantially, and among MSAs non-synchronously. Only in 1975-76 did peak landings occur simultaneously for MSAs 17, 18, and 19.

Estimates of instantaneous total mortality rate (Z) for 1955-58 were 1.27-1.77, based on growth parameters and length-frequency data, and tag returns (Ketchen 1961). Instantaneous natural mortality rate (M) for the same period, was estimated to be 1.39. Thus, instantaneous fishing mortality rate was apparently relatively low - ca 0.29. Equivalent annual rates are: 72-83% total; 75% natural, and 25% fishing.

4.2.2 Stock assessment

Previous assessments of the Pacific cod stock(s) in Georgia Strait and vicinity have all concluded that the fishery was not the major factor in the substantial fluctuations in abundance (Forrester and Ketchen 1963; Forrester and Smith 1974; Ketchen 1967). Production, though variable and somewhat cyclical, shows no trend (Fig. 4.2), and no evidence is currently available to refute the conclusions of past stock assessments.

4.2.3 Recommendations

A TAC of 1,000 t is recommended for Pacific cod in the Strait of Georgia (Area 4B) in 1980.

4.3 West Vancouver Island (Areas 3C and 3D)

Pacific cod is currently the most important species in the Canada-U.S. trawl landings from Area 3C (Area 3D production is negligible)--- 33% during 1965-74 (Westrheim 1977). Canadian share of the landings has exceeded 60% since 1966 (Fig. 4.1). Identifiable fishing grounds are

Lennard Island (MSA 24), Amphitrite Bank⁷, Big Bank⁸, Clo-oose, Swiftsure, and Cape Flattery Spit (Fig. 4.2). For analytical purposes, Area 3D has been excluded from further discussion.

Age composition of landings was essentially age-2 fish during April-September, and age-3 fish during January-March. Thus, the fishery generally depends upon the abundance of one-year class in each April-March period. Passage through the fishery of weak or strong year classes can alter this relationship.

Stock delineation is difficult with the limited information available. Results of past tagging experiments suggest some migration of cod between Area 3C and Areas 4A, 4B, 3A, and 3B, but no quantification is possible. It is possible that several stocks reside in or pass through Area 3C.

4.3.1 Statistics and mortality rates

During 1956-78, Canada-U.S. trawl landings of Pacific cod from Area 3C averaged 2,036 t and ranged from 390-5,487 t -- with peaks in 1957, 1963, 1966, 1972, and 1975 (Table 4.2). Seasonal distribution of landings has changed during 1956-78 -- 81% April-September during 1956-64; 79% January-June during 1965-76. During April-September, the fishery harvests maturing, feeding cod; and during January-March, spawning cod.

Major fishing grounds in Area 3C, based on proportion of 1960-78 landings, were Amphitrite Bank (51%) and Big Bank (20%) (Table 4.3). Minor fishing grounds were Clo-oose (12%), Swiftsure (9%), Lennard Island (4%), and Cape Flattery Spit (4%). For the minor grounds, principal time of landings was January-June for Clo-oose, and April-September for Lennard Island, Swiftsure, and Cape Flattery Spit.

4.3.1.1 Amphitrite Bank

During 1960-78, annual production from Amphitrite Bank ranged from 170-2,558 t, and has been increasing -- 170-383 t during 1960-64; 547-1,144 t during 1965-70; and 789-2,558 t during 1971-78 (Table 4.4). Principal season of landings has gradually changed from April-June (49-58%) during 1960-64 to January-March (71-96%) during 1973-78. The low value in 1978 was due to a closure of the Canadian portion of Area 3C to trawling during late February and all of March.

Conventional analysis of landings, effort and CPUE is virtually precluded by the variable nature of the fishery, which has evolved from a spring fishery (1960-64) on maturing and mature feeding fish to a winter fishery (1972-78) on spawning fish. Furthermore, during 1972-78 the fishery reportedly evolved from interception on the bank's periphery, of cod moving

⁷Includes Firing Range and Cabbage Patch Grounds.

⁸Includes S.E. Corner, S.W. Corner, Gunsight, and Finger Bank Grounds.

onto and off the spawning grounds, to trawling on schools concentrated for spawning on the bank itself. This latter development began about 1974. Nevertheless, the January-March landing statistics for Amphitrite Bank are shown in Table 4.5. The relatively large landings and catch rates during 1972-76 reflect heavier (older) individual fish, denser concentrations of spawning fish (than feeding fish), and probably relatively more abundant year-classes. However, the sustained production was in part caused by the new method of targetting on spawning fish. Unfortunately, data are not available yet for standardizing effort.

Estimated rates of instantaneous total mortality for year-classes 1967-71 ranged from 1.00-1.38, and varied directly with year-class abundance. Equivalent annual rates were 63-75%. Details of the computations were presented in the 1979 report (Ketchen, ed. 1980).

4.3.1.2 Big Bank

During 1960-78, annual production from Big Bank ranged from 48-1,729 t, with peak production periods in 1965-66, 1971-72, and 1974-76 (Table 4.4). Principal season of landings has been April-September (79% of mean annual landings) throughout 1960-78.

Conventional analysis of landings, effort and CPUE is warranted, providing that two constraints are acknowledged. First, the Canadian fleet has increased its efficiency (new, larger vessels) during the 1970s, although apparently no new fishing techniques have been developed. Second, during the same period, dogfish has become so abundant that they sometimes represent a hazard to trawling on Big Bank during April-September. Neither of these constraints has been quantified.

Analysis of landing statistics was restricted to April-September when annual proportions landed were greatest (79%) and most consistent (Table 4.4). Canada-U.S. landings and calculated fishing effort have generally fluctuated directly with one another (Table 4.5), with peaks in 1963, 1966, 1972, and 1976. Canadian vessels' catch rate likewise fluctuated, but not consistently with landings and effort. Catch rate peaks occurred in 1964, 1966, 1968, 1972, and 1977. Absence of a peak in 1976, and the relatively low values during 1974-77 (234-521 kg/hr), suggest that the Pacific cod stock on the Big Bank is now at a relatively low level of abundance.

Estimated rates of instantaneous total mortality for year-classes 1968-72 ranged from 0.66-1.52, and varied directly with year-class abundance. Equivalent annual rates were 48-78%. Details of the computations were presented in the 1979 report (Ketchen, ed. 1980).

4.3.2 Stock assessment

Currently, abundance of Pacific cod in Area 3C appears to be at a relatively low level, based on landing statistics and age composition data, and no new strong year-classes have been detected. Historically, cod abundance has fluctuated regularly and substantially.

However, the Canadian fleet has increased its efficiency with new, larger vessels, and improved fishing techniques (on spawning fish). Thus, for the first time, recruitment overfishing is a distinct possibility, during the January-March fishery on spawning fish. In 1979, the January-March fishery for Pacific cod was restricted, by area closure, to January only, because projected landings were only 400-800 t. Echo-sounder and trawl surveys on Amphitrite Bank during February-March indicated that abundance of spawning cod was low. A similar closure will be considered for 1980 if the projected January-March landings are also small (see Appendix I for details on method of prediction).

4.3.3 Recommendations

A TAC of 1,500 t is recommended for Pacific cod in Areas 3C and 3D combined, for 1980, together with a prohibition of target fishing for Pacific cod during the months of January, February, and March, if necessary.

4.3.4 Addendum

Quarter III Canadian landings from Area 3C totalled 225 t, and the predicted Quarter I total landings in 1980 is 775 t, compared to 1,207 t using the Quarter II predictor. We believe the Quarter II predictor overestimates the 1980 Quarter I landings, because most of the Quarter II landings consisted of age-3 and age-4 cod, most of which will not survive to spawn the following winter. The Quarter III prediction of 775 t indicates spawning cod will be in relatively low abundance during January-March 1980. Therefore, we recommend that Area 3C (shallower than 100 fm) be closed to trawling during January-March.

4.4 Queen Charlotte Sound (Areas 5A and 5B)

Pacific cod is relatively unimportant in the Canada-U.S. trawl landings from Queen Charlotte Sound. During 1965-74, Pacific cod ranked third (12%) behind Pacific ocean perch (43%) and Other rockfish (26%) (Westrheim 1977). Canadian share of these cod landings has rarely exceeded 30% over the long term, but the proportion has risen markedly during the last several years (Fig. 4.1). Size and age composition data from commercial landings are intermittent and too sparse for analysis.

Principal fishing grounds are Goose Island Bank (Area 5B) and the grounds lying off the north coast of Vancouver Island (Area 5A) (Fig. 1).

No tagging experiments have been undertaken for Pacific cod in Queen Charlotte Sound, nor any other studies which would provide evidence for inter- or intra-regional stock delineation. Indirect evidence of regional isolation is the near-absence of cod recaptured in Queen Charlotte Sound which had been tagged elsewhere (Ketchen, ed. 1980). It is possible that cod in Area 5A are to a large degree separate from those in Area 5B.

4.4.1 Statistics and mortality rates

During 1956-78, Canada-U.S. landings of Pacific cod from Queen Charlotte Sound averaged 1,403 t, and ranged from 239-2,744 t, with peaks in 1957, 1965, 1972, and 1975 (Table 4.6). Principal time of landings was April-September in Areas 5A (78%) and 5B (90%). In Area 5A, landings ranged from 98-2,244 t, with peaks in 1957, 1966, 1972, 1974, and 1976. Trend is downward, based on landings in peak years. In Area 5B, landings ranged from 144-1,751 t, with peaks in 1960, 1965, 1972, and 1975. Trend is upward, based on landings in peak years.

Mortality rates have not been established for Pacific cod in Queen Charlotte Sound, primarily due to the paucity of available data.

4.4.2 Stock assessment

On the basis of the limited data available, there is no indication that the fishery is a major factor in the fluctuating abundance of Pacific cod in Queen Charlotte Sound. No explanation is available for the opposing production trends in Areas 5A and 5B. In summary, the Pacific cod stock in Queen Charlotte Sound appears to be in satisfactory condition.

4.4.3 Recommendation

A TAC of 2,000 t is recommended for Pacific cod in Queen Charlotte Sound (Areas 5A and 5B) for 1980.

4.5 Hecate Strait and Dixon Entrance (Areas 5C and 5D)

Pacific cod is currently the most important species in the trawl landings from Hecate Strait and Dixon Entrance (Areas 5C and 5D). During 1965-74, Pacific cod accounted for 56% of the Canada-U.S. trawl landings from this region (rock sole was second at 18%) (Westrheim 1977). Canadian share of the cod landings has exceeded 70% since 1960, and has been 100% since 1971 (Fig. 4.1). Landings are currently reported from seven fishing grounds -- Tow Hill; Two Peaks-Butterworth (hereafter referred to as Two Peaks); Freeman Pass-White Rocks-Bonilla (hereafter referred to as White Rocks); Shell (Potholes); Ole Spot; Horseshoe; and Reef Island (Fig. 4.3).

Tagging studies have demonstrated a migration of cod between winter spawning grounds at White Rocks and spring-summer feeding grounds at Two Peaks, but the relationship has not been quantified. A similar relationship appears to hold between Bonilla and Ole Spot-Horseshoe. Intra-regional stock delineation is not well understood at this time.

Age composition of Pacific cod landings is generally 2+ and 3+ fish during April-September, and 3+ and 4+ during October-March. Thus the fishery relies primarily on the abundance of two year-classes during each year.

4.5.1 Statistics and mortality rates

During 1956-78, annual Canada-U.S. landings averaged 3,895 t, and ranged from 1,339-9,520 t, with peak production periods during 1958-59, 1964-68, and 1973-76 (Table 4.7). No trend in production is evident. Principal time of landing was January-September (91%). Mean percentages were 30, 33, and 28, respectively for Quarters I-III, and 9% for Quarter IV. Quarter I landings have become relatively less important since 1971 (8-25%).

Major fishing grounds, based on percentage contribution of landings during 1956-78 are Two Peaks (38%), White Rocks (26%), and Horseshoe (19%) (Table 4.8). Minor fishing grounds are Ole Spot (6%), Shell (5%), Reef Island (4%), and Tow Hill (1%). Shell and Reef Island Grounds did not come into continuous production until the late 1960s and their 1968-78 mean percentages are 10 and 8, respectively, compared to 76% for the three major grounds combined. Winter fisheries on spawning cod predominate at White Rocks and Reef Island, while spring-summer fisheries for feeding cod prevail elsewhere in Hecate Strait.

4.5.1.1 Two Peaks Ground

During 1956-78, annual landings of Pacific cod from Two Peaks Ground ranged from 505-3,194 t, with peak production periods during 1957-59, 1964-68, and 1972-77 (Table 4.9). Principal time of landings is April-September (78%).⁹ Quarters II and III were more consistently important than Quarters I and IV. Landing statistics for Quarters II and III have been used to assess this stock.

Statistics for Pacific cod landed from Two Peaks Ground during April-September indicate substantial fluctuations in abundance, but no long-term trend upward or downward. Canada-U.S. landings have ranged from 406-2,473 t with peaks in 1959, 1966, and 1975 (Table 4.10). The 1978 landing was 480 t. CPUE likewise has fluctuated without trend, with values ranging from 0.376 t/hr in 1972 to 1.808 t/hr in 1964. Peak values occurred in 1959, 1967, and 1974. In 1978, CPUE was 0.436 t/hr.

Estimates of total instantaneous mortality rate (Z) were obtained from three time periods and methods -- years 1954-63, with growth parameters and length-frequency data (Ketchen 1964); year-classes 1968-72 (Quarters II and III), by scales; and year-classes 1957-72 (Quarter III), by length-frequency analysis (Foucher, personal communication). Values of Z from the three sources were 1.11-1.27 (1954-63), 0.02-1.16¹⁰ (year-classes 1968-72) and 0.76-2.57 (year-classes 1957-72). For the 1957-72 year-classes, Z generally varied directly with year-class abundance. Equivalent annual rates were 53-92%. Details were provided in the 1979 report (Ketchen, ed. 1980).

⁹High percentages for Quarter I in 1956 and 1957 are considered to be erroneous. Probable origin was White Rocks.

¹⁰Results questionable. Further studies on age determination are underway.

4.5.1.2 White Rocks Ground

During 1958-78¹¹, annual landings of Pacific cod from White Rocks Ground ranged from 319 t-2,341 t, with peak production periods during 1958-60, 1963-68, and 1975-76 (Table 4.11). No trend is evident. Principal time of landings is October-March -- 1956-78 mean proportions were 55% for Quarter I and 26% for Quarter IV. Proportions landed during Quarter I were more consistent than for Quarters II, III, and IV, but for analytical purposes, catch statistics were assembled which combined Quarter IV with Quarter I in the following year.

Statistics for Pacific cod landed from White Rocks Ground during Quarters IV and I show a generally close relationship between landings, effort, and CPUE, with peaks in 1962-63, 1964-65, 1967-68, 1972-73, and 1975-76 (Table 4.12). Only in 1958-59 did CPUE fail to peak with landings and effort. No trend is evident in landings, effort, or CPUE, but landings, effort and CPUE have declined steadily since 1975-76.

Estimated instantaneous total mortality rate (Z) was 1.17 for the 1968 year-class and 1.11 for the 1972 year-class. Details of the computations were provided in the 1979 report (Ketchen, ed. 1980).

4.5.1.3 Horseshoe Ground

During 1956-78, annual landings of Pacific cod from Horseshoe Ground ranged from 20 t to 3,110 t (Table 4.13). Peak production periods were 1958, 1964-68, and 1973-74. No trend is evident. Principal time of production was Quarters II and III, and landing statistics for these quarters have been combined for assessment of cod stock on Horseshoe Ground.

Quarter II and III landing statistics did not display the close relationship between landings, effort and CPUE noted for cod from Two Peaks and White Rocks Grounds. Landings peaked in 1958, 1966, 1973, and 1976 (Table 4.14). Peaks in effort occurred in 1960, 1965, 1968, and 1974 while CPUE peaks occurred in 1958, 1964, 1973, and 1976. Only in 1976 did the three factors peak simultaneously. No trend is evident in landings, effort, or CPUE.

Estimated values of instantaneous total mortality rate ranged from 0.94 to 2.12 for year-classes 1969-72, and varied directly with year-class abundance. Details of the computations were included in the 1979 report (Ketchen, ed. 1980).

4.5.1.4 Minor grounds

Minor grounds in Hecate Strait are Ole Spot, Shell Ground, and Reef Island -- the latter two are relatively new discoveries.

¹¹1956-57 values are deemed inaccurate. See footnote in preceding Two Peaks Section.

Ole Spot. Landings have been reported from Ole Spot since prior to 1956. During 1956-78, landings ranged from nil-1,580 t (Table 4.15). Landings peaked in 1958, 1966, and 1973, and have been less than 100 t/annum since 1971. Principal time of landings is April-June (89%). Age composition data are intermittent and too sparse for analysis.

Shell Ground. Landings have been reported from Shell Ground since 1966 on a regular basis. During 1966-78, landings ranged from 49-1,113 t without trend (Table 4.15). Peak landings occurred in 1968 and 1975. Principal time of landings was January-June (83%). Age composition data are intermittent and too sparse for analysis.

Reef Island. Landings have been reported from Reef Island Ground since 1968 on a regular basis. During 1968-78, landings ranged from 100-580 t with peaks in 1969, 1971, 1973, and 1976, without evident trend (Table 4.15). Principal time of landings was January-March (71%) when cod are spawning. Age composition data are intermittent and too sparse for analysis.

4.5.2 Stock assessment

During 1956-78 Pacific cod landings from Areas 5C - 5D, and presumably abundance, exhibited substantial, quasi-cyclic fluctuations which were, for the most part non-synchronous among grounds. No trend in landings or CPUE was evident for any fishing ground, except White Rocks. On the basis of the available evidence, Pacific cod stocks in Hecate Strait are in satisfactory condition, despite the fluctuations in annual landings.

4.5.3 Recommendation

A TAC of 2,000 t is recommended for Pacific cod in Hecate Strait and Dixon Entrance (Areas 5C and 5D) in 1980.

Table 4.1. Trawl landings (t) of Pacific cod from Georgia Strait and vicinity (Area 4B), and important Minor Areas, October-September 1960-78.

Year	Area 4B	Minor Statistical Area						
		18	17	19	14	20	12+ 15+ 13+ 16	29
1960-61	486	156	100	103	78	29	12	8
1961-62	434	161	69	49	55	78	10	12
1962-63	561	227	151	37	48	71	14	12
1963-64	772	349	138	74	111	54	16	28
1964-65	502	214	45	81	37	88	18	20
1965-66	326	77	16	117	18	76	13	8
1966-67	464	154	151	22	28	52	52	4
1967-68	381	96	126	49	22	58	16	13
1968-69	326	124	59	20	17	82	16	7
1969-70	509	192	93	80	25	95	11	12
1970-71	743	178	340	48	81	86	8	4
1971-72	665	169	302	20	69	98	3	2
1972-73	513	188	133	12	150	11	11	8
1973-74	526	247	144	51	58	8	16	TR
1974-75	740	218	75	258	74	83	26	6
1975-76	1,096	418	89	467	83	14	25	2
1976-77	895	385	60	244	98	55	53	TR
1977-78	1,444	421	85	696	130	73	39	1
1960-78 Mean	632	221	121	135	66	62	20	8
%	99	35	19	21	10	10	3	1

Table 4.2. Distribution (%), by quarter-year, of annual Canada-U.S. landings of Pacific cod from Southwest Vancouver Island (Area 3C), 1956-78.

Year	Quarter					Total landings (t)
	I	II	III	IV	T	
1956	2	64	15	20	101	1,147
1957	3	68	25	5	101	1,582
1958	7	54	22	17	100	763
1959	2	56	22	20	100	673
1960	3	54	28	14	99	590
1961	T	62	26	11	99+	390
1962	17	50	28	5	100	567
1963	25	59	14	2	100	1,196
1964	21	61	15	4	101	1,143
1965	37	37	22	4	100	2,535
1966	31	35	32	2	100	2,644
1967	56	30	10	5	101	1,653
1968	68	22	4	6	100	1,173
1969	54	31	9	6	100	960
1970	37	32	25	7	101	965
1971	27	48	17	8	100	3,077
1972	43	40	13	4	100	5,487
1973	68	18	11	3	100	3,597
1974	54	24	18	8	100	3,365
1975	48	23	21	8	100	4,467
1976	44	38	16	3	101	3,916
1977	40	27	31	3	101	3,592
1978 ^a	43	41	10	6	100	1,344
1956-78 Mean	32	42	19	7	100	2,036

^aCanada data only.

Table 4.3. Distribution (%), by ground, of annual Canada-U.S. Pacific cod landings from Area 3C, 1960-78.

Year	Ground						Total	Annual landing (t)
	Lennard Island	Amphitrite Bank	Big Bank	Clo-oose	Swiftsure	Cape Flattery Spit ^a		
1960	10	43	25	10	10	3	101	590
1961	3	44	12	29	10	3	99	390
1962	2	49	19	20	5	5	100	567
1963	1	31	21	33	12	2	100	1,196
1964	1	34	22	23	19	1	100	1,143
1965	2	45	29	18	5	1	100	2,535
1966	2	39	30	22	5	1	99	2,644
1967	8	49	11	30	1	1	100	1,653
1968	1	78	9	9	3	1	101	1,173
1969	2	75	15	3	4	1	100	960
1970	2	57	26	11	2	2	100	965
1971	4	45	37	11	3	1	101	3,077
1972	4	47	32	7	8	1	101	5,487
1973	1	69	14	5	10	1	100	3,597
1974	3	57	19	1	18	2	100	3,365
1975	4	49	14	1	16	16	100	4,467
1976	3	54	21	T	13	9	100	3,916
1977	5	42	10	1	13	30	101	3,593
1978 ^b	10	59	20	1	10	-	100	1,344
1960-78 Mean	4	51	20	12	9	4	100	2,245

^aLocated in U.S. portion of Area 3C.

^bCanada only.

Table 4.4. Distribution (%), by quarter-year, of Canada-U.S. landings of Pacific cod from Amphitrite Bank and Big Bank, 1960-78.

Year	Amphitrite Bank					Total landings (t)	Big Bank					Total landings (t)
	I	II	III	IV	Total		I	II	III	IV	Total	
1960	5	85	6	4	100	251	-	16	47	37	100	146
1961	1	81	14	5	101	170	-	30	40	30	100	48
1962	35	53	12	T	100	276	T	43	43	13	99	107
1963	48	49	3	T	100	368	2	46	50	2	100	253
1964	12	70	18	1	101	383	T	62	26	12	100	256
1965	54	33	11	1	99	1,144	26	24	38	12	100	739
1966	40	33	26	T	99	1,039	23	25	52	1	101	803
1967	65	32	1	1	99	816	1	44	21	34	100	178
1968	80	19	T	1	100	913	1	36	35	29	101	103
1969	71	28	1	T	100	720	-	33	51	17	101	145
1970	54	31	14	T	99	547	1	25	62	13	101	254
1971	58	40	3	T	101	1,389	-	41	37	22	100	1,137
1972	77	21	2	T	100	2,558	10	51	32	8	101	1,729
1973	90	9	T	T	99	2,489	23	34	33	10	100	494
1974	95	5	T	T	100	1,902	-	35	44	21	100	651
1975	96	2	2	T	100	2,187	T	51	31	18	100	630
1976	80	18	2	T	100	2,113	1	43	47	9	100	824
1977	86	13	Tr	Tr	99	1,513	Tr	45	48	7	100	357
1978 ^a	71	29	-	-	100	789	-	63	27	11	101	269
1960-78 Mean	59	34	6	1	100	1,135	5	39	40	16	100	480

^aCanada only.

Table 4.5. Pacific cod landings (t), calculated effort (hr), and catch rate (t/hr) from Amphitrite Bank, (January-March) and Big Bank (April-September), by Canadian and United States vessels, 1960-78.

Year	Amphitrite Bank (Jan.-Mar.)			Big Bank (Apr.-Sept.)		
	Canada-U.S. landings (t)	Calculated ^b effort (hr)	Canada catch rate (t/hr)	Canada-U.S. landings (t)	Calculated ^c effort (hr)	Canada catch rate (t/hr)
1960	12	838	.014	91	463	.197
1961	1	-	-	34	440	.076
1962	95	321	.297	93	622	.149
1963	178	875	.204	241	1,330	.181
1964	45	120	.374	225	476	.473
1965	621	5,189	.120 ^a	460	1,200	.384
1966	418	1,382	.303	616	1,485	.415
1967	528	1,882	.281	117	386	.302
1968	729	2,302	.317	73	159	.459
1969	513	1,425	.360	121	376	.321
1970	297	1,030	.288	218	891	.245
1971	799	1,676	.477	899	1,617	.550
1972	1,963	2,467	.796	1,422	2,115	.672
1973	2,232	1,856	1.202	331	1,020	.324
1974	1,801	2,181	.826	517	1,991	.259
1975	2,098	3,115	.674	518	1,947	.266
1976	1,695	2,210	.767	740	2,984	.248
1977	1,306	1,812	.721	333	639	.521
1978 ^c	562	1,021	.550	241	837	.288

^aDoubtful, based on only 27,000 kg landed.

^bCalculated effort equals Canada-U.S. landings divided by Canadian CPUE at 25% qualification level.

^cCanada data only.

Table 4.6. Distribution (%), by quarter-year, of Canada-U.S. landings of Pacific cod from Queen Charlotte Sound (Areas 5A and 5B), by area, 1956-78.

Year	Area 5A					5A landings (t)	Area 5B					5B landings (t)	5A+5B landings (t)
	I	II	III	IV	Total		I	II	III	IV	Total		
1956	14	28	33	25	100	1,159	19	32	43	6	100	594	1,754
1957	9	37	35	19	100	2,244	8	46	13	33	100	499	2,744
1958	16	49	27	8	100	681	2	68	22	9	101	497	1,178
1959	9	58	26	7	100	599	3	72	24	2	101	347	946
1960	4	60	26	11	101	233	12	41	46	1	100	386	619
1961	13	65	10	12	100	98	9	80	9	1	99	142	239
1962	21	26	46	7	100	174	4	44	50	3	101	248	422
1963	5	23	64	8	100	287	T	58	39	2	99	390	677
1964	3	41	29	27	100	513	3	39	49	9	100	762	1,275
1965	1	35	26	39	101	797	1	66	32	1	100	1,143	1,940
1966	6	33	37	25	101	1,066	T	59	34	7	100	745	1,811
1967	8	31	32	28	99	761	T	65	34	1	100	740	1,501
1968	7	59	27	7	100	626	1	56	35	8	100	334	960
1969	11	40	31	18	100	389	8	41	45	6	100	310	699
1970	8	42	30	20	100	185	6	50	38	5	99	114	299
1971	T	46	39	15	100	461	-	51	44	5	100	467	928
1972	1	56	30	12	99	756	T	55	39	6	100	1,564	2,320
1973	13	53	25	9	100	623	2	64	32	1	99	1,336	1,914
1974	5	53	35	8	101	868	1	60	35	3	99	1,424	2,292
1975	1	59	29	12	101	712	T	37	50	13	100	1,751	2,463
1976	2	27	54	7	100	1,142	T	24	56	20	100	1,129	2,271
1977	1	58	37	4	100	702	3	41	45	11	100	568	1,270
1978 ^a	2	56	35	8	101	838	1	18	75	6	100	919	1,757
1960-78 Mean	7	45	33	15	100	692	4	51	39	7	101	713	1,403

^aCanada only.

Table 4.7. Distribution (%), by quarter-year, of Canada-U.S. Pacific cod landings from Hecate Strait and Dixon Entrance (Areas 5C and 5D), 1956-78.

Year	Quarter					Total landings (t)
	I	II	III	IV	T	
1956	34	51	12	3	100	1,483
1957	45	28	6	21	100	2,319
1958	38	38	10	14	100	5,202
1959	48	17	23	12	100	5,125
1960	37	23	32	8	100	2,360
1961	56	24	14	7	101	1,616
1962	48	11	33	8	100	1,689
1963	40	31	21	8	100	2,927
1964	17	39	29	14	99	5,228
1965	22	31	39	8	99	9,059
1966	19	54	22	5	100	9,520
1967	25	27	27	21	100	5,081
1968	44	40	14	2	100	5,185
1969	35	39	23	2	99	2,959
1970	49	23	21	8	101	1,339
1971	34	38	25	3	100	1,476
1972	13	26	45	16	100	2,688
1973	14	39	39	9	101	4,002
1974	8	37	48	8	101	4,764
1975	17	42	31	9	99	4,963
1976	25	28	37	10	100	4,986
1977	12	25	55	8	100	3,522
1978	17	47	27	9	100	2,100
1956-78 Mean	30	33	28	9	100	3,895

^aCanada only.

Table 4.8. Distribution (%) of annual Canada-U.S. landings of Pacific cod from Hecate Strait and Dixon Entrance (Areas 5C and 5D), by ground, 1956-78.

Year	Tow Hill	Two Peaks Butterworth	White Rocks Bonilla	Shell	Ole Spot	Horseshoe	Reef Island	Other	Total	Total landings (t)
1956	-	65	-	-	24	11	-	-	100	1,483
1957	-	66	26	-	1	6	-	-	99	2,319
1958	-	32	33	-	11	24	-	-	100	5,202
1959	-	39	46	-	6	10	-	-	101	5,125
1960	-	37	43	T	-	21	-	-	101	2,360
1961	1	45	52	1	-	1	-	-	100	1,616
1962	T	36	53	-	4	7	-	-	100	1,689
1963	-	32	38	-	4	26	-	-	100	2,927
1964	-	42	21	-	11	26	-	-	100	5,228
1965	-	35	24	-	12	29	-	-	100	9,059
1966	7	30	12	2	17	33	T	-	101	9,520
1967	2	23	29	6	19	21	-	-	100	5,081
1968	9	22	23	7	10	27	3	-	101	5,185
1969	4	25	21	10	12	18	9	-	99	2,959
1970	T	43	30	6	8	5	7	-	99	1,339
1971	T	34	22	9	6	13	16	-	100	1,476
1972	T	47	17	4	T	26	6	-	100	2,688
1973	T	30	9	9	2	39	10	-	99	4,002
1974	1	34	10	17	T	31	7	-	100	4,764
1975	T	35	19	22	T	16	7	-	100	4,963
1976	T	26	30	12	T	19	12	-	99	4,986
1977	T	54	16	9	1	10	6	5 ^a	101	3,522
1978	T	32	28	2	T	26	8	4 ^b	100	2,089
1956-1978 Mean	1	38	26	5	6	19	4	Tr	99	3,895
1968-1978 Mean	1	35	20	10	4	21	8	1	100	3,179

^aCumshewa (29%); Ramsay I. (39%); S. Bonilla (1%); Dundas (17%); Lawn Pt. (13%).

^bCumshewa (98%) & Lawn Pt. (2%).

Table 4.9. Distribution (%) of annual Canada-U.S. landings of Pacific cod from Two Peaks Ground, by quarter-year, 1956-78.

Year	Quarter					Total landings (t)
	I	II	III	IV	T	
1956	53	42	-	5	100	957
1957	58	36	6	T	100	1,442
1958	27	46	7	20	100	1,582
1959	28	19	48	4	99	1,988
1960	8	14	64	14	100	870
1961	21	48	30	1	100	723
1962	19	19	62	T	100	610
1963	28	22	41	8	99	927
1964	17	18	62	4	101	2,199
1965	24	6	66	4	100	3,194
1966	12	62	26	1	101	2,817
1967	11	26	47	16	100	1,188
1968	27	45	26	2	100	1,153
1969	14	38	42	6	100	746
1970	12	35	40	12	99	577
1971	2	24	70	4	100	505
1972	2	22	69	8	101	1,251
1973	1	17	78	4	100	1,202
1974	-	6	89	5	100	1,600
1975	1	23	74	2	100	1,749
1976	1	24	72	3	100	1,305
1977	2	4	94	Tr	100	1,562
1978	6	31	63	-	100	510
1956-78 Mean	16	27	51	5	99	1,332

Table 4.10. Canada-U.S. landings (t) calculated effort (hr), and Canadian CPUE (t/hr) for Pacific cod landed from Two Peaks Ground during April-September, 1956-78.

Year	Canada-U.S. landing (t)	Calculated effort ^a (hr)	Canada CPUE (t/hr)
1956	406	670	.600
1957	606	1,138	.689
1958	837	1,215	.689
1959	1,348	1,633	.826
1960	680	916	.743
1961	565	1,135	.498
1962	496	644	.770
1963	591	723	.817
1964	1,753	970	1.808
1965	2,281	1,324	1.723
1966	2,473	2,041	1.212
1967	863	666	1.296
1968	816	1,667	.489
1969	596	1,202	.496
1970	437	1,162	.376
1971	473	1,167	.405
1972	1,128	1,913	.590
1973	1,147	1,065	1.077
1974	1,516	1,040	1.458
1975	1,704	1,695	1.006
1976	1,261	2,052	.614
1977	1,523	2,068	.736
1978	480	1,102	.436

^aCalculated effort equals Canada-U.S. landings divided by Canadian CPUE, based on 25% qualification level.

Table 4.11. Distribution (%) of annual Canada-U.S. landings of Pacific cod from White Rocks Ground, by quarter-year, 1956-78.

Year	Quarter					Total landings (t)
	I	II	III	IV	T	
1956	-	-	-	-	-	-
1957	31	T	-	69	100	614
1958	77	2	-	21	100	1,713
1959	82	-	3	16	101	2,341
1960	79	14	T	7	100	1,004
1961	87	1	T	12	100	845
1962	78	T	7	15	100	889
1963	82	-	5	13	100	1,109
1964	43	2	5	50	100	1,108
1965	48	9	17	27	101	2,189
1966	59	6	2	32	99	1,136
1967	35	T	15	50	100	1,467
1968	74	8	11	8	101	1,176
1969	52	13	31	4	100	608
1970	95	2	3	T	100	398
1971	78	21	1	1	101	319
1972	29	-	2	70	101	454
1973	45	1	6	48	100	358
1974	35	18	7	40	100	474
1975	59	2	2	38	101	951
1976	44	11	15	31	101	1,520
1977	28	17	27	28	100	546
1978	31	21	19	29	100	577
1957-78 Mean	55	6	8	26	95	991

Table 4.12. Canada-U.S. landings (t), calculated effort (hr), and CPUE (t/hr) for Pacific cod landed from White Rocks Ground during October- March 1957-78.

Year	Canada-U.S. landing (t)	Calculated effort ^a (hr)	Canada CPUE (t/hr)
1957-58	1,734	2,737	.633
1958-59	2,268	4,529	.501
1959-60	1,158	4,035	.287
1960-61	810	2,319	.347
1961-62	790	2,945	.268
1962-63	1,040	3,021	.344
1963-64	629	2,031	.309
1964-65	1,593	2,854	.558
1965-66	1,267	2,786	.455
1966-67	857	2,179	.393
1967-68	1,424	3,026	.470
1968-69	298	1,527	.195
1969-70	404	817	.494
1970-71	248	792	.313
1971-72	132	481	.274
1972-73	476	877	.542
1973-74	337	780	.431
1974-75	748	1,213	.616
1975-76	1,015	2,166	.469
1976-77	617	1,799	.334
1977-78	333	1,205	.276

^aCalculated effort equals Canada-U.S. landings divided by Canada CPUE at 25% level of qualification.

Table 4.13. Distribution (%) of annual Canada-U.S. landings of Pacific cod from Horseshoe Ground, by quarter-year, 1956-78.

Year	Quarter					Total landings (t)
	I	II	III	IV	T	
1956	-	85	15	-	-	170
1957	-	33	28	38	-	151
1958	-	68	32	-	-	1,251
1959	-	72	28	-	-	499
1960	-	59	40	T	-	484
1961	-	56	35	9	-	20
1962	-	8	92	-	-	124
1963	-	75	25	-	-	775
1964	-	82	9	9	-	1,345
1965	T	59	41	-	-	2,624
1966	-	65	34	1	-	3,110
1967	T	56	44	-	-	1,059
1968	53	35	11	-	-	1,403
1969	30	55	15	1	-	541
1970	3	8	44	45	-	69
1971	5	79	4	12	-	188
1972	3	50	47	T	-	697
1973	1	57	37	5	-	1,578
1974	-	48	50	2	-	1,494
1975	5	69	25	1	-	774
1976	-	45	54	1	-	954
1977	-	47	39	14	100	363
1978	1	79	20	-	100	540
1956-78 Mean	5	56	33	6	99	879

Table 4.14. Canada-U.S. landings (t), calculated effort (hr), and CPUE (t/hr) for Pacific cod landed from Horseshoe Ground during April-September 1956-78.

Year	Canada-U.S. landing (t)	Calculated effort ^a (hr)	Canada CPUE (t/hr)
1956	170	87	1.950
1957	93	98	.949
1958	1,251	537	2.331
1959	499	703	.710
1960	483	1,017	.475
1961	18	61	.290
1962	124	223	.555
1963	775	603	1.285
1964	1,229	845	1.454
1965	2,620	2,359	1.110
1966	3,084	2,006	1.538
1967	1,054	1,024	1.030
1968	654	1,274	.513
1969	376	1,263	.298
1970	36	100	.358
1971	156	416	.375
1972	676	819	.825
1973	1,486	1,053	1.411
1974	1,466	1,202	1.220
1975	725	1,088	.666
1976	943	1,187	.795
1977	311	562	.595
1978	536	743	.721

^aCalculated effort equals Canada-U.S. landngs divided by Canada CPUE at 25% level of qualification.

Table 4.15. Distribution (%) of annual Canada-U.S. landings of Pacific cod from Ole Spot, Shell Ground and Reef Island Grounds, by quarter-year, 1956-78.

Year	Quarter					Total landings (t)
	I	II	III	IV	T	
<u>Ole Spot</u>						
1956	-	57	43	-	100	352
1957	-	100	-	-	100	17
1958	37	62	1	-	100	571
1959	4	45	-	51	100	297
1960	-	-	-	-	-	-
1961	-	-	-	-	-	-
1962	-	100	-	-	100	65
1963	-	100	-	-	100	116
1964	9	91	-	-	100	577
1965	17	82	1	-	100	1,053
1966	31	51	14	4	100	1,580
1967	56	36	8	-	100	961
1968	3	86	11	-	100	511
1969	51	48	-	-	99	357
1970	37	60	2	-	99	113
1971	47	53	-	-	100	93
1972	-	100	-	-	100	3
1973	-	100	-	-	100	88
1974	2	98	-	-	100	17
1975	15	52	-	33	100	24
1976	-	-	100	-	100	Tr
1977	-	100	-	-	-	22
1978	-	100	-	-	100	4
1956-78 Mean ^a	15	71	9	4	99	340
<u>Shell Ground</u>						
1966	36	64	-	-	100	207
1967	18	33	19	30	100	329
1968	32	47	21	-	100	352
1969	27	69	4	-	100	300
1970	82	18	1	-	101	78
1971	66	34	-	-	100	127
1972	4	73	22	-	99	112
1973	39	61	-	-	100	352
1974	-	-	100	-	100	808
1975	11	86	3	-	100	1,113
1976	30	50	20	1	100	622
1977	14	84	2	-	100	313
1978	17	83	-	-	100	49
1966-78 Mean	29	54	15	2	100	366

Table 4.15 (cont'd).

Year	Quarter					Total landings (t)
	I	II	III	IV	T	
			<u>Reef Island</u>			
1968	99	-	-	-	99	151
1969	74	25	1	-	100	276
1970	100	-	-	-	100	100
1971	46	54	-	-	100	243
1972	98	2	-	-	100	167
1973	55	33	-	12	100	420
1974	55	31	1	14	101	327
1975	30	51	1	17	99	338
1976	70	26	3	1	100	580
1977	82	7	6	5	100	206
1978	77	16	-	7	100	160
1968-78 Mean	71	22	1	5	99	270

^aExcluding 1960-61 and 1977.

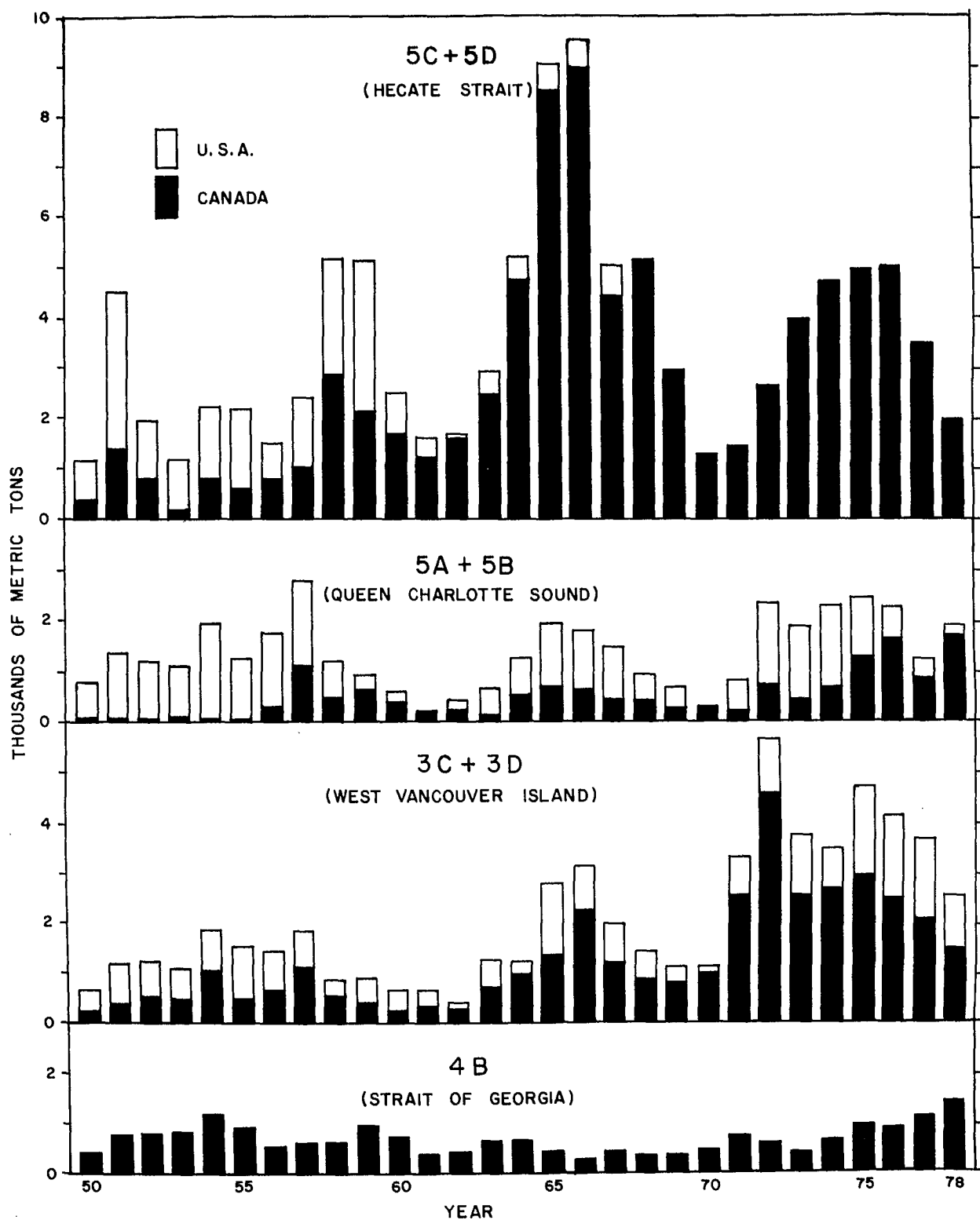


Fig. 4.1. Trawl landings of Pacific cod by major statistical area, combined Canada-U.S. versus Canadian only (solid bars), 1950-1978.

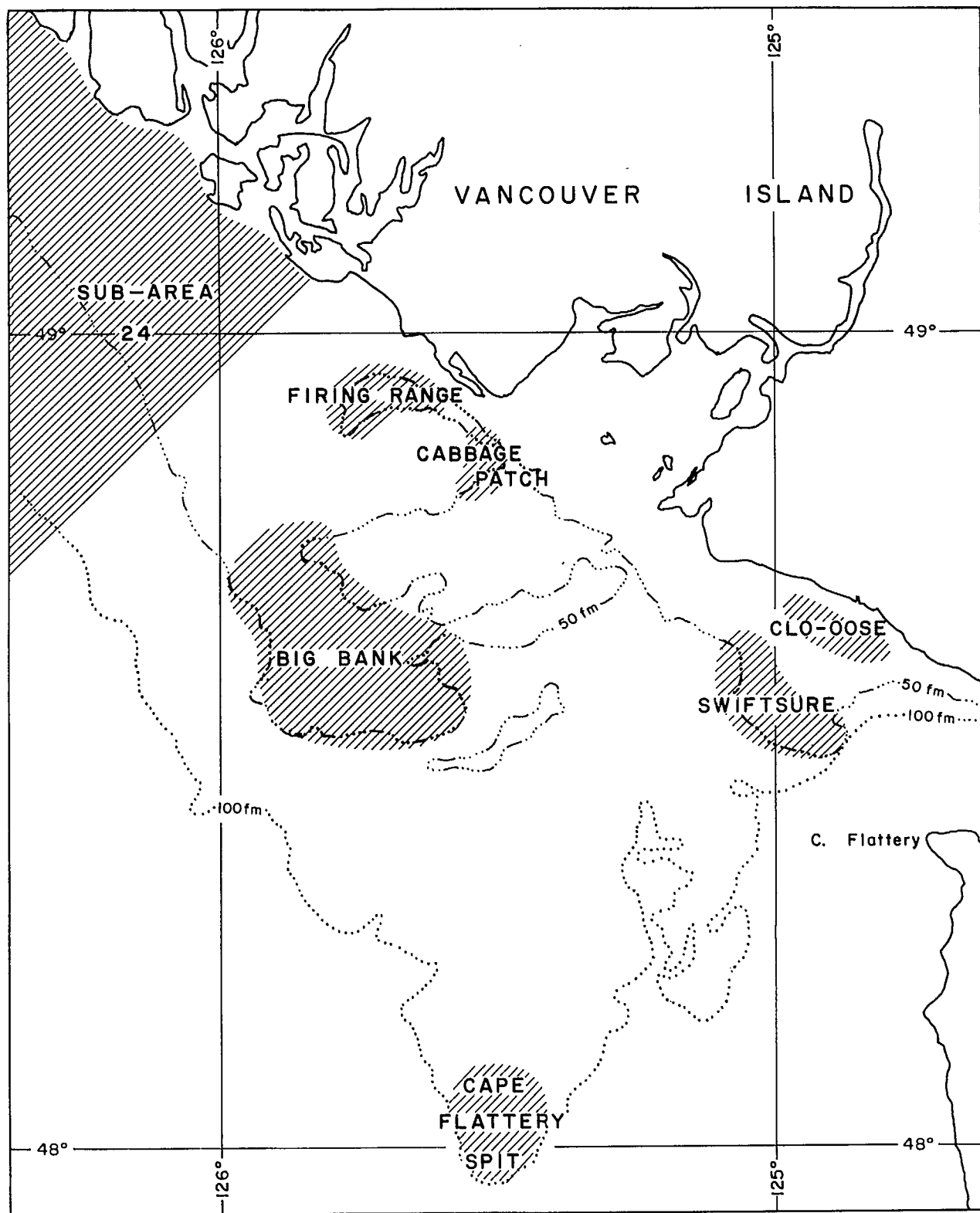


Fig. 4.3. Trawling grounds off Southwest Vancouver Island.

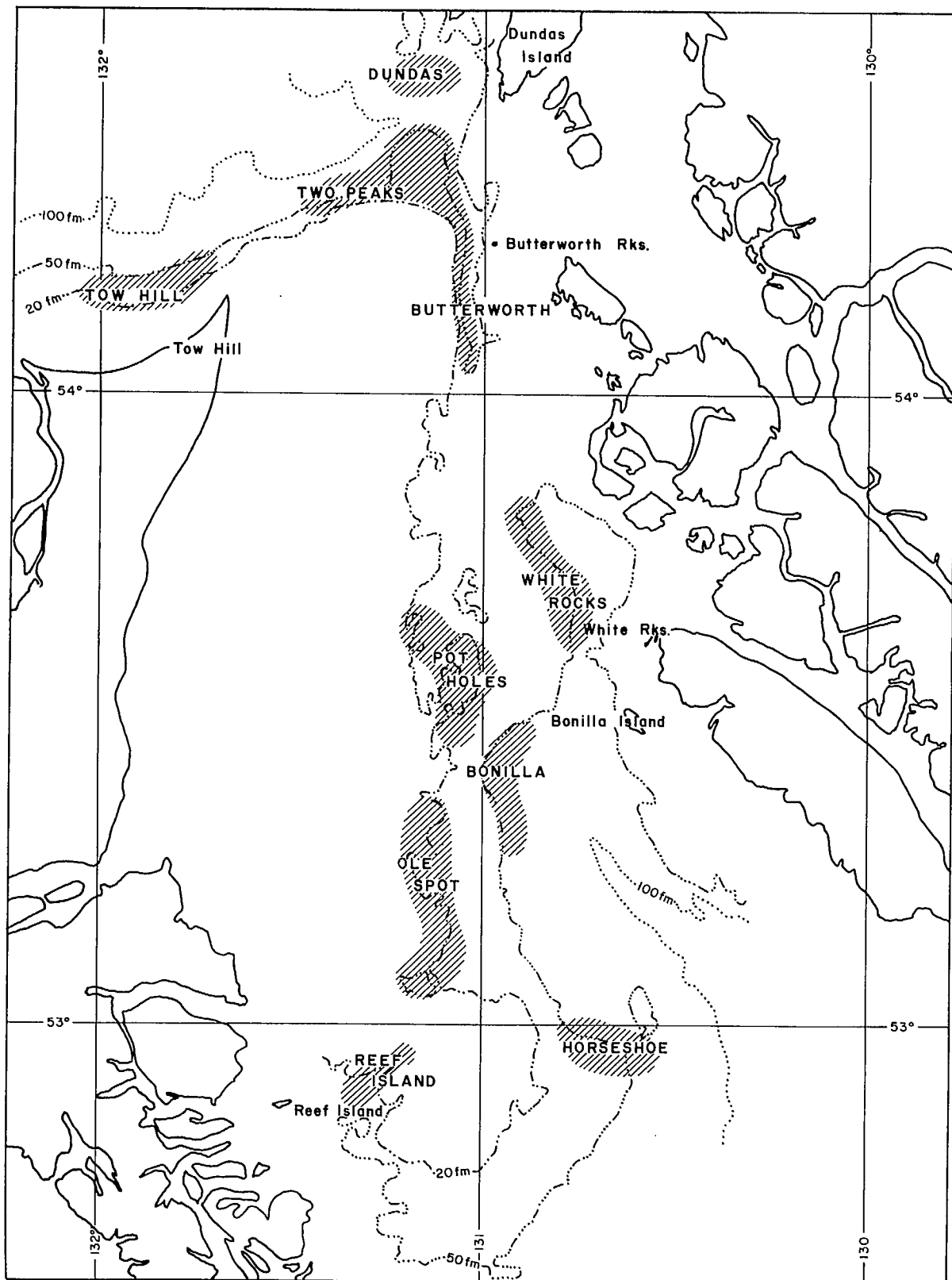


Fig. 4.5. Trawling grounds in Hecate Strait.

5. LINGCOD STOCK ASSESSMENTS

5.1 Introduction

Lingcod (Ophiodon elongatus) are fished commercially in waters off Canada's west coast by bottom trawl, handline, troll, longline, and, to a lesser extent, by sunken gill-nets, traps, beach seines and spear-fishing methods. Historically, both Canadian and U.S. fishermen have participated in the trawl fishery, but unknown and presumably insignificant quantities have also been caught by distant water trawlers since 1965. Other commercial fisheries for lingcod have been solely Canadian except for incidental catches by the U.S. halibut fleet and foreign longliners fishing for blackcod. As well as being of commercial interests, lingcod are landed by recreational fishermen using jig, troll, and spear fishing gear.

Over its long history dating from the early years of this century, the commercial fishery for lingcod has evolved from a traditional line fishery to a trawl-oriented fishery in most areas. However, the bulk of lingcod landed from the relatively sheltered inside waters of Vancouver Island is still caught by line gear.

Delineation of lingcod stocks is not clearly understood, since taggings have been conducted in only a few areas. Results, such as they are, suggest that the lingcod do not migrate extensively and probably exist as a large number of local stocks along the Canadian coast. For present purposes, the state of the lingcod resource will be examined in terms of major statistical areas, on the assumption that negligible intermingling occurs among these areas (Fig. 1).

5.2 Abundance indices

One method used as an index of lingcod abundance was selected in order to cover as much of the fishery as possible, namely the United States and Canadian trawl fisheries. The index is obtained by dividing the total Canada-U.S. landings of lingcod by the total fishing effort of both countries.¹² This will be referred to as TOTAL CPUE. In multispecies trawl fisheries it is difficult if not impossible to identify accurately the effective fishing effort directed at a single species. In some areas much of the U.S. fishing effort is directed to species which are clearly beyond

¹²Sources of data: 1950-55, Ketchen (1976); 1956-77, Pacific Marine Fisheries Commission Data Series; 1978, Provisional.

the bathymetric range of lingcod. Although TOTAL CPUE is based on total Canada-U.S. production, this method will include effort directed to species other than lingcod and will therefore bias CPUE calculations based on total Canada-U.S. effort.

There are several techniques for eliminating extraneous effort, but for present purposes attention will be confined to separation of Canadian fishing effort according to three levels of landing qualification. For example, we may confine the analysis to those hauls or trips in which lingcod constitute say 25% or more of the landing. Dividing this landing by the corresponding fishing effort yields what we shall call a Type-1 CPUE. Alternatively, we may examine those hauls or trips in which lingcod were recorded - regardless of proportion of the total landing. In other words the landing qualification level is >0%, which, when divided by the corresponding effort provides a Type-2 CPUE. Finally, we may obtain a Type-3 CPUE in which the catch of lingcod is divided by all fishing effort whether it resulted in the capture of lingcod or not.

In the situation where an actual decline in abundance is in progress year by year, Type-1 CPUE may underestimate the decline, since no allowance is made for the possibility that the number of qualifying hauls or trips is diminishing and the analysis is being confined to only the most successful operations. At the other extreme, Type-3 CPUE will tend to overestimate the decline, because no allowance is made for the possibility that fishermen have turned their attention to species more remunerative than lingcod.

5.3 Strait of Georgia and vicinity (Area 4B)

5.3.1 Landing statistics

In Area 4B, lingcod have been caught by Canadian commercial vessels using handline, troll, trawl, and longline fishing gear. Quantities of lingcod are also taken by spear-fishing and sport-fishing gear.

The trawl fishery in the Strait of Georgia has accounted for only about 10% of the total annual commercial lingcod production since 1965. For this reason trawl catch and effort statistics are of little value in assessing state of stocks. Incomplete biological data have also precluded analysis based on trends in size composition. Suffice it to say that over the long term, trawl production of lingcod has shown little or no trend (Fig. 5.2A), except for a brief flurry of activity in 1959 and 1960 associated with the discovery and fishing down of a stock inhabiting waters near Victoria (Ketchen, ed. 1980).

Production from the commercial handline and troll fisheries account for about 88% of the annual commercial landings since 1965. Landing records for the line fishery are only reported on sales slips that do not

permit the separation of handline landings from troll landings.¹³ Landings from the commercial handline/troll fisheries have declined substantially from an average of 1,330 t/yr during 1951-62 to little more than 375 t/yr during 1973-78 (Table 5.1; Fig. 5.1A). Since 1967 handline/troll effort (boat-days) has been partitioned between that directed primarily at lingcod and that directed primarily at salmonids. During 1967-75 the decline in handline/troll lingcod landings was closely paralleled by a decline in the effort directed to lingcod (Fig. 5.1B). CPUE during this period remained fairly constant. After 1975 handline/troll effort increased substantially, however landings remained at low levels. CPUE subsequently declined, reaching a record low in 1978. At this time we do not have an estimate of the sports fishing effort applied to lingcod, but in 1976 an estimated 270 t, excluding SCUBA catches, were taken from the Strait of Georgia (R. Boyd, personal communication).

5.3.2 Stock condition

Of primary concern is the pronounced 70% decline in the average handline/troll landings of lingcod from the 1951-62 period to the 1973-78 period. The decline in lingcod handline/troll landings and effort during 1967-75 indicates the drop in landings resulted from a reduction in the amount of fishing effort. The decline in handline/troll CPUE after 1975 to a recorded low in 1978 indicates stocks have declined in recent years. The reason(s) for the decline in handline/troll landings prior to 1967 are difficult to explain using sales slip information because of the problems associated with determining the amount of effort directed for lingcod. In an attempt to provide an additional assessment of the condition of the lingcod stocks, a survey of commercial line and recreational fishermen, including SCUBA divers was conducted in February 1979. The preliminary results indicate that of the fishermen who fished lingcod intentionally in the Strait of Georgia for five or more years, 73% feel lingcod stocks have declined. Of the fishermen who fished lingcod intentionally for 10 or more years, 82% feel stocks have declined. Although these results are preliminary, they support evidence from catch and effort analysis indicating stocks have declined.

5.3.3 Recommendations

The growing sports fishery including SCUBA divers and the declining production of the commercial line fishery in the presence of increasing fishing pressure since 1975 are indicative of a decline in lingcod abundance. Therefore, we recommend that some conservation measures be adopted. The timing of the winter fishing closure prior to 1979 appears to be based on little empirical evidence. Recent studies (Low and Beamish 1978) indicate the pre-spawning aggregation of lingcod begins in November. Spawning occurs in January and February and the peak hatching period occurs in March. Starting in November with pre-spawning aggregation and lasting until hatching is completed (occasionally as late as June), male lingcod

¹³Source: British Columbia Catch Statistics, Department of Fisheries and Environment, Annual Reports 1951-78.

assume a territorial behaviour pattern that makes them highly vulnerable to fishing. The presence of the male during incubation is absolutely essential for the survival of the nest and consequently forms a primary basis for maintaining lingcod stocks. In order to provide greater protection during the pre-spawning aggregation, spawning and nesting periods and to reduce the catch in an attempt to rebuild stocks, it is recommended that the closed season, for all types of fishing, extend from November 15 to April 15. This will also prevent landings at a time when the quality of the flesh is allegedly poor. It is also recommended that the regulation presently preventing the retention of lingcod that are less than 58 cm in total length by the commercial fishery be expanded to include removals by the sports fishery as well.

Due to reported violations of existing regulations, primarily by recreational line fishermen and spear fishermen, an intensification of enforcement is recommended during the closure and during the open season to enforce the existing bag limit on recreational catches, including SCUBA, and to prevent the retention of under-sized lingcod (<58 cm - total length).

Ichthyoplankton studies are planned for 1980 to monitor the impact of the closure on year-class strength. In addition, a logbook program was implemented in 1979 to provide more adequate coverage of the commercial line fishery.

5.4 Southwest coast of Vancouver Island (Area 3C)

5.4.1 Landing statistics

Trawling grounds off the southwest coast of Vancouver Island are the most important in terms of lingcod production from waters off Canada. During 1973-78, an average of 1,000 t or 54% of all Canada-U.S. trawl-caught lingcod landed from international statistical areas adjacent to the Canadian coast originated in Area 3C. In recent years trawl production has declined substantially, from about 1,800 t in 1976 to a recorded low of 440 t in 1978. The decline is, in part, the result of a 53% decline in effort by the Canadian trawl fleet during 1977-78 and the absence of U.S. activity in Canadian waters since the closure to U.S. trawlers in June 1978. The decline in production must also be attributed, in part, to declining abundance as indicated by falling CPUE (Total, and Canadian Type 2, and 3) throughout 1975-78 (Table 5.2; Fig. 5.2, 5.3).

Historically, trawl production from this area has fluctuated substantially (440-2,000 t/yr) in a quasi-cyclical manner (without trend) since at least 1950 (Table 5.2; Fig. 5.2). Production from the line fishery has also fluctuated without trend, but the fluctuations have been modest (100-300 t/yr).

Fluctuations in TOTAL CPUE have closely paralleled total trawl landings, as a reflection of highly variable natural fluctuations in recruitment. Evidence in support of this view is contained in length-frequency data which show an above-average presence of small (young) fish when CPUE is rising and below-average when CPUE is declining.

5.4.2 Stock condition

There are no outstanding differences in trends exhibited by the three CPUE estimates for the Canadian fishery (Fig. 5.3B). All three, including TOTAL CPUE (Fig. 5.2), do not reflect any long term trend in stock abundance, however during 1975-78 stocks have declined to a low level of abundance. The fact that production has declined considerably since 1975 warrants some concern especially if it is related to recent stock depletion.

5.4.3 Recommendations

A fishing closure for all types of lingcod fishing is recommended for the period November 15 to April 15. This will prevent landings of lingcod when the quality of the flesh is allegedly poor and will remove fishing pressure at a time when stocks are highly vulnerable. Catch records for 1978-79 indicate a closure during the November 15-April 15 period will not affect the rockfish and Pacific cod trawl fisheries off the west coast of Vancouver Island. In addition, a provisional total allowable catch (TAC) of 600 t of lingcod is recommended for Area 3C during the open season and is designed to maintain catches at present levels.

5.5 Northwest coast of Vancouver Island (Area 3D)

5.5.1 Landing statistics

Canada-U.S. trawl landings of lingcod from the northwest coast of Vancouver Island were relatively low during the period 1950-64, frequently being lower than those of the line fisheries (Table 5.2; Fig. 5.4). However, during 1965-70, Canadian effort in Area 3D increased substantially and was directed primarily at lingcod. During this time the Canadian trawl fleet was responsible for 84% of the Canada-U.S. lingcod trawl landings compared to an expenditure of only 36% of the Canada-U.S. trawl effort. The fact that lingcod was the target species is supported by the closeness (relative to Area 3C) of the Type-1, -2, and -3 CPUE estimates (Fig. 5.5A). Catch reached a peak of 870 t in 1968 but fell abruptly between then and 1972. All three Canadian CPUE estimates paralleled the fluctuations in annual trawl landings and Total CPUE during the 1959-78 course. The sharp decline in Canadian effort between 1971 and 1972 (Fig. 5.5) suggests that abundance of lingcod fell to a level which could no longer support a target fishery. From 1972 onwards calculated fishing effort stabilized at a low level even though CPUE rebounded sharply in 1974 and again in 1978 to levels comparable to that which prevailed in 1968. The small line fishery has fluctuated without trend during the 1951-78 period.

5.5.2 Stock condition

The fluctuation in annual trawl landings paralleled by similar fluctuations in CPUE estimates indicate landings are related to natural

variability in recruitment. Canadian CPUE estimates indicate stocks have undergone a relatively recent (1978) surge of recruitment similar to that which peaked in 1974 and 1968. In summary, Canadian CPUE has fluctuated substantially during 1959-78, but without trend indicating stocks in Area 3D are not being depleted, assuming that a more obvious decline in CPUE is not being masked by increased fishing efficiency.

5.5.3 Recommendations

A closure covering the November 15-April 15 period is recommended for all types of lingcod fishing and as indicated for Area 3C (Sec. 5.4.3) should not disrupt the trawl fishery for other species. Although stocks do not appear depleted the close proximity of Area 3D with Area 3C makes it difficult to separate Area 3D from Area 3C with respect to a closure without jeopardizing the effectiveness of the closure in Area 3C. A provisional TAC of 200 t is recommended during the open season, subject to review in mid-season or at such a time when the assigned quota becomes fully utilized.

5.6 Cape Scott grounds (Area 5A)

5.6.1 Landing statistics

Total Canada-U.S. trawl landings followed an irregular upward trend from 1950 to 1968 (Table 5.2; Fig. 5.6). Apparently this was the result of increased effort, which did not reach a peak until 1969 (Fig. 5.7), after which time both effort and landed catch followed a general decline through 1975. Landings and effort increased slightly in 1976 however, landings have remained at relatively low levels throughout the 1971-78 period. During the 1961-78 period Canadian Type-1 and Type-2 CPUE exhibit a slight downward trend. Total CPUE, on the other hand, followed a sharp downward course after 1968 paralleling the decline in landings (Table 5.2; Fig. 5.6): this inconsistency might be attributed to extraneous U.S. fishing effort (directed to rockfish) prompted by declining lingcod abundance or increasing markets of other species (rockfish) or both. This would tend to exaggerate a CPUE decline in lingcod, if fishing effort was being directed to other species beyond the normal bathymetric range of lingcod. Although there has been an increase in line production since 1964, landings from the line fishery have been negligible.

5.6.2 Stock condition

There has been a gradual downward trend in CPUE during the past decade which was less evident in the Type-1 than Type-2 and-3 CPUE analysis (Fig. 5.7). No strong fluctuations in recruitment (as in Areas 3C and 3D) were evident except during 1967-69 when one or more strong year-classes evidently produced the sudden and substantial increase in production. Disregarding this peak, there has been a gradual downward trend in CPUE.

5.6.3 Recommendations

CPUE (Total Canada-U.S. and Canadian Type 2 and 3) declined to record lows in 1977 and showed little appreciable recovery in 1978. Concern for lingcod stocks is warranted, particularly if fishing efficiency has increased. A provisional TAC of 100 t is recommended, subject to review in mid-season. This will permit landings at present levels.

5.7 Goose Island grounds (Area 5B)

5.7.1 Landing statistics

Following a pattern rather similar to that observed in Area 5A, Canada-U.S. trawl production of lingcod from the Goose Island grounds rose to a peak of 1,050 t in 1968 as a result of increasing effort. A sharp drop in landings occurred immediately thereafter (Table 5.2; Fig. 5.8) though total effort remained relatively high. Landings stabilized from 1969-75 at 400-500 t and then entered another decline reaching 162 t in 1978, the lowest point since 1957.

Canadian CPUE estimates may not reflect abundance as well in Area 5B as in other areas because in some years Canadian landings were a small proportion of the total catch. Trends in CPUE estimates (all 3 types) were, however, similar to those of Area 5A, exhibiting a slight long-term decline that is more apparent in the Type 2 and Type 3 estimates (Fig. 5.9).

Landings of line-caught lingcod have remained small throughout the 1951-78 period, however in years of poor trawl production, landings from the line fishery equalled those of the Canadian trawl fleet.

5.7.2 Stock condition

The lingcod stock in Area 5B appears to be in a similar condition to that in Area 5A. That is CPUE is currently at levels lower than previous years.

5.7.3 Recommendation

A TAC of 200 t is recommended for lingcod in Area 5B. This will be reviewed in mid-season.

5.8 Hecate Strait and Dixon Entrance (Area 5C and 5D)

5.8.1 Landing statistics

Throughout the history of the Canada-U.S. trawl fishery in Hecate Strait and Dixon Entrance, lingcod has never been an important species.

Landings have averaged about 180 t/yr since 1950. Peak production of 380 t was reached in 1968, as in Areas 3D, 5A, and 5B. Although production in large measure is a function of fishing effort, the 1968 peak and adjacent years may have marked a period of above-average recruitment. Production has been marked by a general decline since 1968 and reached a recorded low in 1978 (Table 5.2; Fig. 5.10).

Landings by the line fishery, as in most other areas have been less than those of the trawl fishery. However, since 1971 production from the line fishery has been almost equal to that of the trawl fishery.

5.8.2 Stock condition

Abundance of lingcod in Hecate Strait and Dixon Entrance appears to be currently at relatively low levels based on Canada-U.S. trawl landings (Table 5.2; Fig. 5.9) and Canadian CPUE (Fig. 5.10; 5.11). However, the species is a minor component in the trawl and line landings.

5.8.3 Recommendations

A provisional TAC of 200 t is recommended for lingcod in Areas 5C + 5D. This will be reviewed in mid-season.

5.9 West coast of the Queen Charlotte Islands (Area 5E)

Trawling in waters off the west coast of the Queen Charlotte Islands was first reported in late 1976. The incidental landing of lingcod was 0.03 t. In the much-expanded rockfish fishery of the following two years, lingcod production was again incidental. The lingcod catch in 1977 and 1978 was 4.6 t and 3.4 t, respectively (Table 5.2). A small line fishery has been active since at least 1951, probably occurring in sheltered inlets. Landings during the past decade have averaged about 12 t/yr.

5.10 General summary of lingcod stock conditions

Except for the early growth period of offshore trawl fisheries, production of lingcod appears to be dependent on recruitment. This dependence is most evident in Areas 3C and 3D and less so in grounds further to the north (Areas 5A-5D). In the latter areas the most recent surge of recruitment was around 1968 and abundance is at a relatively low level, showing some indication of decline. Stocks off the west coast of Vancouver Island (Areas 3C and 3D) have received more recent surges of recruitment (ca. 1974) however abundance in Area 3C is currently at a low level. There is insufficient evidence to say whether intervention in the fishery would have any measurable impact. The current minimum size limit of 58 cm permits capture of a large number of 3-year-olds which are immature (50% of the fish are mature at 75 cm). Assuming that mesh size cannot be increased because it would result in excessive gilling of the ubiquitous dogfish, the benefit of a larger minimum size limit would depend on the survival prospects for discards and their later potential yield. Research has been proposed to address the problems associated with survival of discards.

Table 5.1. Lingcod production statistics from Area 4B by handline/troll vessels, 1951-78.^a

Year	Landings (t) ^a	Effort (boat-days)	CPUE (t/boat-day)
1951	1,279.4	-	-
1952	1,488.7	-	-
1953	1,178.8	-	-
1954	1,449.3	-	-
1955	1,157.4	-	-
1956	1,510.7	-	-
1957	1,539.6	-	-
1958	1,445.7	-	-
1959	1,182.9	-	-
1960	1,250.5	-	-
1961	1,157.5	-	-
1962	1,272.8	-	-
1963	989.2	-	-
1964	870.3	-	-
1965	779.7	-	-
1966	771.3	-	-
1967	778.5	4,776	0.163
1968	728.0	4,758	0.153
1969	875.5	4,974	0.176
1970	788.7	4,065	0.194
1971	564.1	3,973	0.142
1972	513.3	3,693	0.139
1973	371.9	2,353	0.158
1974	363.7	2,393	0.152
1975	330.5	1,933	0.171
1976	315.5	2,607	0.121
1977	410.2	4,508	0.091
1978	455.4	5,503	0.083

^aBritish Columbia Catch Statistics, Department of Fisheries and Environment, Annual Reports 1951-78.

Table 5.2. Canada-U.S. lingcod production (t) in waters off Canada's west coast, by area, 1950-78.

Year	Area 4B		
	Total trawl ^b landings (t)	Total trawl ^b CPUE(t/hr)	Line fishery ^c landings (t)
1950	34.5	-	-
1951	48.1	-	1,317.1
1952	54.0	-	1,512.5
1953	28.1	-	1,187.4
1954	68.0	-	1,462.3
1955	49.0	-	1,169.2
1956	49.4	-	1,523.9
1957	34.5	-	1,545.8
1958	75.7	-	1,451.2
1959	310.3	-	1,192.1
1960	198.7	0.018	1,280.2
1961	102.1	0.011	1,199.9
1962	75.7	0.008	1,292.6
1963	39.9	0.004	1,002.1
1964	92.1	0.008	877.9
1965	93.9	0.012	788.7
1966	53.1	0.010	798.8
1967	50.8	0.007	793.0
1968	83.9	0.014	740.5
1969	64.9	0.010	905.9
1970	47.6	0.008	819.7
1971	55.3	0.008	598.5
1972	36.7	0.008	533.5
1973	15.0	0.002	403.2
1974	49.0	0.008	381.2
1975	33.1	0.005	368.1
1976	43.5	0.007	334.6
1977	27.4	0.004	435.2
1978	42.7	0.007	507.8

Table 5.2 (cont'd).

Year	Area 3C			Area 3D		
	Total trawl ^b landings(t)	Total trawl ^b CPUE(t/hr)	Line fishery ^c landings(t)	Total trawl ^b landings(t)	Total trawl ^b CPUE(t/hr)	Line fishery ^c landings(t)
1950	970.7	-	-	135.6	-	-
1951	978.4	-	210.7	122.9	-	166.5
1952	766.1	-	188.7	115.2	-	184.2
1953	625.5	-	82.4	72.6	-	88.0
1954	781.1	-	239.5	59.0	-	105.9
1955	1,246.9	-	167.5	141.1	-	92.5
1956	1,142.1	-	154.5	164.2	-	124.2
1957	1,035.6	-	293.0	129.7	-	134.6
1958	1,018.3	-	154.4	110.2	-	119.5
1959	1,743.2	0.192	179.6	64.0	0.016	93.4
1960	1,866.5	0.158	216.8	87.1	0.023	105.5
1961	1,971.3	0.136	135.4	199.6	0.042	114.8
1962	889.9	0.057	226.4	285.8	0.037	103.1
1963	645.5	0.049	152.0	115.2	0.023	121.4
1964	1,183.0	0.110	100.0	225.9	0.070	84.5
1965	1,889.2	0.120	121.2	505.3	0.117	89.6
1966	2,053.4	0.155	156.9	584.7	0.146	135.1
1967	1,784.0	0.181	244.2	459.5	0.152	165.8
1968	1,693.7	0.201	160.6	868.2	0.226	107.2
1969	1,082.7	0.132	169.3	618.7	0.119	77.1
1970	729.8	0.084	112.3	455.9	0.075	157.4
1971	984.7	0.087	229.6	264.0	0.065	113.7
1972	629.1	0.048	165.0	84.8	0.033	180.8
1973	879.5	0.093	182.5	172.4	0.062	83.9
1974	1,044.2	0.108	224.1	241.8	0.079	112.7
1975	1,798.9	0.134	214.7	347.0	0.092	89.5
1976	1,304.5	0.081	251.0	245.4	0.090	90.1
1977	1,042.6	0.069	264.8	157.9	0.086	107.0
1978	441.1	0.035	198.7	197.7	0.035	93.8

Table 5.2 (cont'd).

Year	Area 5A			Area 5B		
	Total trawl ^b landings(t)	Total trawl ^b CPUE(t/hr)	Line fishery ^c landings(t)	Total trawl ^b landings(t)	Total trawl ^b CPUE(t/hr)	Line fishery ^c landings(t)
1950	65.8	-	-	140.2	-	-
1951	264.0	-	1.1	193.2	-	33.2
1952	288.0	-	5.4	188.2	-	32.1
1953	42.2	-	0.6	103.4	-	2.9
1954	47.6	-	5.5	168.7	-	4.4
1955	373.3	-	0.0	161.5	-	18.4
1956	346.5	-	2.1	250.4	-	33.0
1957	417.8	-	1.2	162.4	-	10.6
1958	304.8	-	0.1	267.6	-	1.7
1959	192.3	0.033	0.1	428.6	0.140	3.7
1960	280.3	0.056	1.8	377.4	0.079	20.8
1961	387.8	0.097	1.1	323.0	0.082	47.4
1962	531.2	0.105	10.6	406.9	0.076	57.9
1963	285.3	0.061	7.7	357.0	0.047	68.4
1964	352.0	0.063	5.2	335.2	0.050	27.7
1965	331.1	0.058	15.6	566.1	0.084	7.4
1966	706.7	0.086	23.6	826.4	0.087	35.2
1967	759.3	0.093	21.3	900.8	0.087	18.5
1968	1,226.5	0.124	81.8	1,042.8	0.102	15.5
1969	616.9	0.049	28.8	516.6	0.038	27.7
1970	590.1	0.067	28.6	389.6	0.040	53.3
1971	229.5	0.034	29.0	414.6	0.043	29.0
1972	163.7	0.028	50.4	476.3	0.040	58.3
1973	232.2	0.035	36.3	349.3	0.039	30.0
1974	338.8	0.059	38.8	532.1	0.055	44.4
1975	82.1	0.023	40.1	450.9	0.039	34.4
1976	257.6	0.037	38.8	345.2	0.049	52.6
1977	120.9	0.018	45.7	257.0	0.036	31.9
1978	126.9	0.030	17.9	161.9	0.031	11.0

Table 5.2 (cont'd).

Year	Areas 5C-5D			Area 5E		
	Total trawl ^b landings(t)	Total trawl ^b CPUE(t/hr)	Line fishery ^c landings(t)	Total trawl ^b landings(t)	Total trawl ^b CPUE(t/hr)	Line fishery ^c landings(t)
1950	190.1	-	-	0.0	0.0	-
1951	249.0	-	52.3	0.0	0.0	13.8
1952	230.0	-	46.2	0.0	0.0	1.9
1953	87.1	-	5.2	0.0	0.0	0.1
1954	99.3	-	9.8	0.0	0.0	0.6
1955	198.2	-	3.2	0.0	0.0	0.4
1956	100.7	-	4.6	0.0	0.0	0.1
1957	125.2	-	5.8	0.0	0.0	2.9
1958	278.1	-	8.9	0.0	0.0	0.4
1959	117.5	0.012	16.7	0.0	0.0	0.8
1960	154.2	0.018	21.3	0.0	0.0	1.0
1961	95.7	0.013	33.9	0.0	0.0	1.7
1962	112.9	0.017	53.5	0.0	0.0	4.0
1963	146.1	0.021	65.3	0.0	0.0	4.5
1964	214.5	0.025	42.3	0.0	0.0	5.6
1965	255.4	0.024	63.4	0.0	0.0	9.3
1966	264.4	0.022	46.7	0.0	0.0	7.4
1967	325.2	0.031	61.3	0.0	0.0	6.5
1968	382.8	0.031	42.3	0.0	0.0	5.7
1969	243.1	0.020	91.1	0.0	0.0	13.1
1970	208.7	0.021	118.7	0.0	0.0	10.1
1971	264.9	0.026	135.2	0.0	0.0	16.3
1972	151.5	0.020	127.5	0.0	0.0	10.6
1973	122.0	0.018	92.0	0.0	0.0	9.4
1974	119.7	0.019	112.0	0.0	0.0	18.1
1975	172.8	0.017	105.8	0.0	0.0	14.4
1976	98.8	0.007	73.2	0.0	0.0	13.1
1977	119.8	0.011	62.6	4.6	0.004	5.0
1978	48.1	0.006	64.9	3.4	0.003	6.9

Footnotes to Table 5.2

^aLandings do not include production from recreational fisheries, shrimp trawling, trap, gillnet, beach seining or spear-fishing.

^bSources: 1950-55, Ketchen (1976); 1956-77, Pacific Marine Fisheries Commission. Data Series; 1978, provisional.

^c1951-78. British Columbia Catch Statistics, Department of Fisheries and Environment, Annual Reports.

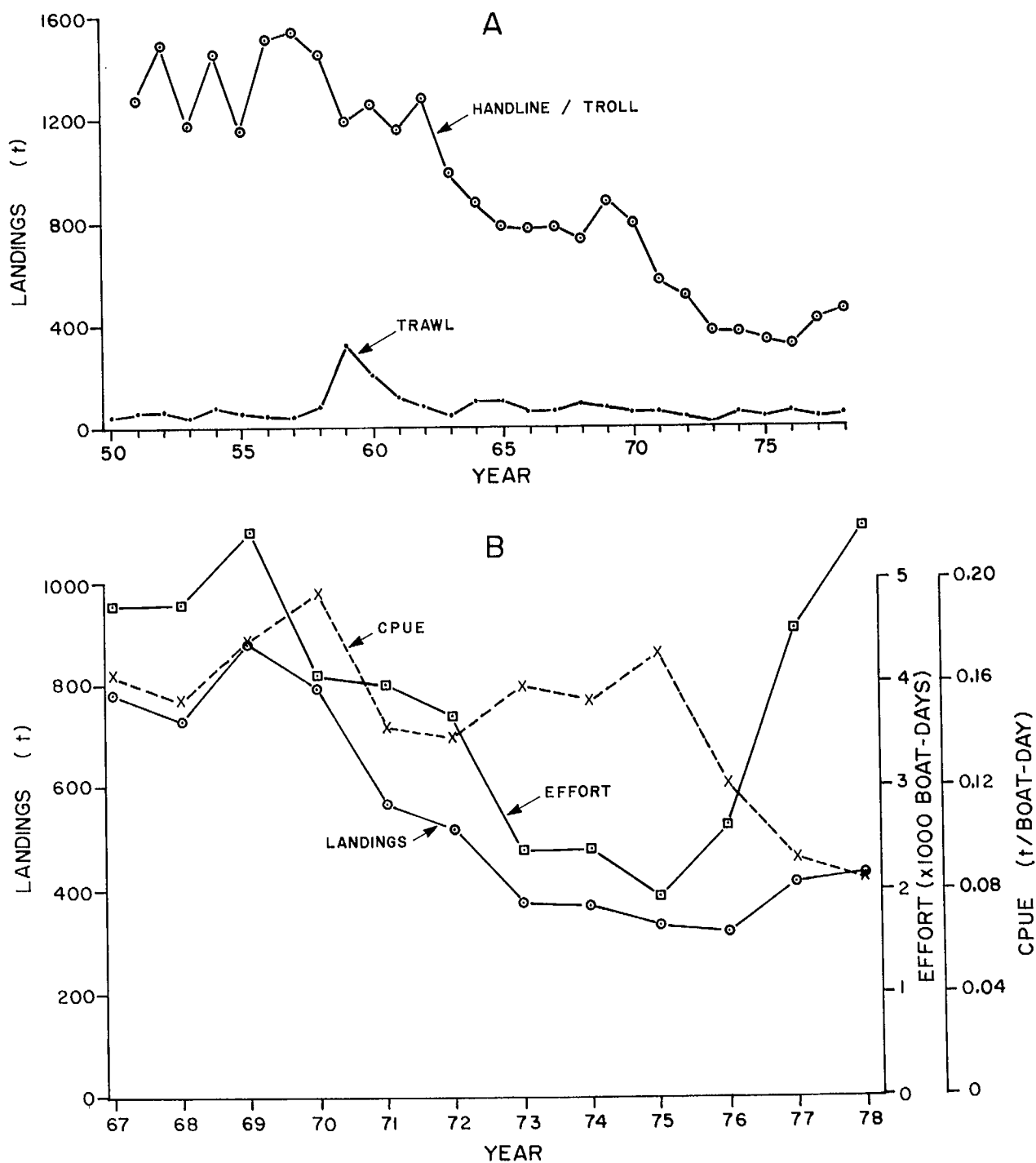


Fig. 5.1. Lingcod catch statistics for Area 4B (Canadian portion of the inside waters off Vancouver Island): A. Handline/troll and trawl landings (t), 1950-78. B. Handline/troll landings (t), effort (boat-days) and CPUE (t/boat day), 1967-78.

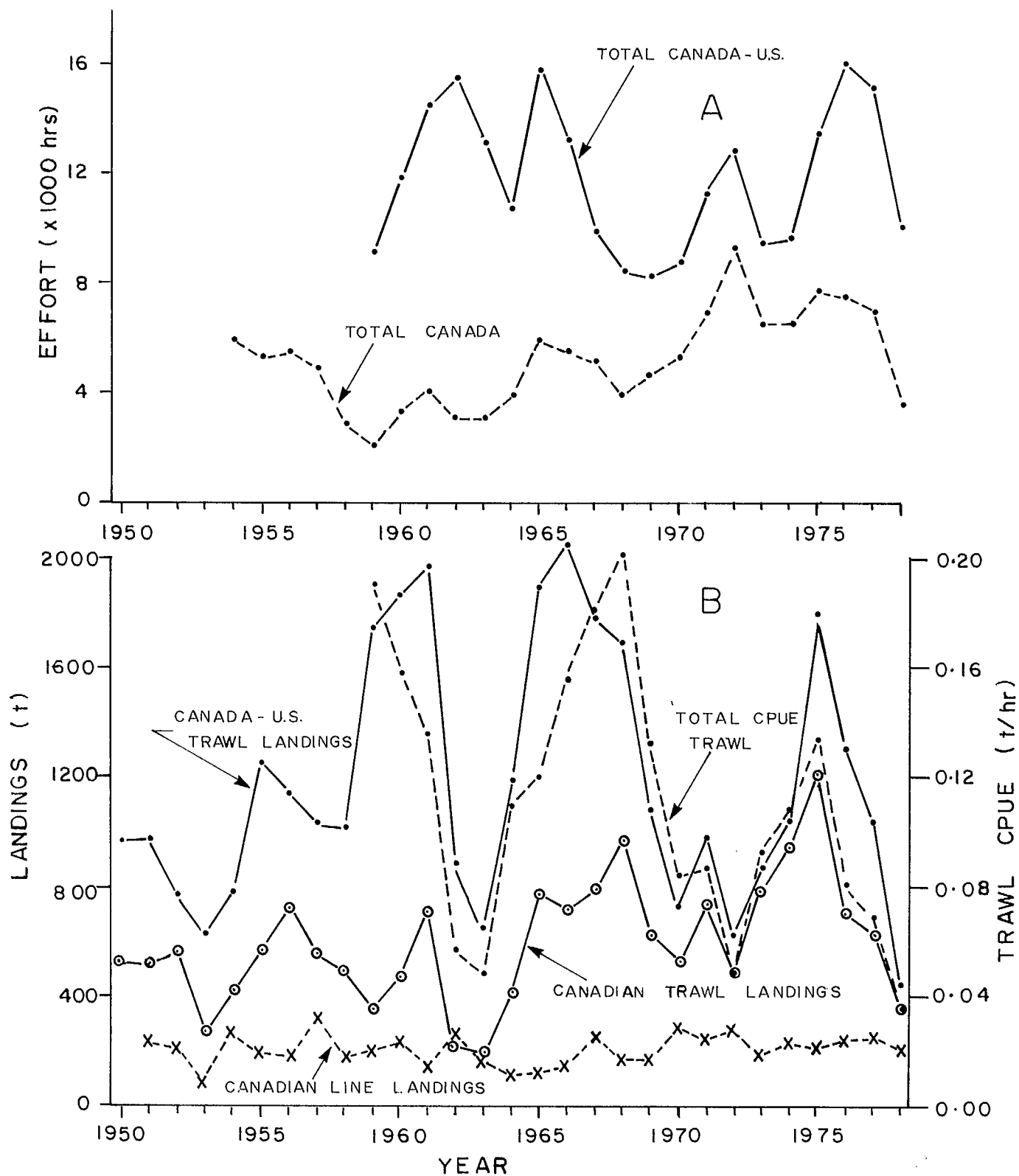


Fig. 5.2. Lingcod catch statistics for Area 3C (southwest Vancouver Island) 1950-78: A. Total trawl effort (hr), Canada-U.S. and Canada. B. Total landings (t); Canada-U.S. and Canada trawl, and Canada line; and total Canada-U.S. CPUE (t/hr).

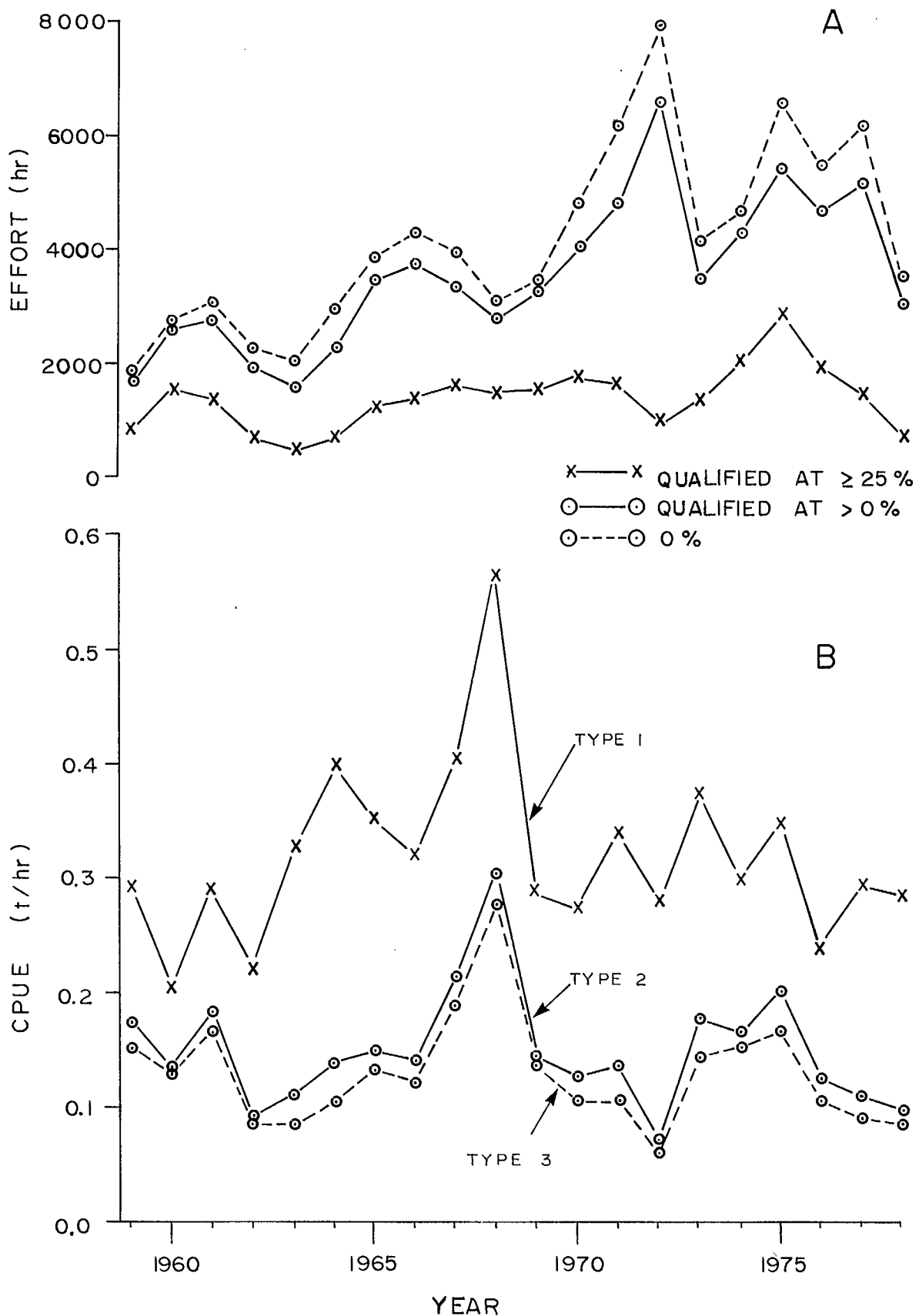


Fig. 5.3. Interviewed Canadian fishing effort (A) and CPUE (B) for lingcod in Area 3C, 1959-78.

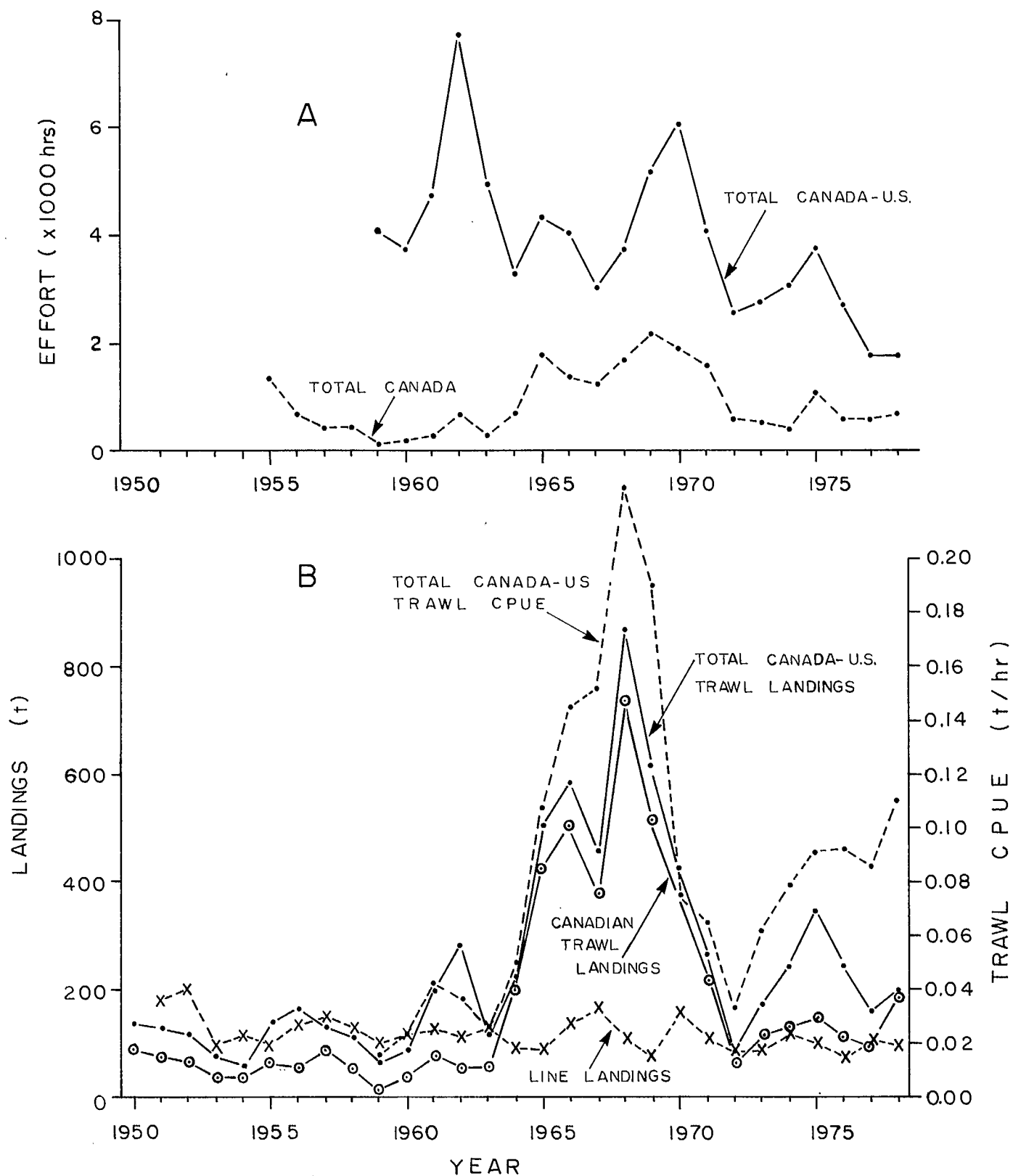


Fig. 5.4. Lingcod catch statistics for Area 3D (northwest Vancouver Island) 1950-78: A. Total trawl effort (hr), Canada-U.S. and Canada. B. Total landings (t); Canada-U.S. and Canada trawl, and Canada line; and total Canada-U.S. CPUE (t/hr).

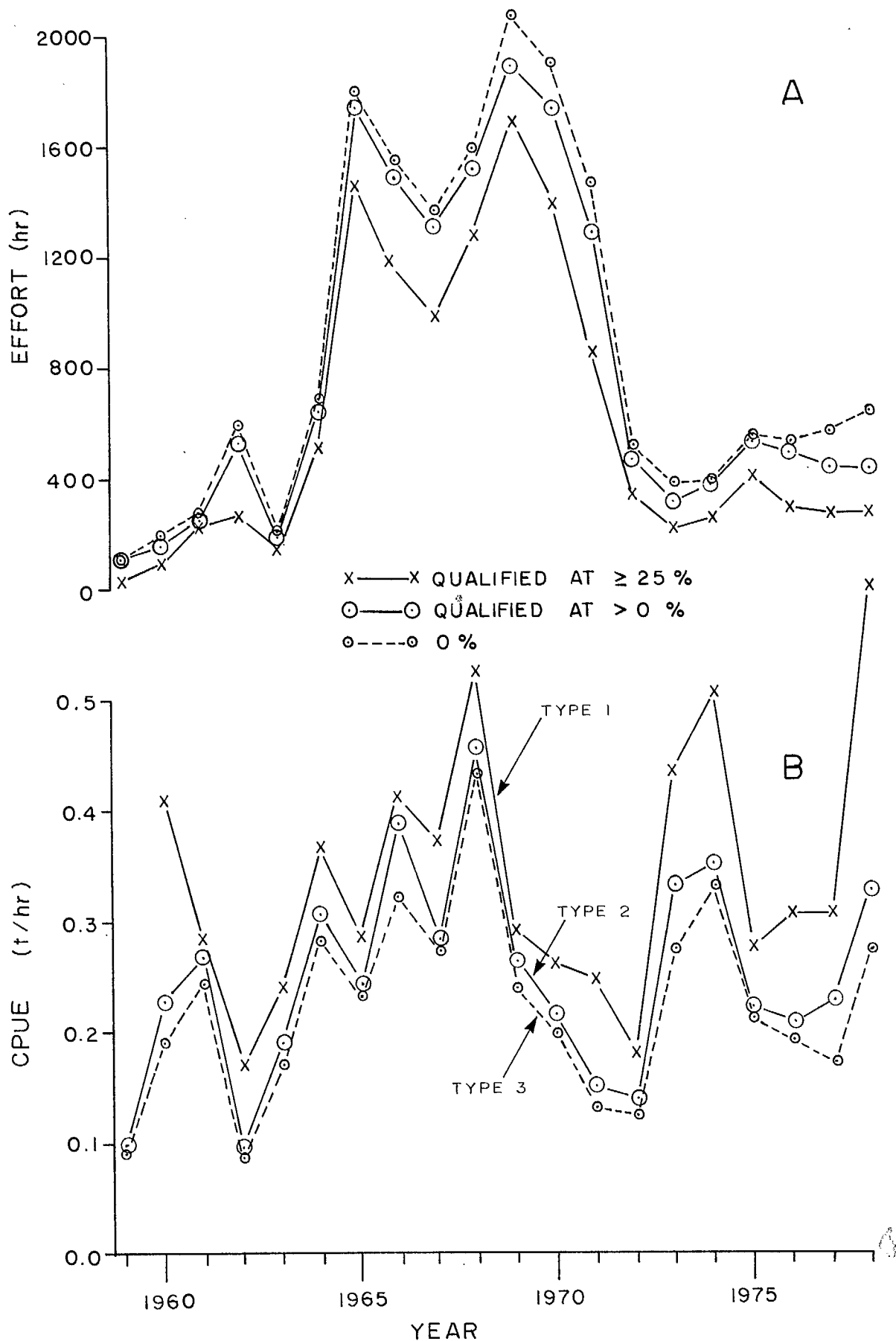


Fig. 5.5. Interviewed Canadian fishing effort (A) and CPUE (B) for lingcod in Area 3D, 1959-78.

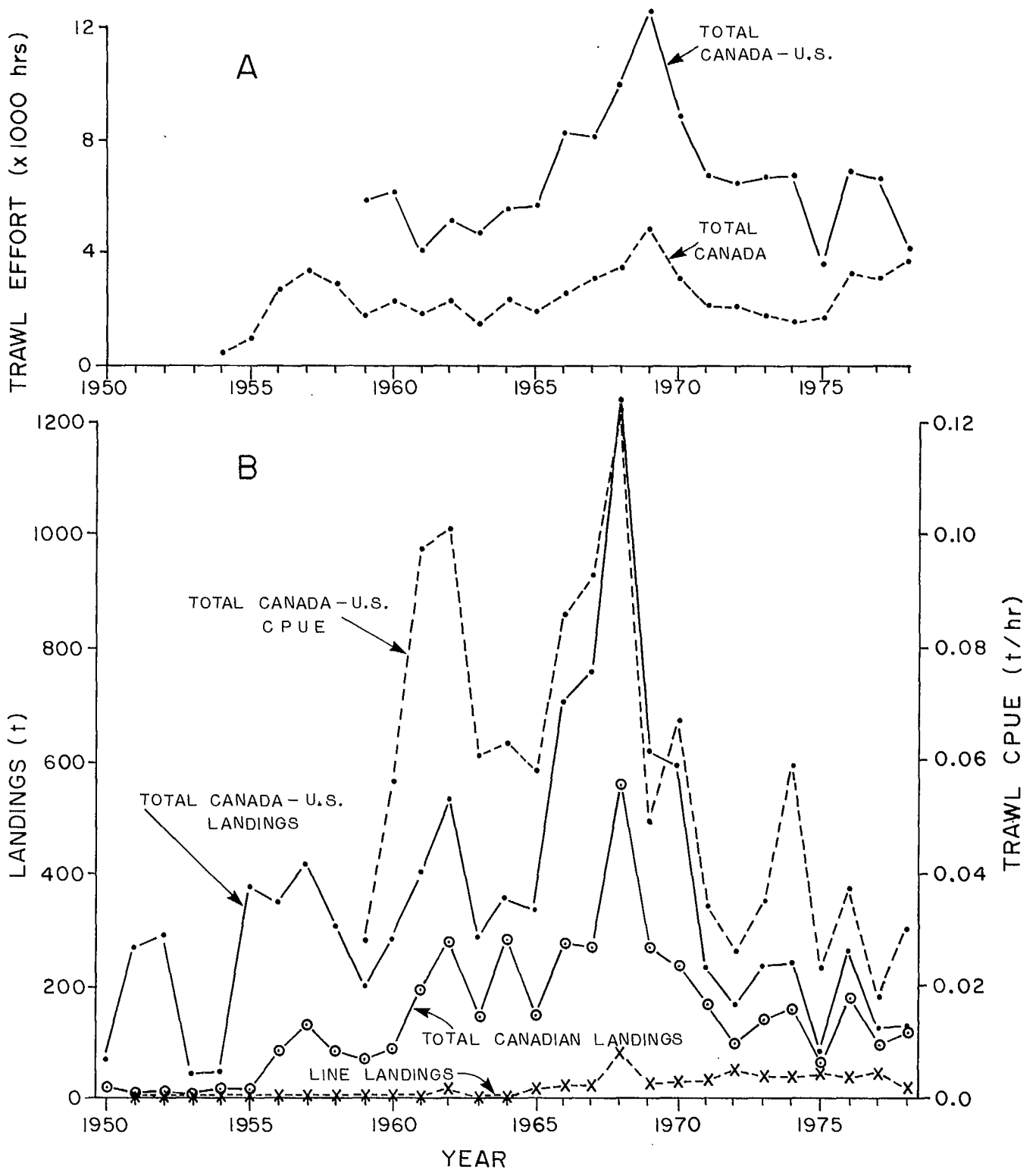
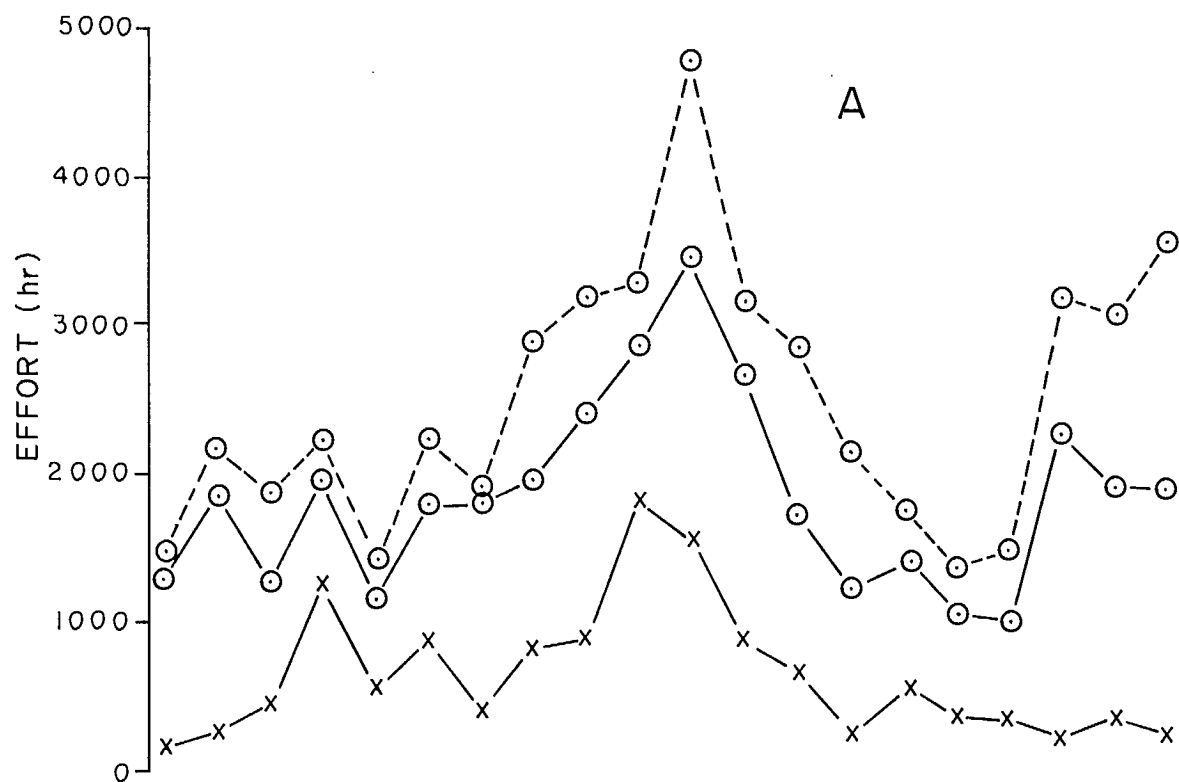


Fig. 5.6. Lingcod catch statistics for Area 5A (Cape Scott grounds) 1950-78:
A. Total trawl effort (hr), Canada-U.S. and Canada. B. Total landings (t);
Canada-U.S. and Canada trawl, and Canada line; and total Canada-U.S. CPUE (t/hr).



x—x QUALIFIED AT $\geq 25\%$
 ○—○ QUALIFIED AT $> 0\%$
 ○---○ 0%

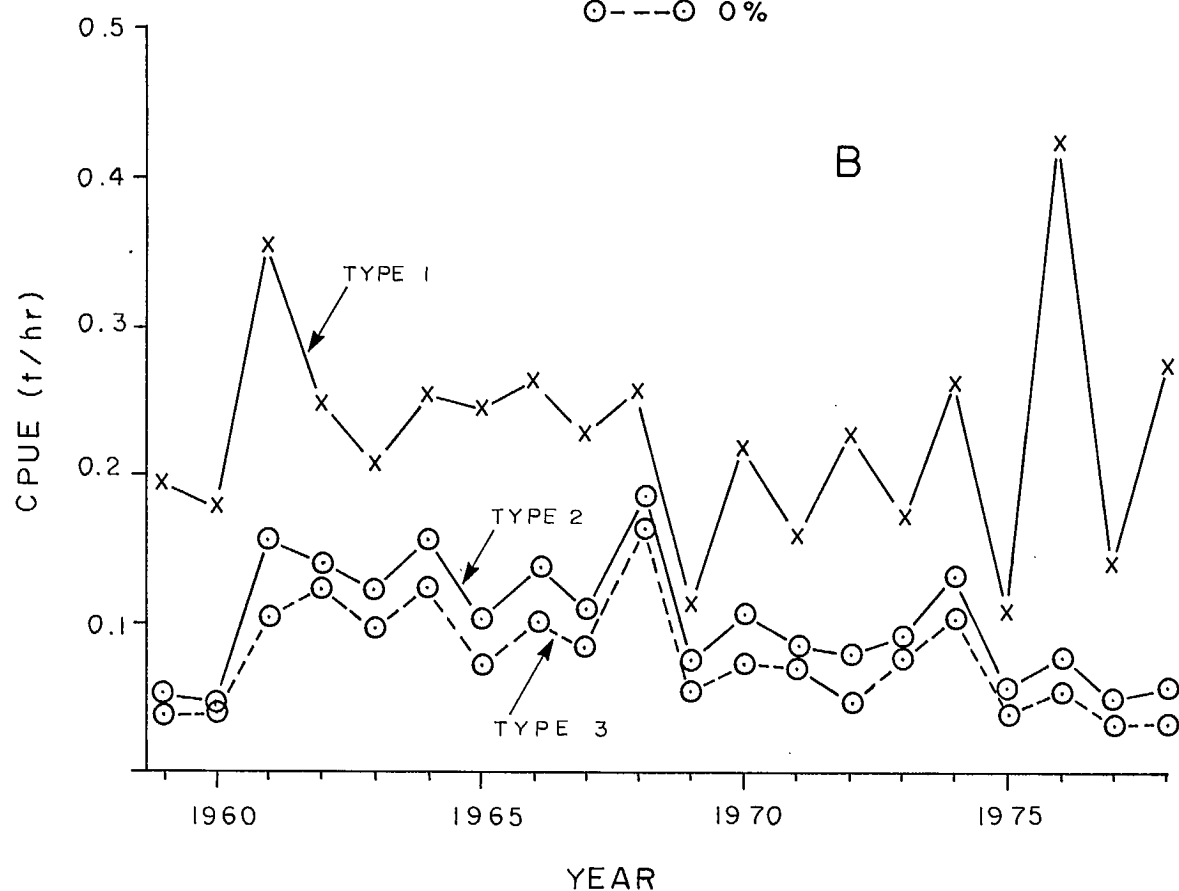


Fig. 5.7. Interviewed Canadian fishing effort (A) and CPUE (B) for lingcod in Area 5A, 1959-78.

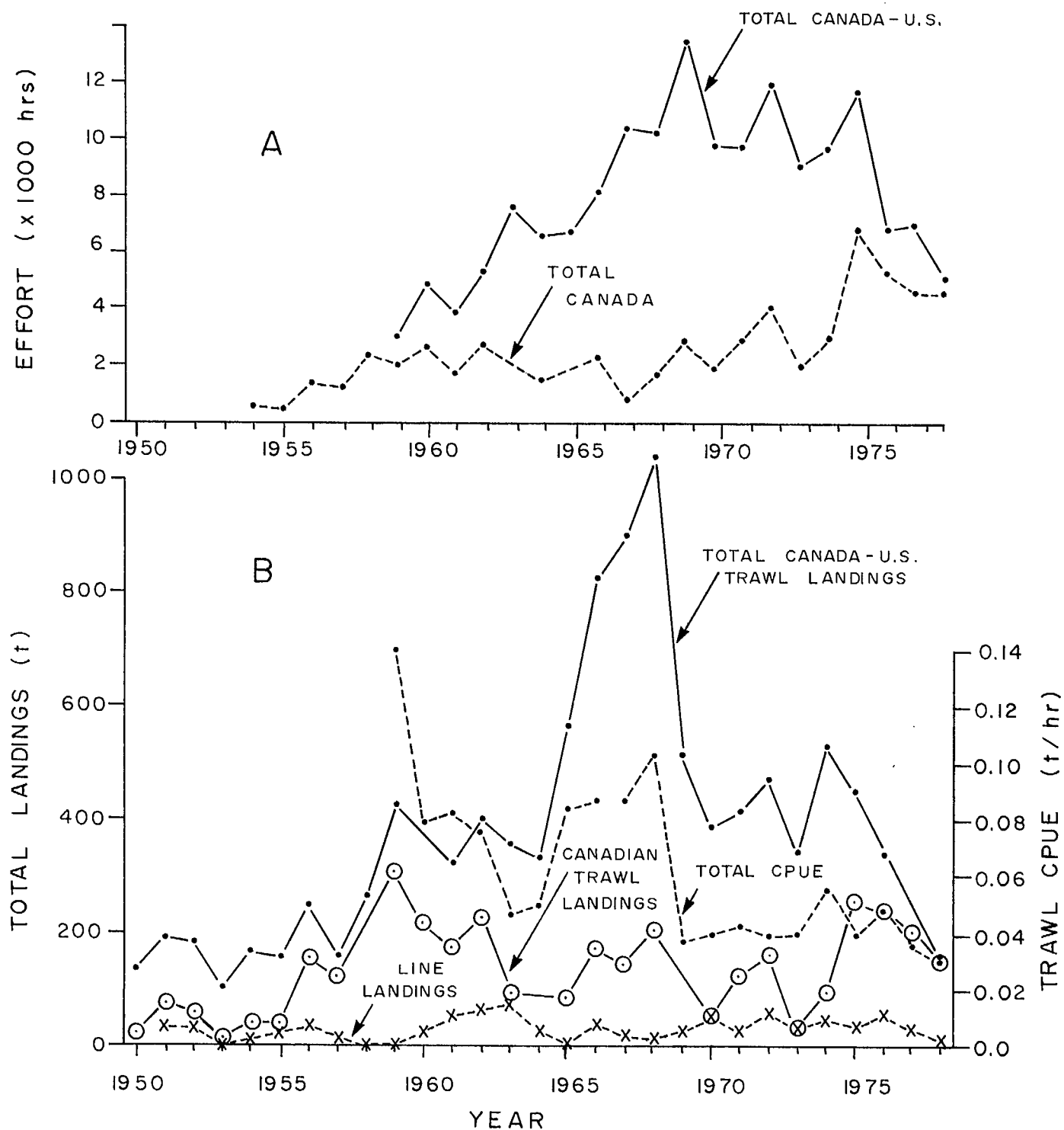


Fig. 5.8. Lingcod catch statistics for Area 5B (Goose Island grounds) 1950-78:
A. Total trawl effort (hr), Canada-U.S. and Canada. B. Total trawl landings (t);
Canada-U.S. and Canada trawl, and Canada line; and total Canada-U.S. CPUE (t/hr).

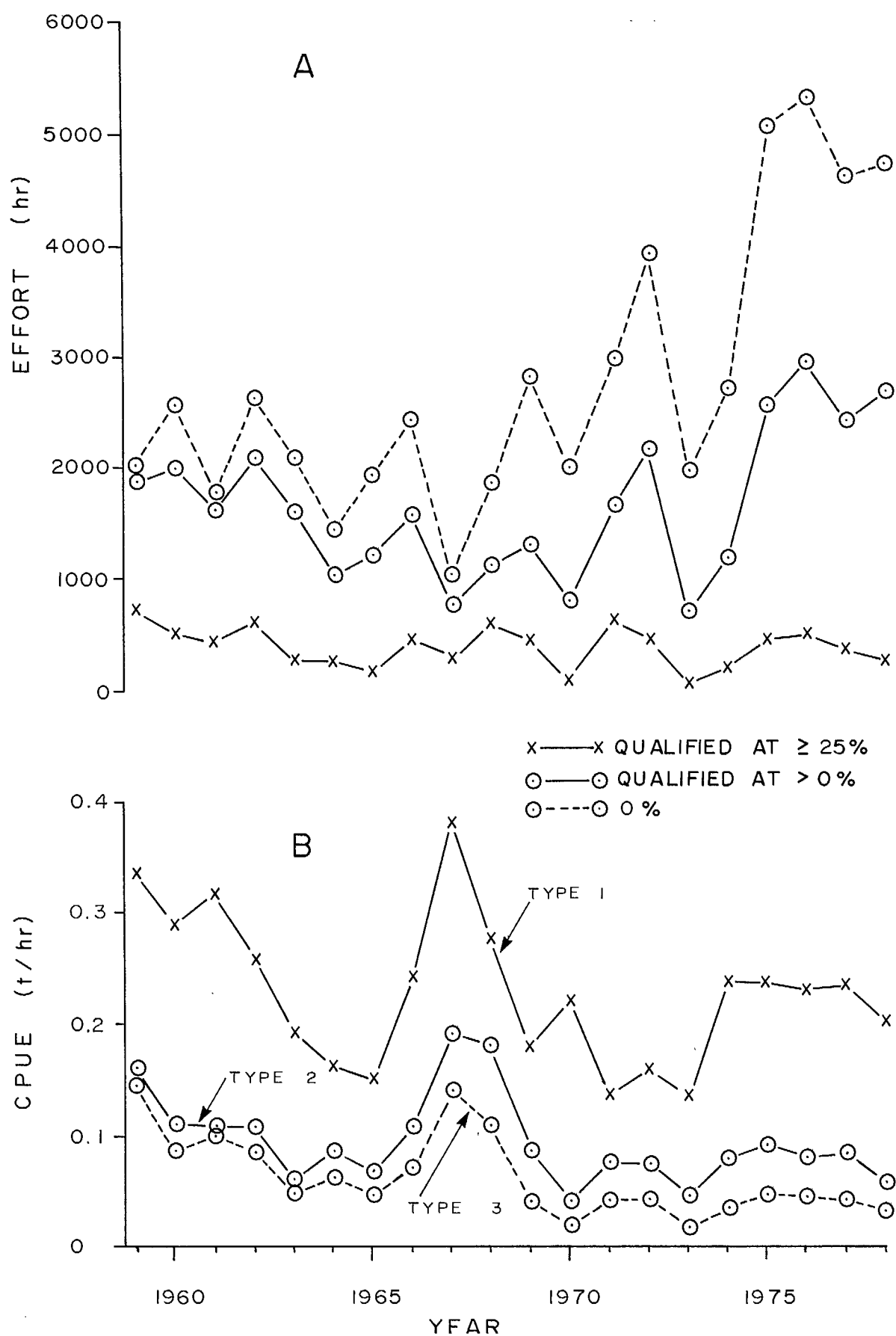


Fig. 5.9. . Interviewed Canadian fishing effort (A) and CPUE (B) for lingcod in Area 5B, 1959-78.

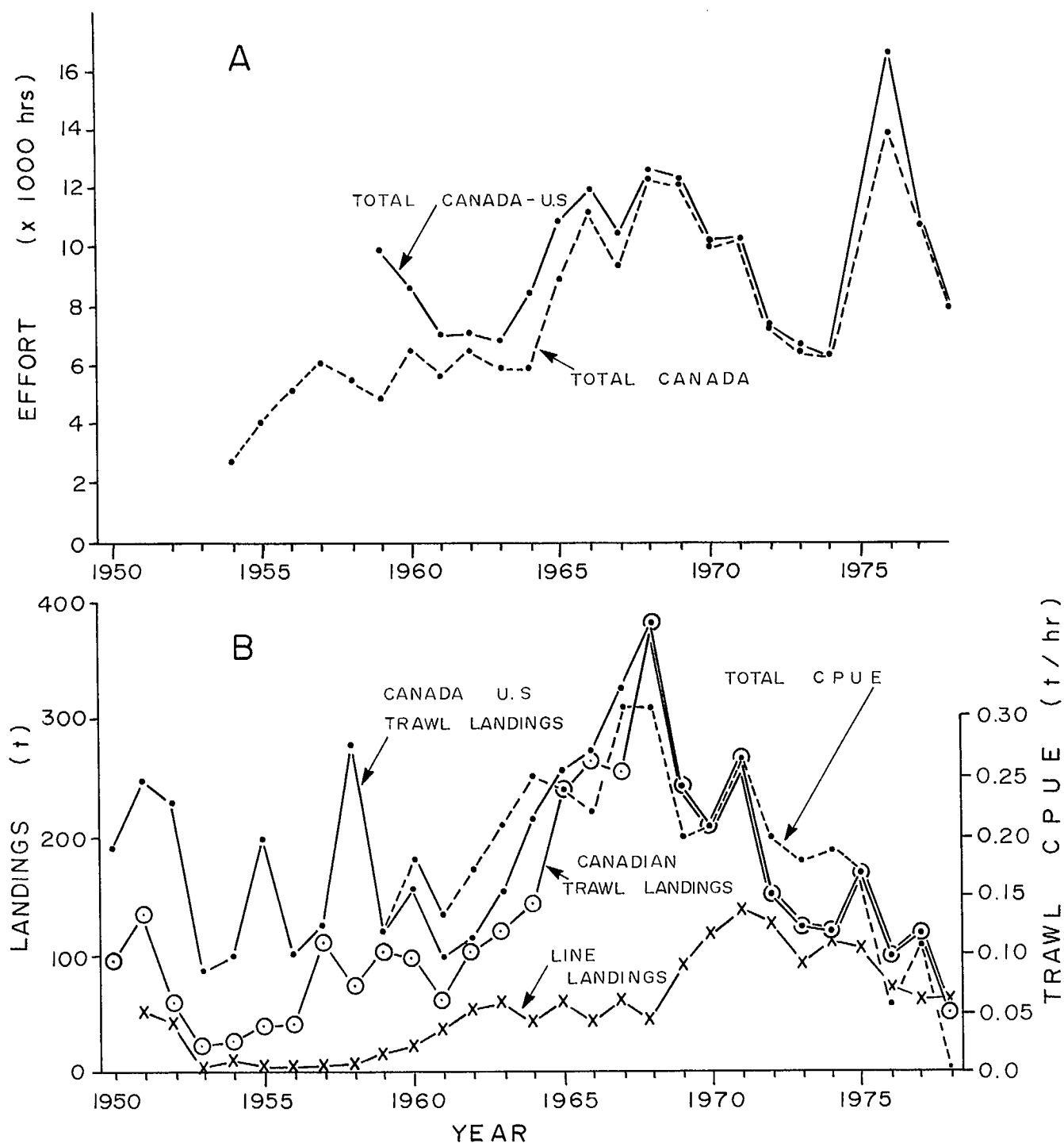


Fig. 5.10. Lingcod catch statistics for Area 5C and 5D (Hecate Strait and Dixon Entrance) 1950-78: A. Total trawl effort (hr), Canada-U.S. and Canada. B. Total trawl landings (t); Canada-U.S. and Canada trawl, and Canada line; and total Canada-U.S. CPUE (t/hr).

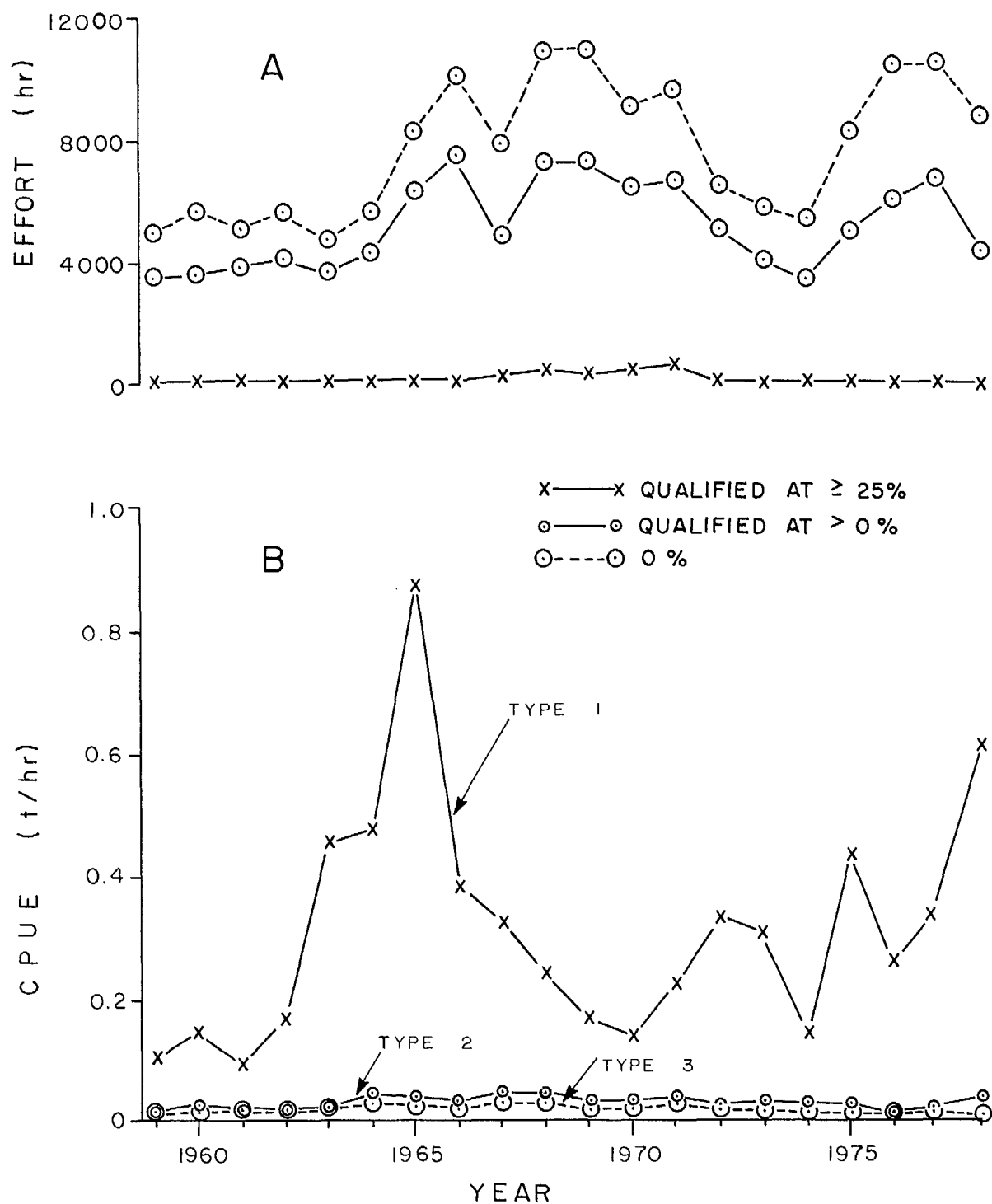


Fig. 5.11. Interviewed Canadian fishing effort (A) and CPUE (B) for lingcod in Areas 5C and 5D, 1959-78.

6. DOGFISH STOCK ASSESSMENT

6.1 History of the fishery

During 1940-49, dogfish (Squalus acanthias) were the object of an intensive liver fishery along the British Columbia coast which reached a peak production of about 35,000 t in 1944. With the development of synthetic Vitamin A, and importation of low-priced liver products, in 1949, the fishery collapsed and remained dormant until 1958. During 1959-75 a total of eleven subsidy programs resulted in a small dogfish fishery that took place mainly in the Strait of Georgia. During 1959-62, the sole aim of the subsidy was to reduce dogfish abundance below what was considered a nuisance level. The last three subsidies, starting in 1973, established potential foodfish markets but economic and processing difficulties kept production at low levels. Since the end of the subsidy programs, production has risen from 175 t in 1976 to 3,100 t in 1978. All of this production was for human consumption abroad.

6.2 Stock assessment

The absence of a continuing fishery for dogfish makes it very difficult to clearly define the number of stocks present in the Canadian zone or to determine current stock size. Catch and effort statistics from the 'liver fishery' of the 1940's indicate that the virgin biomass of marketable stock (approximately >75 cm) in British Columbia waters was in the order of 200,000 t. These statistics also suggest that the marketable stock was reduced to perhaps as little as one quarter of its primitive abundance by a fishery which averaged about 15,000 t/yr between 1937 and 1949 - a period of 13 years (Ketchen 1969).

A discrete-time, deterministic 'age-structure' model incorporating recent information on growth and reproduction of dogfish in the northeast Pacific has been developed to assess the overall potential of the dogfish resource (Wood et al. 1979). The analysis treats dogfish in British Columbia waters as a single stock and utilizes the estimate of primitive abundance and historical catch data to simulate past fisheries (Fig. 6.1). The model predicted that the liver fishery reduced the marketable biomass to at least half of its primitive abundance by 1949, but that the stock would recover as early as 1960, due to the considerable biomass of juveniles, inhabiting mid-water regions, that would have escaped the fishery. This apparent recovery is corroborated by the growing number of complaints about the 'dogfish problem' as early as the late 1950's which led to the introduction of the subsidized 'eradication fishery' of 1959-62. But while the marketable stock appeared to recover quickly, it is likely that the population is approaching its historic levels. The present biomass of marketable stock is probably in the order of 120,000-150,000 t.

6.3 Sustainable yield

From the biomass estimates it might be expected that the current stock(s) off British Columbia could support a substantial fishery

indefinitely. However, because of the unique biological features of the dogfish, it is extremely sensitive to overfishing.

If the stocks were to be fished with the object of obtaining a maximum sustainable yield of large fish (approximately >75 cm), the yield would be only about 8,000-10,000 t with one-third (3,000 t) assignable to the Strait of Georgia and the remaining two-thirds (6,000 t) to all other areas. It is important to note that production from the Strait of Georgia utilized 94% of the 3,000 t quota assigned to that area in 1978. However, at present, it is not possible to adequately assess the impact of the recently intensified longline fishery on the abundance of marketable stock using catch and effort statistics. This is because of difficulties in standardizing an appropriate measure of effort for the period prior to September 1978.

There are other possible fishing strategies which can be employed depending on whether the dogfish stock is to be maintained at its MSY or is to be reduced as efficiently and quickly as possible to a level where the species ceases to be a nuisance to fisheries for other species. A periodic fishery which attempts to fish dogfish intensively for short periods can harvest up to 16,000 t per year (11,000 t in Zones 5 and 3) of fish larger than 78 cm and may reduce abundance below some "nuisance" level. If our calculations of stock size are correct, then the stocks could not sustain this fishing pressure for more than 10-15 yr and would quickly be reduced to levels where fishing would discontinue for economic reasons.

A periodic fishery will only reduce the dogfish stocks below a "nuisance" level for a short time (5-15 yr). Because a considerable biomass of juvenile dogfish exist in the midwater, they are not fished and become recruited into the fishable stock after a fishery ends. This recruitment of juveniles from the midwater, and the disruptions in age structure caused by a periodic fishery, will result in oscillations in abundance (Fig. 6.2, 6.3). A sustained fishery will also produce oscillations in abundance, but these oscillations will dampen with time (Fig. 6.2). Any type of periodic fishery will perpetuate these cycles of abundance (Fig. 6.3). Furthermore, the greater the intensity or longer the duration of the periodic fishery, the greater are the oscillations in abundance. It is somewhat paradoxical that an intensive periodic effort to reduce dogfish as a nuisance can result in a perpetuation of the problem.

6.4 Recommendations

It is recommended that a TAC for dogfish of 3,000 t be assigned for the Strait of Georgia (PMFC Area 4B) and a TAC of 6,000 t be set to cover all other areas of the Canadian zone.

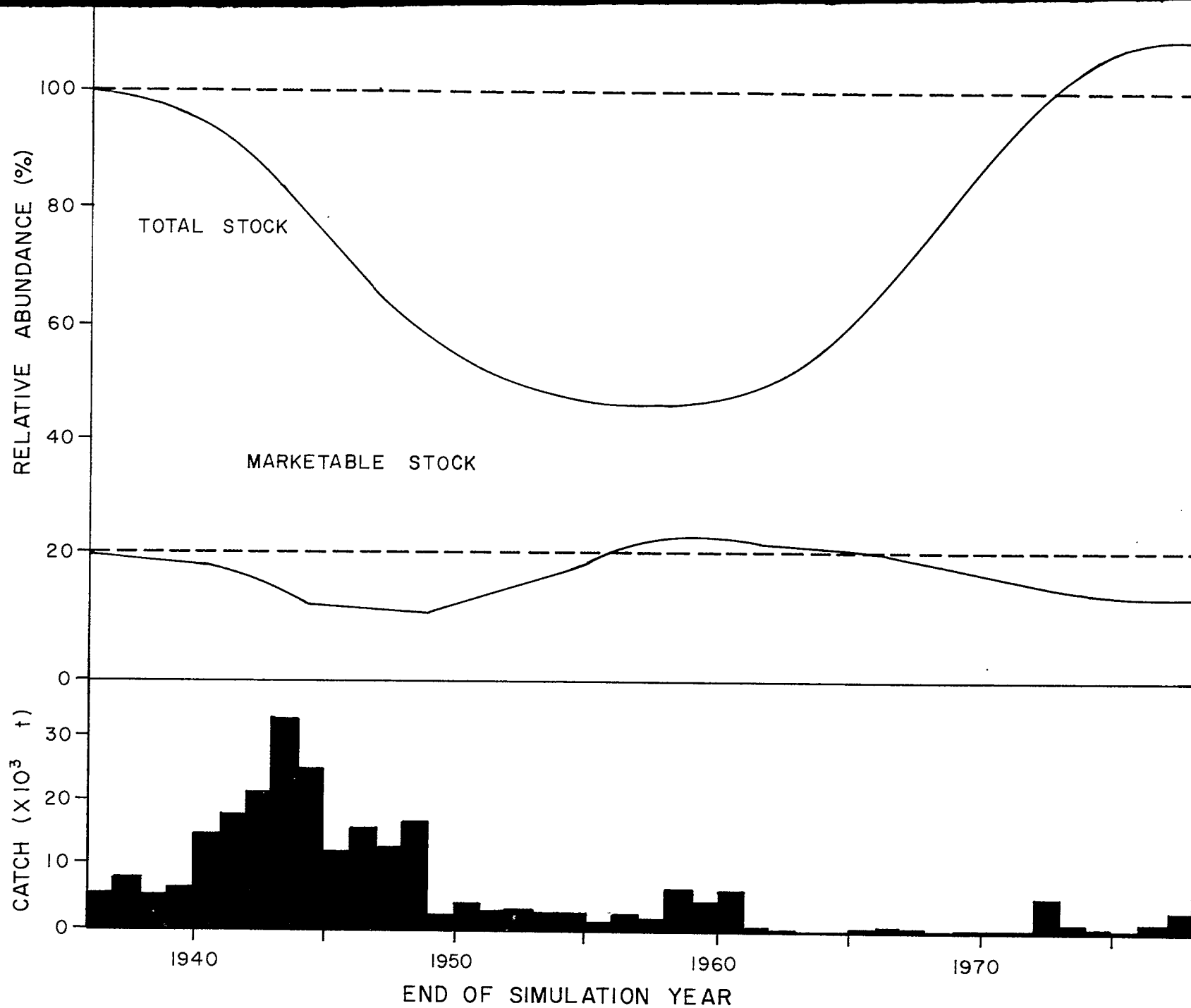


Fig. 6.1. Simulation of dogfish abundance following intensive 'liver fishery'.

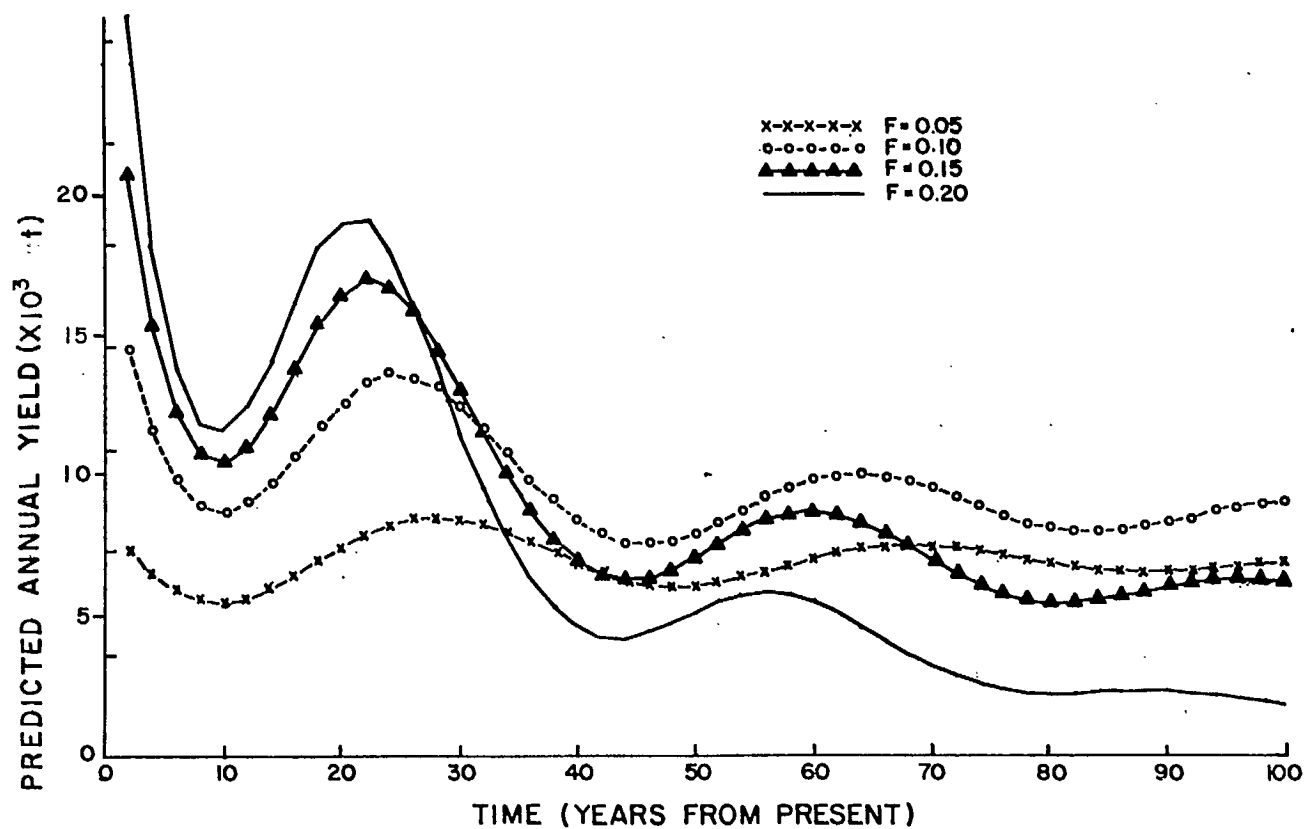


Fig. 6.2. Predicted yield to hypothetical dogfish fishery at four sustained fishing rates. (F = instantaneous rate of fishing mortality.)

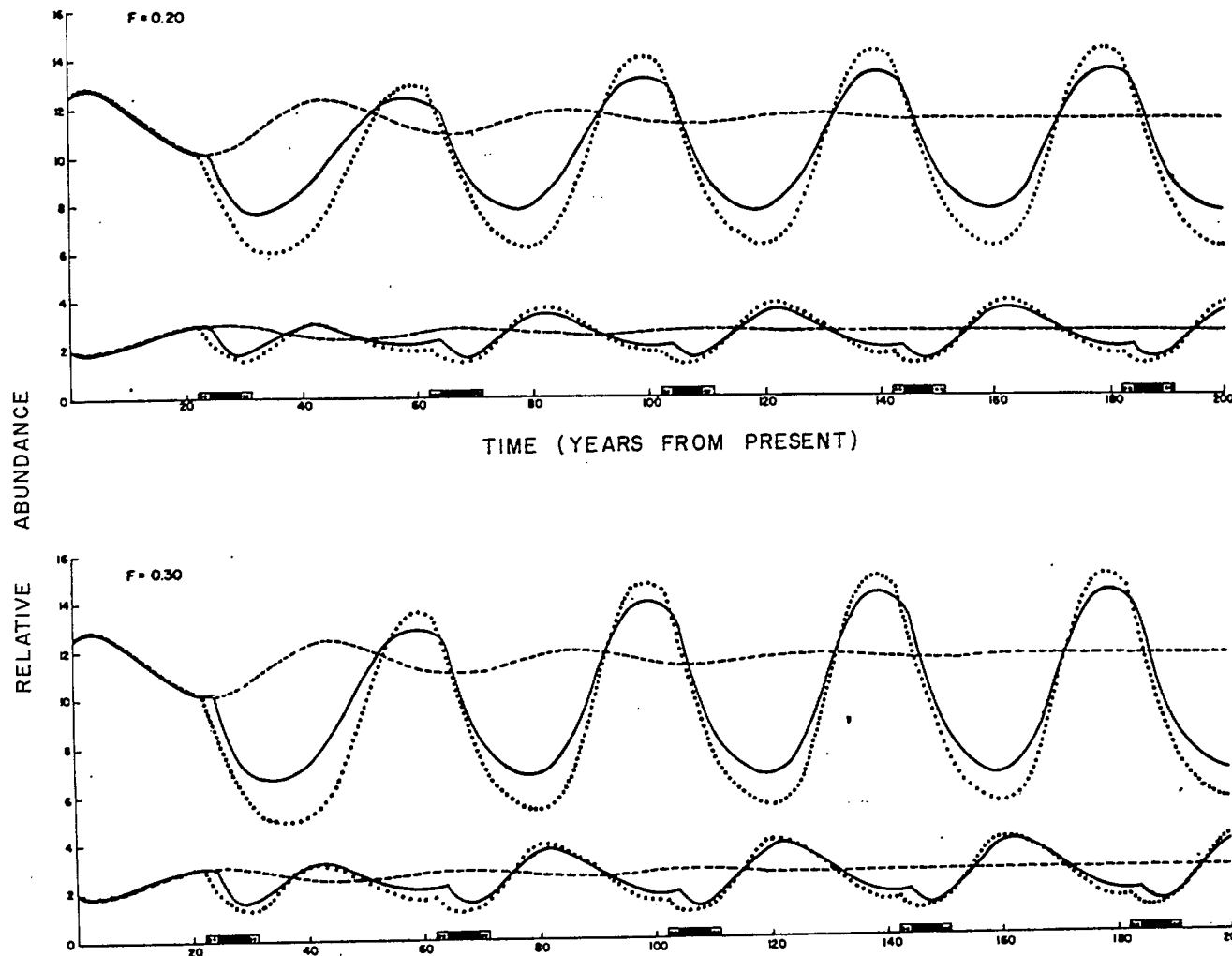


Fig. 6.3. Abundance of dogfish predicted by model when exploited by a periodic fishery commencing every 40 yr. The upper lines in each diagram represent the total stock (i.e., all age groups) whereas the lower lines represent only the marketable-sized stock. Dashed lines predict the abundance with no fishery; solid lines, the abundance during a 5-yr periodic fishery; and dotted lines, the abundance during a 9-yr periodic fishery. F = instantaneous rate of fishing mortality.

7. ROCK SOLE STOCK ASSESSMENTS

7.1 Introduction

The rock sole (Lepidopsetta bilineata) is an important component of the Canadian trawl fishery off the coast of British Columbia. Commercially exploited stocks are located off the west coast of Vancouver Island, in Queen Charlotte Sound, Hecate Strait and Strait of Georgia. Canadian and U.S. vessels have traditionally participated in the rock sole fishery. In recent years, however, only Canadian trawl fishermen have landed rock sole.

In this assessment, surplus production models are presented and used to estimate stock productivity, maximum sustainable yields, corresponding effort levels and recommended TACs for 1980.

7.2 Commercial fishery

Since the early 1950s, rock sole has been the dominant flatfish in trawl landings in British Columbia, and production has varied between 1,099 t and 3,931 t with an average of 2,038 t/yr (Table 7.1). The bulk of landings have originated from fishing grounds between Cape Scott and Dixon Entrance. The principal fishing grounds are Two Peaks-Butterworth and Ole Spot, in Hecate Strait.

The period of initial exploitation was complete by 1958. This was followed by a period of lower catches with fluctuations between 1,100 and 2,200 t during 1959-65. A sharp rise in rock sole catch occurred in the mid-1960s followed by a rapid decline in the early 1970s. Recently, catches have been moderate, fluctuating around the 1,500 t level (Fig. 7.1).

7.3 Stock considerations

For the purpose of this analysis the rock sole resource is viewed as six discrete units or stocks (Fig. 7.2): North Hecate Strait (southern boundary 53°50'N), Middle Hecate Strait (northern boundary 53°50'N), Goose Island Ground (Area 5B), Cape Scott Ground (Area 5A), west coast of Vancouver Island (Areas 3C and 3D), and Strait of Georgia (Area 4B). these delineations are based mainly on earlier tagging studies (Forrester and Thomson 1969).

7.4 Trends in catch and CPUE

A measure of abundance based on the qualified catch-per-unit-effort (CPUE) was used for this investigation. Abundance of rock sole for Hecate Strait stocks was estimated using the 25% qualified CPUE from interviewed catch data. For the other stocks, 50% qualified CPUE was used as an estimate of abundance. Estimates of effort were obtained by dividing annual CPUEs into annual total landings.

The results for the various stocks of the Canadian zone are summarized in Tables 7.2-7.4. CPUE in North Hecate Strait has fluctuated widely since 1954. Rock sole abundance in this important fishing area peaked in 1960-61 and 1965, and gradually declined to a low of 0.28 t/hr in 1972. In recent years, CPUE has fluctuated around 0.40 t/hr (Table 7.2).

In Middle Hecate Strait production has also been quite variable. Landings peaked in 1957 and were generally high from 1966 to 1970 and then declined sharply to a low of 275 t in 1972. In recent years landings have increased and CPUE has not shown a significant trend (Table 7.3).

On the Goose Island and Cape Scott Grounds, rock sole production showed moderate fluctuations. For the time period considered CPUE remained notably stable. Similarly no trend in CPUE is shown for the west coast of Vancouver Island and the Strait of Georgia stocks (Table 7.4).

7.5 Yield

The relationship between catch and effort for the years 1954 to 1979 was examined using surplus production models. Model parameters were estimated using three methods. The first involves a regression of CPUE on average fishing effort (\bar{f}) over a number of preceding years (K). The line ($CPUE = a - b\bar{f}$) ideally, will be very close to the true relation between CPUE (abundance) and effort in a steady state (Gulland 1961). Estimates of a and b are related to fisheries parameters as follows:

$$MSY = \frac{a^2}{4b} \text{ and } f_{opt} = \frac{a}{2b}$$

The second method involves a difference-equation version of the Schaefer model (Walters and Hilborn 1976). Transforming the equation into a linear regression form and using the time series of CPUE and effort, estimates of biological (r' , q , k) and fisheries parameters (MSY , f_{opt}) are obtained:

$$MSY = \frac{r'k}{4} \text{ and } f_{opt} = \frac{r'}{2q}$$

where: MSY = maximum sustainable yield
 f_{opt} = optimum fishing effort
 r' = population growth parameter
 q = catchability coefficient
 k = unfished equilibrium population size

The third method represents a discrete-time, stochastic version of Schaefer's production model (Schnute 1977). The analysis provides estimates of biological (r' , q , k), fisheries (MSY , f_{opt}), and variance parameters (σ , I).

7.5.1 North Hecate Strait

Table 7.5 presents the results of the parameter estimates for the North Hecate Strait rock sole stock. The best fit to the data (as determined by the correlation coefficient; $r = -0.744$) was obtained by the Gulland linear regression model with $K = 5$. The resulting estimate of MSY is 754 t with a corresponding optimal fishing effort of 1,084 hours for an optimal CPUE of 0.70 t/hr.

Parameters estimated by the linear Schaefer model were rejected due to the low coefficient of determination ($R^2 = 0.241$). Similarly the dynamic Schaefer model produced a high failure rate index ($I = 0.910$) indicating that past and present effort levels are poor predictors of catch for the Northern Hecate Strait rock sole fishery.

7.5.2 Middle Hecate Strait

Table 7.6 presents the results of the parameter estimates obtained for the Middle Hecate Strait stock. The best fit to the data (as determined by the failure rate index; $I = 0.85$) was obtained from the dynamic Schaefer model analysis (Schnute 1977). The resulting estimate of MSY is 622 t with a corresponding optimal fishing effort of 1,388 hours for an optimal CPUE of 0.45 t/hr. The dynamic Schaefer model gives a good fit to historical data for the Middle Hecate Strait rock sole fishery, as shown in Fig. 7.3. Parameters from the two other estimation procedures were rejected on the basis of variance considerations.

7.5.3 Other stocks

Tables 7.7 to 7.9 present the results of the parameter estimates obtained for Goose Island Ground, Cape Scott Ground, and west coast of Vancouver Island stocks. The best fits to the data were obtained by the Gulland linear regression model with $K = 3$. However, the resulting parameters have to be viewed with caution since the correlation between abundance and average effort was very low ($r = -0.500$). The estimates for MSY are 577 t, 335 t, and 224 t for Goose Island, Cape Scott, and west coast of Vancouver Island, respectively. Estimates of the corresponding optimal fishing efforts were 2,953 hr, 2,118 hr, and 2,201 hr.

Parameter estimates by the linear Schaefer model were rejected because of low coefficients of determination and negative parameter values. Also the dynamic Schaefer model analysis produced negative parameter estimates for the three stocks.

7.6 Yield forecasts for 1980

The estimates of the biological, fishery, and variance parameters were used to predict 1980 yields for the various stocks.

7.6.1 Northern Hecate Strait

Walter (1976) studied the yield of a fishery under non-equilibrium condition using Schaefer's surplus production model. He developed a simple graphical procedure for determining the total allowable catch (TAC) based on the preceding year's catch and effort and fishery parameter estimates (previous section). On a plot of equilibrium catch versus equilibrium effort, the most recent non-equilibrium point (C_{79} , f_{79}) is located and a straight line drawn through the origin. Intersection of this line and the vertical line through f_{opt} locates the TAC point for 1980 (Fig. 7.4). Using this method, the response is adequate when the unharvested equilibrium biomass (k) has not been reduced below one-fourth. If the stock has been reduced to a level below one-fourth k , the maximum speed of recovery is achieved when no harvesting is allowed. Accordingly, the TAC for 1980 should be 460 t if recovery to the MSY level is desired (Fig. 7.4).

7.6.2 Middle Hecate Strait

The estimates of the biological and variance parameters combined with information on most recent catch and effort (C_{79} , f_{79}) was used to predict 1980 catch levels for the existing non-equilibrium situation (Schnute 1977). The catch predictions and upper and lower 95% confidence limits are shown in relation to possible effort levels for 1980 (Fig. 7.5). Present stock abundance would yield close to MSY in 1980 if fished at the predicted effort level (f_{opt}). These results suggest that in 1980 effort should be held at levels below equilibrium levels producing a yield of about 500 t. This reduced catch level is precautionary due to large error margins in catch predictions (Fig. 7.5).

7.6.3 Other stocks

With the large uncertainty about parameter estimates, it is difficult to forecast rock sole yield for Goose Island, Cape Scott and the west coast of Vancouver Island stocks. Even though the Gulland analysis indicates that stocks in these regions show relatively high abundance, these conclusions have to be viewed with caution since the effort data stemming from multispecies exploitation may be weak. Despite these shortcomings it is anticipated that for 1980 present stock abundances should yield 200 t, 100 t, and 100 t for Goose Island, Cape Scott, and the west coast of Vancouver Island, respectively. These stocks are of relatively minor importance accounting for less than 30% of the Canadian rock sole production. Nevertheless, further studies are planned to include analysis of the multispecies complex and appropriate assignments of effort levels.

7.7 Recommendations

Based on the described analysis, which for some stocks produced highly variable results, the following TACs are recommended for rock sole in 1980:

North Hecate Strait (North of 53°50')	460 t
Middle Hecate Strait (South of 53°50')	500 t
Goose Island Ground (5B)	200 t

Cape Scott Ground (5A)	100 t
West coast of Vancouver Island grounds (3C and 3D)	100 t
Strait of Georgia (4B)	20 t

If further analyses, particularly those including age structure, establish considerable departure from present estimates of the stock conditions, these figures may be altered accordingly during a mid-season review.

Table 7.1. Canada - U.S. rock sole landings (t) from British Columbia waters, 1954-78.

Year	Landings (t) ^a
1954	1,360
1955	2,097
1956	2,252
1957	2,122
1958	2,284
1959	1,122
1960	2,194
1961	1,594
1962	1,827
1963	1,749
1964	1,618
1965	1,842
1966	3,931
1967	3,456
1968	3,454
1969	3,547
1970	1,957
1971	2,206
1972	1,179
1973	1,099
1974	1,252
1975	1,915
1976	2,226
1977	1,298
1978	1,313

^aData sources:

Canada - sales slips & trip logs;
U.S. - 1954-75 Ketchen (1976)
- 1976-77 supplied by Washington
State Department of Fisheries.
1978, provisional.

Table 7.2. Canada-U.S. rock sole landings (t), CPUE (t/hr), and calculated effort (hr) for North Hecate Strait (north of 53°50'), 1954-79.

Year	Total landings ^a (t)	CPUE ^b (t/hr)	Effort ^c (hr)
1954	835	1.01	827
1955	1,324	0.74	1,789
1956	512	0.63	813
1957	211	0.52	406
1958	797	1.06	752
1959	109	0.83	131
1960	626	1.48	423
1961	660	1.55	426
1962	503	1.18	426
1963	754	1.02	739
1964	484	0.77	629
1965	318	1.54	206
1966	1,468	0.83	1,769
1967	1,045	0.85	1,229
1968	1,386	0.45	3,080
1969	1,230	0.78	1,577
1970	455	0.44	1,034
1971	895	0.39	2,295
1972	230	0.28	821
1973	180	0.46	391
1974	220	0.32	688
1975	562	0.64	878
1976	892	0.55	1,622
1977	427	0.36	1,186
1978	394	0.44	895
1979 ^d	420	0.42	1,000

^aData Sources: Canada - sales slips and trip logs.
U.S. - 1954-75 Ketchen (1976)
- 1976-77 supplied by Washington State Department
of Fisheries.
1978-79, provisional.

^bFrom trip logs (25 percent qualification level).

^cTotal landings/CPUE

^dProjected estimate

Table 7.3. Canada-U.S. rock sole landings (t), CPUE (t/hr), and calculated effort (hr) for Middle Hecate Strait (south of 53°50'), 1954-79.

Year	Total landings ^a (t)	CPUE ^b (t/hr)	Effort ^c (hr)
1954	91	0.46	198
1955	235	0.74	318
1956	770	0.73	1,055
1957	1,039	0.48	2,165
1958	483	0.49	986
1959	338	0.43	786
1960	509	0.45	1,131
1961	135	0.29	466
1962	329	0.51	645
1963	160	0.40	400
1964	308	0.41	751
1965	562	0.64	878
1966	1,095	0.68	1,610
1967	1,153	0.51	2,261
1968	1,044	0.38	2,747
1969	1,197	0.30	3,990
1970	950	0.28	3,393
1971	633	0.26	2,435
1972	275	0.38	724
1973	324	0.34	953
1974	403	0.48	840
1975	702	0.28	2,507
1976	544	0.29	1,876
1977	420	0.28	1,500
1978	483	0.37	1,305
1979 ^d	499	0.42	1,188

^aData Sources: Canada - sales slips and trip logs.

U.S. - 1954-75 Ketchen (1976)

- 1976-77 supplied by Washington State Department of Fisheries.

1978-79, provisional.

^bFrom trip logs (25 percent qualification level).

^cTotal landings/CPUE

^dProjected estimate

Table 7.4. Canada-U.S. rock sole landings (t), CPUE (t/hr), and calculated effort (hr) for Goose Island Ground, Cape Scott Ground, West Coast Vancouver Island, and Strait of Georgia, 1954-79.

Year	Goose Island Ground			Cape Scott Ground			West Coast Vancouver Is.			Strait of Georgia		
	Total ^a landings (t)	CPUE ^b (t/hr)	Effort ^c (hr)	Total landings (t)	CPUE (t/hr)	Effort (hr)	Total landings (t)	CPUE (t/hr)	Effort (hr)	Total landings (t)	CPUE (t/hr)	Effort (hr)
1954	203	0.59	344	52	0.17	306	103	0.14	736	76	0.07	1,086
1955	267	0.39	685	118	0.30	393	111	0.14	793	42	0.06	700
1956	265	0.40	663	528	0.28	1,886	104	0.13	800	73	0.10	730
1957	199	0.29	686	524	0.23	2,278	90	0.15	600	59	0.11	536
1958	379	0.24	1,579	504	0.22	2,291	62	0.15	413	59	0.07	843
1959	350	0.32	1,094	213	0.18	1,183	71	0.07	1,014	41	0.14	293
1960	503	0.28	1,796	397	0.21	1,890	108	0.07	1,543	51	0.10	510
1961	423	0.22	1,923	237	0.21	1,129	81	0.10	810	58	0.06	967
1962	535	0.24	2,229	198	0.15	1,320	190	0.18	1,055	72	0.08	900
1963	533	0.26	2,050	161	0.17	947	98	0.14	700	43	0.07	614
1964	483	0.22	2,195	160	0.20	800	130	0.12	1,083	53	0.08	662
1965	568	0.28	2,029	157	0.18	872	187	0.13	1,438	50	0.07	714
1966	773	0.32	2,416	329	0.30	1,097	235	0.14	1,679	31	0.11	282
1967	745	0.33	2,258	253	0.22	1,150	227	0.14	1,621	33	0.06	550
1968	393	0.27	1,456	448	0.26	1,723	155	0.15	1,033	28	0.05	560
1969	652	0.22	2,964	296	0.18	1,644	141	0.12	1,175	31	0.08	387
1970	245	0.23	1,065	167	0.19	879	113	0.12	942	27	0.06	450
1971	373	0.21	1,776	134	0.23	583	157	0.09	1,744	14	0.06	233
1972	382	0.33	1,158	58	0.22	264	211	0.16	1,319	23	0.08	287
1973	324	0.27	1,200	61	0.82	74	171	0.17	1,006	39	0.08	487
1974	371	0.24	1,546	75	0.26	288	165	0.36	458	18	0.06	300
1975	408	0.37	1,103	37	0.10	370	164	0.17	965	42	0.06	700
1976	368	0.32	1,150	181	0.31	584	181	0.25	724	59	0.09	655
1977	188	0.26	723	84	0.21	400	122	0.21	581	52	0.17	306
1978	216	0.52	415	80	0.15	533	78	0.18	433	62	0.14	443
1979 ^d	165	0.40	413	170	0.15	1,133	63	0.15	420	20	0.10	200

^aData sources: Canada - sales slips and trip logs.

U.S. - 1954-75 Ketchen (1976)

- 1976-77 supplied by Washington State Department of Fisheries.

1978-79, provisional.

^bFrom trip logs (50 percent qualification level).

^cTotal landings/CPUE

^dProjected estimate

Table 7.5. Parameter estimates for North Hecate Strait rock sole stock.

I. Parameter estimates from Gulland's (1961) linear regression model.

	K=3	K=4	K=5
<u>Biological:</u>			
a	1.239	1.302	1.392
b	4.857×10^{-4}	5.493×10^{-4}	6.421×10^{-4}
<u>Fishery:</u>			
MSY(t)	790	771	754
f _{opt} (hr)	1,276	1,185	1,084
<u>Correlation:</u>			
r	-0.647	-0.677	-0.744

II. Parameter estimates from linear Schaefer model.

<u>Biological:</u>		<u>Fishery:</u>		<u>Coefficient of Determination:</u>	
r' ^a	0.845	MSY(t)	1,208	R ²	0.241
q	2.101×10^{-4}	f _{opt} (hr)	2,011		
k (t)	5,687				

III. Parameter estimates from dynamic Schaefer model.

<u>Biological</u>		<u>Fishery</u>		<u>"Variance"</u>	
r' ^a	0.355	MSY(t)	724	σ	0.433
q	2.580×10^{-4}	f _{opt} (hr)	688	I	0.910
k(t)	8,158				

a r' = growth parameter.

Table 7.6. Parameter estimates for Middle Hecate Strait rock sole stock.

I. Parameter estimates from Gulland's (1961) linear regression model.

	K=3	K=4	K=5
<u>Biological:</u>			
a	0.560	0.539	0.553
b	9.401×10^{-5}	8.840×10^{-5}	1.002×10^{-4}
<u>Fishery:</u>			
MSY(t)	835	822	762
f_{opt} (hr)	2,980	3,050	2,758
<u>Correlation:</u>			
r	-0.600	-0.589	-0.609

II. Parameter estimates from linear Schaefer model.

<u>Biological:</u>		<u>Fishery:</u>		<u>Coefficient of Determination:</u>	
$r'a$	0.836	MSY(t)	1,040	R^2	0.392
q	1.058×10^{-4}	f_{opt} (hr)	3,950		
k(t)	4,974				

III. Parameter estimates from dynamic Schaefer model.

<u>Biological:</u>		<u>Fishery:</u>		<u>"Variance":</u>	
$r'a$	0.396	MSY(t)	622	σ	0.284
q	1.426×10^{-4}	f_{opt} (hr)	1,388	I	0.848
k(t)	6,290				

$a_{r'}$ =growth parameter.

Table 7.7. Parameter estimates for Goose Island Ground rock sole stock.

I. Parameter estimates from Gulland's (1961) linear regression model.

	K=3	K=4	K=5
<u>Biological:</u>			
a	0.391	0.363	0.365
b	6.618×10^{-5}	5.044×10^{-5}	5.000×10^{-5}
<u>Fishery:</u>			
MSY(t)	577	655	662
$f_{opt}(hr)$	2,953	3,602	3,631
<u>Correlation:</u>			
r	-0.500	-0.370	-0.327

II. Parameter estimates from linear Schaefer model.

<u>Biological:</u>		<u>Fishery:</u>		<u>Coefficient of Determination:</u>	
$r'a$	1.328	MSY(t)	961	R^2	0.329
q	1.169×10^{-4}	$f_{opt}(hr)$	5,679		
k(t)	2,895				

III. Parameter estimates from dynamic Schaefer model.

<u>Biological:</u>	<u>Fishery:</u>	<u>"Variance":</u>
negative parameters		

a_r' =growth parameter.

Table 7.8. Parameter estimates for Cape Scott Ground rock sole stock.

I. Parameter estimates from Gulland's (1961) linear regression model.

	K=3	K=4	K=5
<u>Biological:</u>			
a	0.316	0.316	0.300
b	7.471×10^{-5}	7.511×10^{-5}	5.940×10^{-5}
<u>Fishery:</u>			
MSY(t)	335	332	378
f_{opt} (hr)	2,118	2,102	2,521
<u>Correlation:</u>			
r	-0.158	-0.154	-0.150

II. Parameter estimates from linear Schaefer model.

<u>Biological:</u>		<u>Fishery:</u>		<u>Coefficient of Determination:</u>	
r^1a	1.364	MSY(t)	330	R^2	0.295
q	4.917×10^{-4}	f_{opt} (hr)	1,387		
k(t)	969				

III. Parameter estimates from dynamic Schaefer model.

<u>Biological:</u>	<u>Fishery:</u>	<u>"Variance":</u>
negative parameters		

a_r^1 =growth parameter.

Table 7.9. Parameter estimates for west coast Vancouver Island sole stock.

I. Parameter estimates from Gulland's (1961) linear regression model.

	K=3	K=4	K=5
<u>Biological:</u>			
a	0.204	0.165	0.171
b	4.630×10^{-5}	1.171×10^{-5}	1.700×10^{-5}
<u>Fishery:</u>			
MSY(t)	224	583	429
f_{opt} (hr)	2,201	7,057	5,005
<u>Correlation:</u>			
r	-0.212	-0.048	-0.063

II. Parameter estimates from linear Schaefer model.

<u>Biological:</u>		<u>Fishery:</u>		<u>Coefficient of Determination:</u>	
$r'a$	0.087	MSY(t)	negative	R^2	0.234
q	negative	f_{opt} (hr)	negative		
k(t)	negative				

III. Parameter estimates from dynamic Schaefer model.

<u>Biological:</u>	<u>Fishery:</u>	<u>"Variance":</u>
	negative parameters	

a_r' =growth parameter.

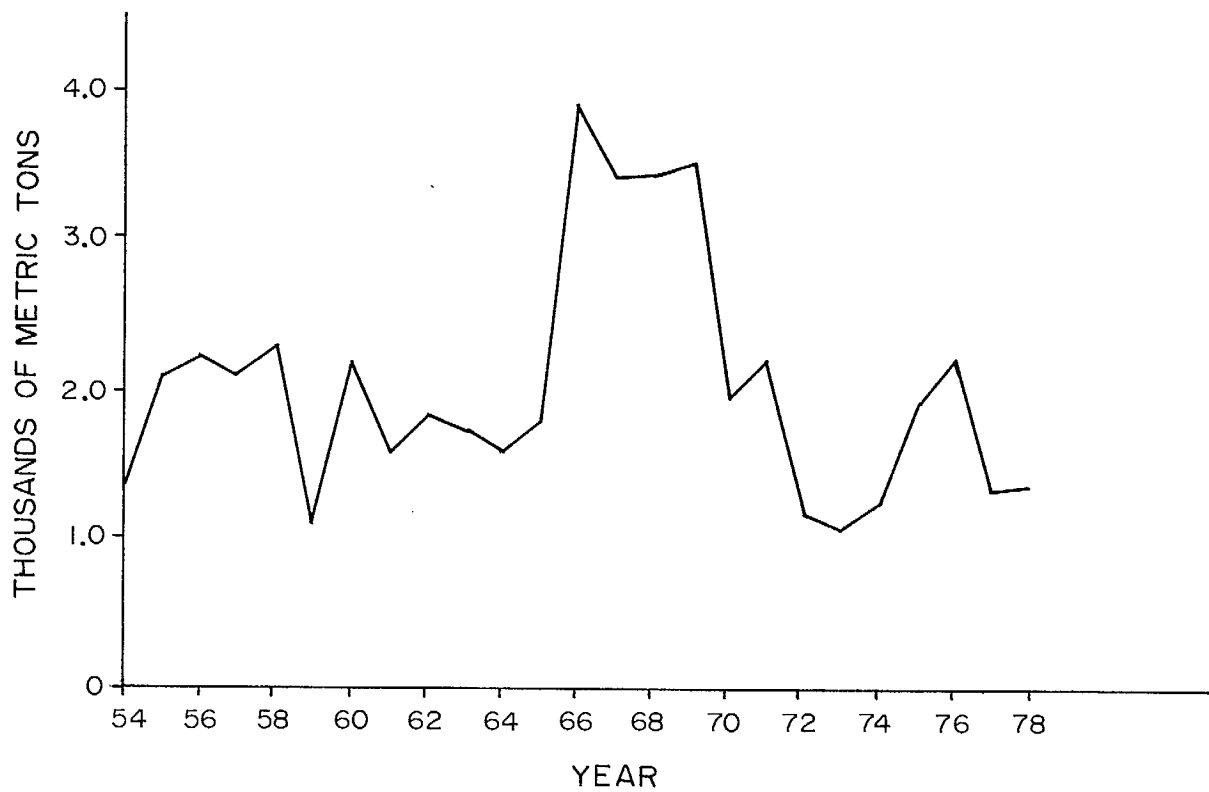


Fig. 7.1. Canada-U.S. rock sole landings (t) from British Columbia waters, 1954-78.

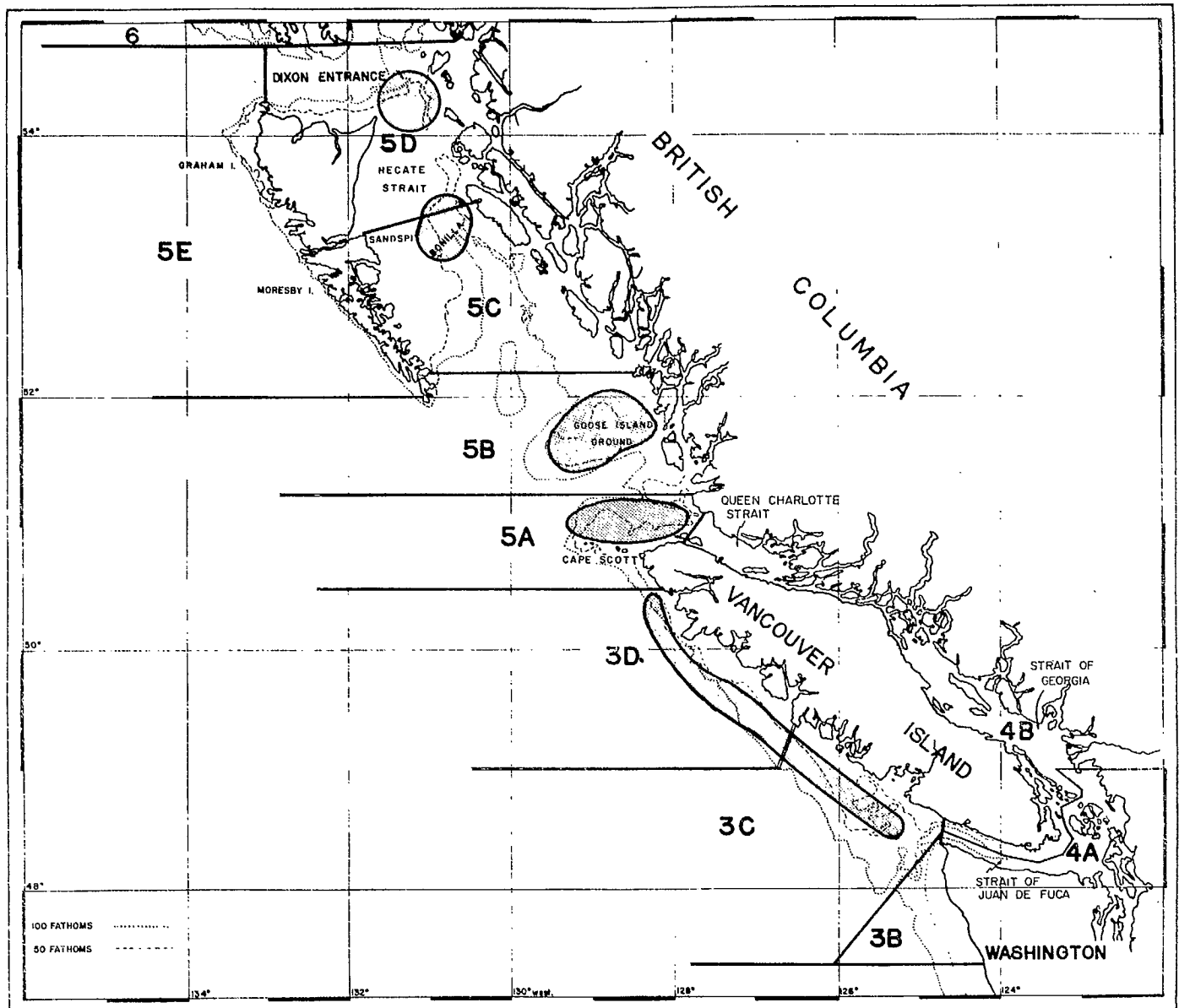


Fig. 7.1. International (Pacific Marine Fisheries Commission) Statistical Areas along the British Columbia coast and rock sole sub-areas.

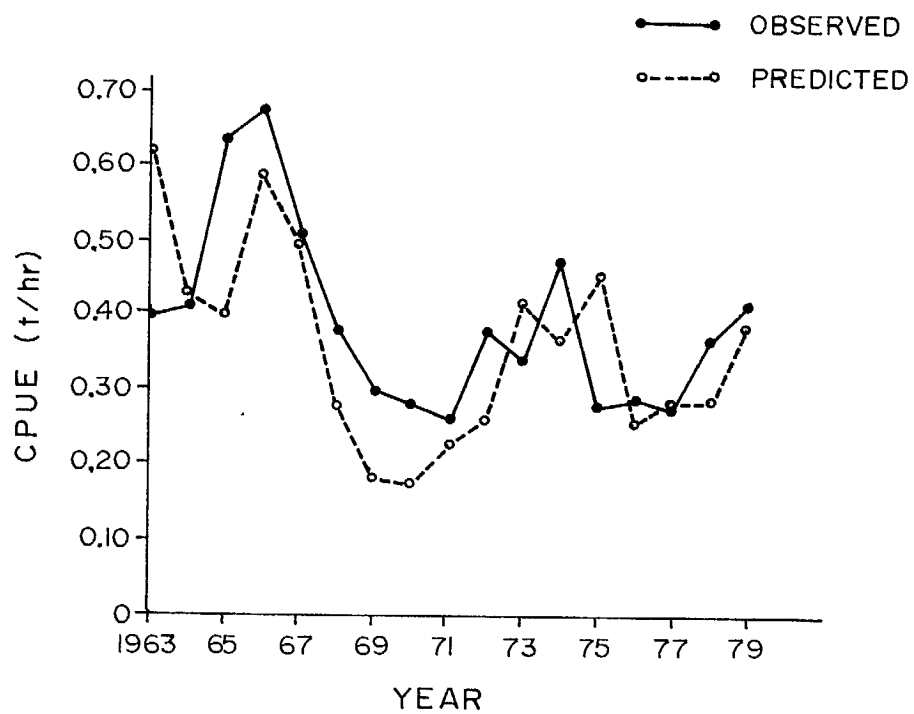


Fig. 7.3. Observed and predicted (Schnute 1977) CPUE (t/hr) for Middle Hecate Strait rock sole stock, 1963-79.

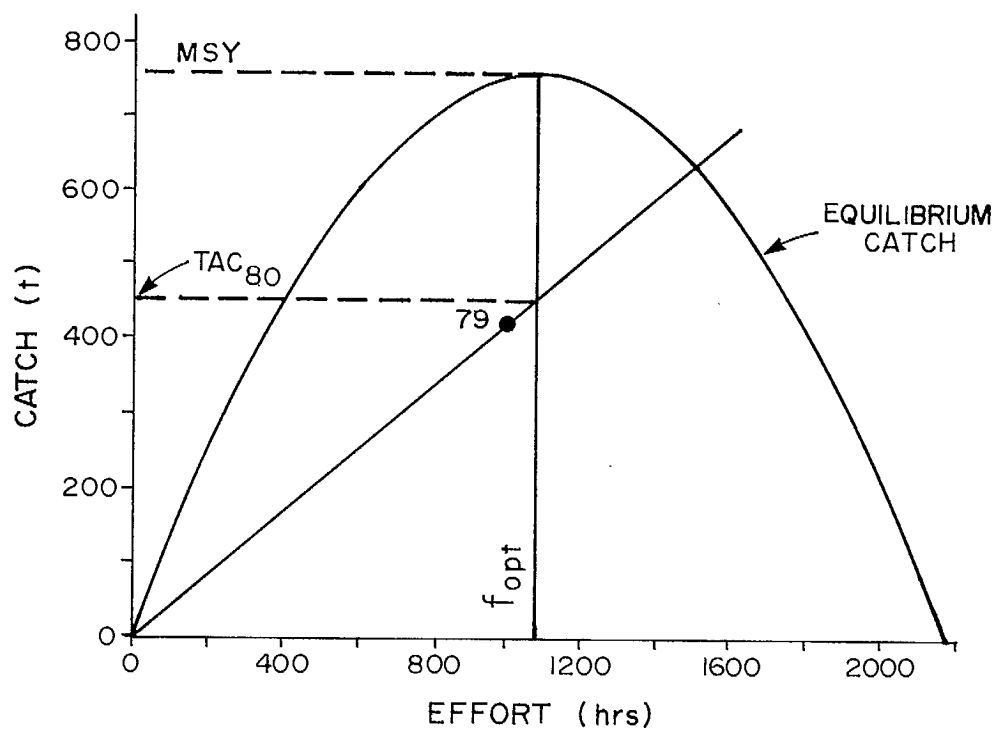


Fig. 7.4. Graphical method for determining TAC for North Hecate rock sole stock (Walter 1976).

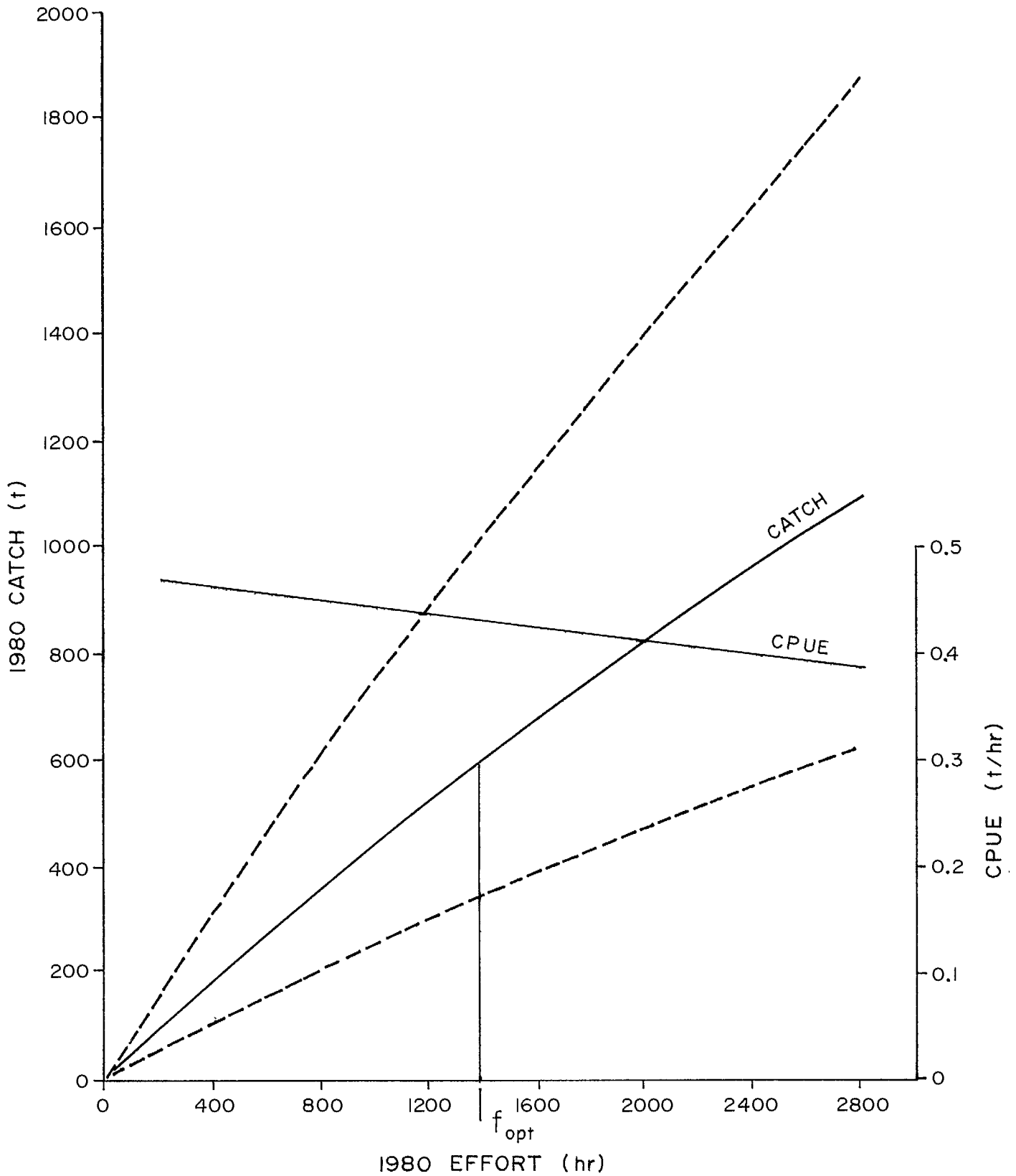


Fig. 7.5. Predicted 1980 catch (t) (\pm 95% CI) and CPUE (t/hr) for given effort levels for Middle Hecate Strait rock sole.

8. DOVER SOLE STOCK ASSESSMENT

8.1 Introduction

Moderate quantities of Dover sole (Microstomus pacificus) are known to exist throughout British Columbia waters, but the only directed fisheries take place in the relatively deep water of northern Hecate Strait (Area 5D). A small fishery developed in the late 1940's adjacent to the Butterworth edge and reached a peak production of 210.4 t in 1952. (A fishery of lesser significance also occurred off White Rocks in what would now be called the northern limit of the Moresby Gully). From 1952 onwards, production followed an irregular downward trend with landings becoming incidental to other species by the 1960s. Marketing problems or distraction by the more lucrative fishery for Pacific cod may have been responsible for the decline.

A reawakening of interest occurred in 1969 with development of an entirely new fishery on the Dundas Ground combined with resumption of fishing on the Two Peaks-Butterworth Ground.

8.2 Catch statistics

During 1969-74, production averaged 771 t, with Dundas accounting for 65% and Two Peaks-Butterworth 34% (Westrheim 1977).

For Area 5D as a whole, production has been fluctuating since 1970, with a noticeable decline since 1976 (Fig. 8.1). CPUE fluctuated widely in the northern Hecate Strait Dover sole fishery (Fig. 8.1). During the early 1970s CPUE declined to 0.57 t/hr in 1972 with a subsequent rise to 0.76 t/hr in 1974. From 1974, CPUE declined steadily to 0.35 t/hr in 1977; for 1978 the CPUE rose to 0.49 t/hr (Table 8.1).

8.3 Stock condition

In general, these data suggest a substantial decline in abundance of Dover sole on the Dundas Ground. Catch, effort, and catch rate have declined substantially. The anomalous increase in catch rate in 1978 was probably caused by a disproportionate decrease in fishing effort. Unfortunately, we cannot ascertain the cause of the apparent decline in abundance. No information on size composition or age composition is available to determine whether the initial fishery was supported by a series of strong year-classes and is now collapsing because of a recruitment failure. While overfishing by the Canadian fleet is a real possibility, there is a complication in that the Dover sole stock, in its seasonal inshore-offshore movements, may have been exposed to the Japanese trawl fishery off Dixon Entrance during the winter (spawning) months. Catches by that fishery are unknown. A tagging program has been initiated for 1979 to investigate migratory patterns of Dover sole on Dundas Ground.

8.4 Yield

The relationship between catch and effort for the years 1969-79 was examined using a regression of CPUE (25% qualified) on average fishing effort (\bar{f}) over a number of preceding years (K). The line ($CPUE = a - bf$) ideally would be very close to the true relation between CPUE (abundance) and effort in a steady state (Gulland 1961). Estimates of a and b are related to fisheries parameters (see Section 7: rock sole).

Table 8.2 presents the results of the parameter estimation procedure. The best fit to the data was obtained for $K = 3$ ($r = -0.632$). The resulting estimate of MSY is 891 t, with a corresponding optimal fishing effort of 2,215 hr for an optimal CPUE of 0.40 t/hr.

8.5 Yield forecast for 1980

The estimates of the biological, fishery, and variance parameters were used to predict 1980 yields for northern Hecate Strait Dover sole.

Due to the high variability encountered (low r value) in the analysis a conservative approach for setting TAC is taken. As already pointed out the inshore-offshore movement of Dover sole is an added complication which would alter parameter values. Accordingly, the TAC for 1980 should be 300 t. This catch level could possibly be increased in the future depending on the results of tagging and other population studies.

8.6 Recommendations

A TAC of 300 t of Dover sole is recommended for Hecate Strait (30 t for 5C and 270 t for 5D). Elsewhere in Canadian waters where Dover sole is a minor component, the recommended TACs are: Area 4B, 40 t; Area 3C (Canada), 100 t; Area 3D, 40 t; Area 5A, 30 t; Area 5B, 100 t; and Area 5E, 100 t.

Table 8.1. Canada-U.S. Dover sole landings (t) and calculated effort (hr) for North Hecate Strait (5D), 1954-79.

Year	Total landings ^a (t)	CPUE ^b (t/hr)	Effort ^c (hr)
1954	105	0.72	146
1955	109	0.49	222
1956	116	1.16	100
1957	90	0.75	120
1958	69	1.22	57
1959	89	1.12	79
1960	102	0.89	115
1961	23	0.53	43
1962	32	0.54	59
1963	29	0.26	112
1964	82	0.55	149
1965	53	0.23	230
1966	66	1.01	65
1967	5	0.05	100
1968	33	0.58	57
1969	271	0.76	357
1970	973	0.63	1,544
1971	912	0.58	1,572
1972	922	0.57	1,618
1973	766	0.72	1,064
1974	760	0.76	1,000
1975	845	0.53	1,594
1976	1,002	0.46	2,178
1977	467	0.35	1,334
1978	316	0.49	645
1979 ^d	420	0.43	977

^aData Sources: Canada - sales slips and trip logs.
U.S. - 1974-75 Ketchen (1976)

^bFrom trip logs (25 percent qualification level).

^cTotal landings/CPUE

^dProjected estimate

Table 8.2. Parameter estimates for northern Hecate Strait Dover sole.

I. Parameter estimates from Gulland's (1961) linear regression model.

	K=3	K=4	K=5
<u>Biological:</u>			
a	0.805	0.758	0.745
b	1.817×10^{-4}	1.527×10^{-4}	1.512×10^{-4}
<u>Fishery:</u>			
MSY(t)	891	941	918
$f_{opt}(hr)$	2,215	2,482	2,464
<u>Correlation:</u>			
r	-0.632	-0.527	-0.520

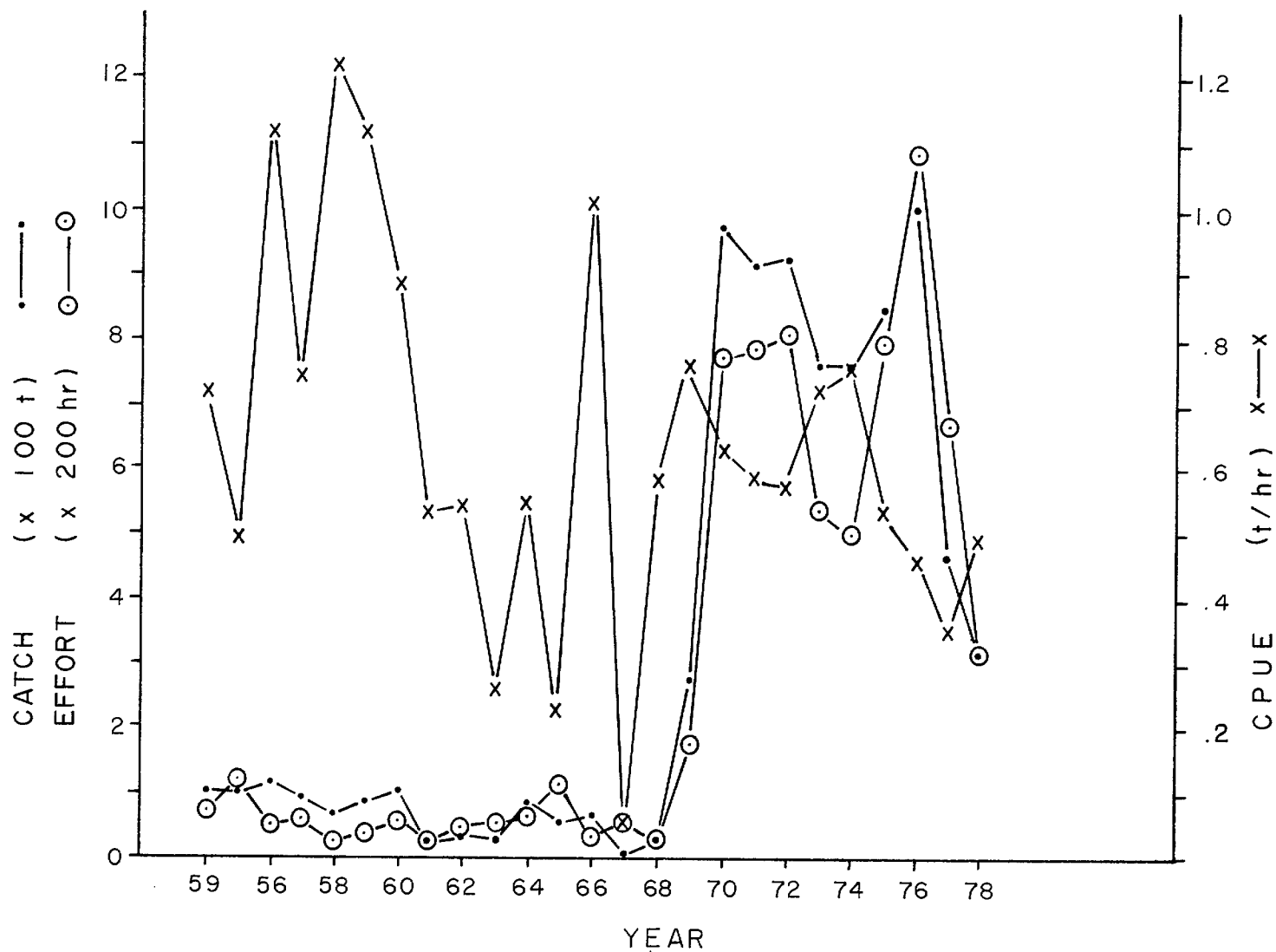


Fig. 8.1. Statistics of the Dover sole fishery in northern Hecate Strait (Area 5D), 1959-78.

9. ENGLISH SOLE STOCK ASSESSMENT

9.1 Introduction

The principal stock of English sole (Parophrys vetulus) in British Columbia waters inhabits northern Hecate Strait. Spawning grounds have never been accurately identified, but probably lie in depths of 110-150 m in east central Hecate Strait adjacent to Banks Island. A small fishery usually occurs on the White Rocks Ground in the fourth and first quarters of the year presumably on fish on their way to or returning from the spawning area. The main fishery usually occurs farther to the north in the second and third quarters along the Butterworth-Warrior Edge and on the Two Peaks, during the post-spawning migration (Ketchen 1956).

A relatively minor stock or group of stocks occurs in the Strait of Georgia and is fished primarily during the winter period (see recent review by Ketchen 1979).

9.2 Trends in catch and effort statistics for Area 5D

Catches have varied substantially over the years, rising from 632 t in 1954 to a peak of 1,086 t in 1960, followed by an irregular downward trend to 340 t in 1966 (Table 9.1). Between 1967 and 1978 there was considerable fluctuation, with catches of more than 900 t being recorded for 1970 and 1975-77.

CPUE has followed a somewhat similar course being highest in the early years of the fishery (prior to 1957) and lowest in the mid-1960s with a highly irregular upward trend thereafter.

9.3 Yield

The relationship between catch and effort for North Hecate Strait English sole was examined using surplus production model analysis. Three related parameter estimation procedures were employed to interpret current stock conditions. Method one involves a regression analysis of CPUE on average fishing effort (\bar{F}), over a number of preceding years (K). Details of the relationship between model parameters and fisheries parameters are given in the section on rock sole. Method two represents a difference equation version of the Schaefer model (Walters and Hilborn 1976). The difference equation is transformed into a linear regression form and estimates of biological and fisheries parameters are obtained. Method three involves a discrete-time, stochastic version of the Schaefer model (Schnute 1977). The analysis provides estimates of biological and fisheries parameters as well as variance parameters.

Table 9.2 presents results of the parameter estimates for North Hecate Strait English sole. The best fit to the data (as determined by a low value for the failure index; $I = 0.442$) was obtained from the dynamic Schaefer model analysis (Schnute 1977). Using this method the MSY was estimated to be 751 t with a corresponding optimal effort level (f_{opt}) of

2,178 hr. A CPUE of 0.34 t/hr is predicted to be the optimal level. Observed and predicted CPUEs for the North Hecate Strait English sole fishery are shown in Fig. 9.1. Parameters from the two other estimation procedures were rejected on the basis of variance considerations.

9.4 Yield forecast for 1980

The estimates of the biological and variance parameters combined with information on most recent catch predictions (C_{79} , f_{79}) were used to predict 1980 catch levels in relation to expected effort levels (Schnute 1977). The catch predictions and 95% confidence limits are shown in Fig. 9.2. Present stock abundance would yield about 90% of the MSY in 1980 if fished at the predicted optimal effort level (f_{opt}). Thus for 1980 a catch of about 675 t is predicted if present effort levels prevail.

9.5 Recommendations

For the northern Hecate Strait stock, a TAC of 680 t is recommended for 1980. For the Strait of Georgia stock, a provisional TAC of 90 t is recommended for the winter fishery (October 1, 1979 to March 31, 1980). Recommended TACs for areas in which the English sole is an incidental species are as follows: Area 3C -- 40 t; Area 3D -- free fishing; Area 5A -- 10 t; Area 5B -- 10 t; and Area 5C -- 70 t.

Table 9.1. Canada-U.S. English sole landings (t) and effort (hr) statistics for North Hecate Strait (5D), 1954-79.

Year	Total Landing(t) ^a	CPUE ^b t/hr	Effort ^c (hr)
1954	632	0.37	1,708
1955	853	0.43	1,984
1956	943	0.39	2,418
1957	537	0.26	2,065
1958	642	0.34	1,888
1959	908	0.32	2,837
1960	1,086	0.33	3,291
1961	879	0.29	3,031
1962	439	0.26	1,688
1963	374	0.20	1,870
1964	436	0.28	1,557
1965	391	0.26	1,504
1966	340	0.25	1,360
1967	509	0.37	1,376
1968	634	0.31	2,045
1969	720	0.38	1,895
1970	918	0.34	2,700
1971	480	0.20	2,400
1972	353	0.24	1,471
1973	595	0.36	1,653
1974	458	0.43	1,065
1975	948	0.51	1,859
1976	943	0.32	2,947
1977	972	0.30	3,240
1978	494	0.27	1,830
1979 ^d	620	0.31	2,000

^aData Sources: Canada - sales slips & trip logs;
U.S. - 1954-75 Ketchen (1976),
- 1976-77 supplied by Washington State
Department of Fisheries.
1978-79, provisional.

^bFrom trip logs (25 percent qualification level)

^cTotal catch/CPUE

^dProjected estimate

Table 9.2. Parameter estimates for North Hecate Strait (5D) English sole stock.

I. Parameter estimates from Gulland's (1961) linear regression model.

	K=3	K=4	K=5
<u>Biological:</u>			
a	0.443	0.542	0.516
b	6.301×10^{-5}	1.172×10^{-4}	9.657×10^{-5}
<u>Fishery:</u>			
MSY(t)	779	627	674
f _{opt} (hr)	3,516	2,314	2,641
<u>Correlation:</u>			
r	-0.418	-0.548	-0.453

II. Parameter estimates from linear Schaefer model.

<u>Biological:</u>		<u>Fishery:</u>		<u>Coefficient of Determination:</u>	
r' ^a	1.004	MSY(t)	766	R ²	0.488
q	1.595×10^{-4}	f _{opt} (hr)	3,148		
k(t)	3,052				

III. Parameter estimates from dynamic Schaefer model

<u>Biological:</u>		<u>Fishery:</u>		<u>"Variance:"</u>	
r' ^a	1.351	MSY(t)	751	σ	0.213
q	3.384×10^{-4}	f _{opt} (hr)	2,178	I	0.442
k(t)	2,224				

^ar' = growth parameter.

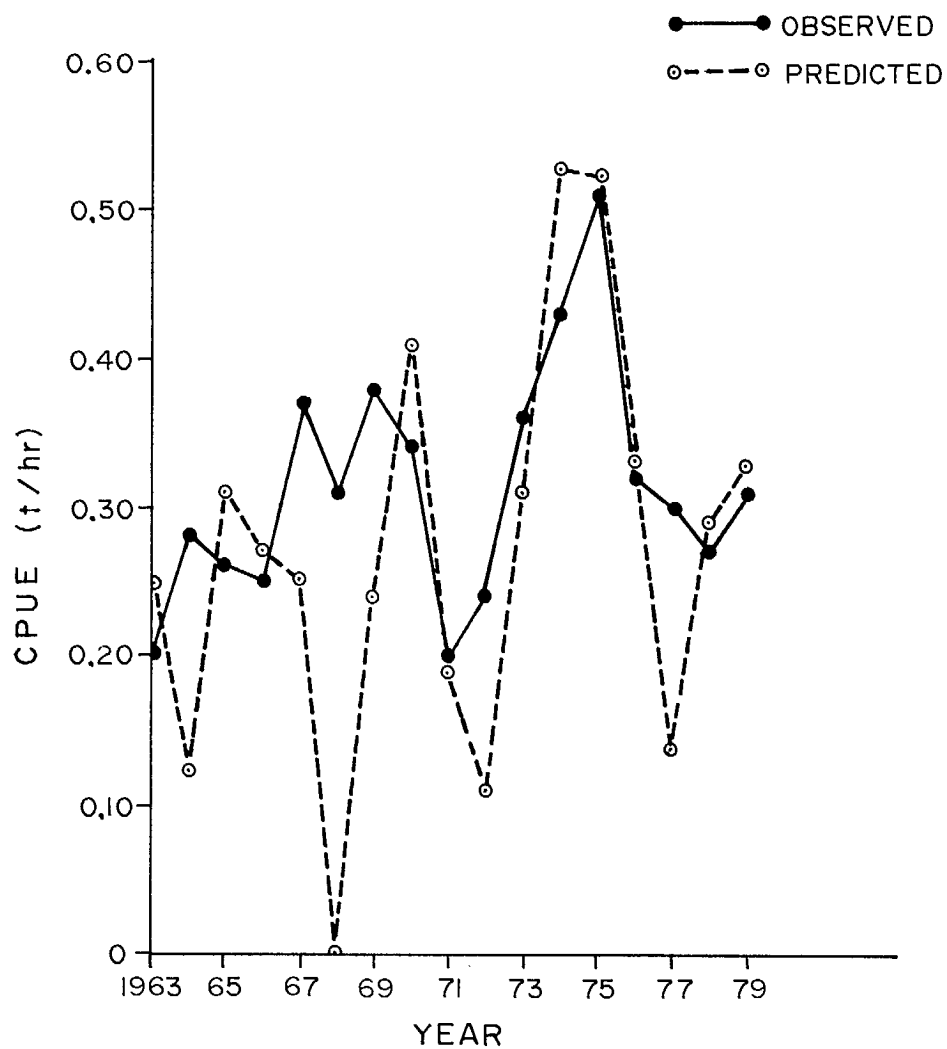


Fig. 9.1. Observed and predicted CPUE (t/hr) for North Hecate Strait English sole, 1963-79.

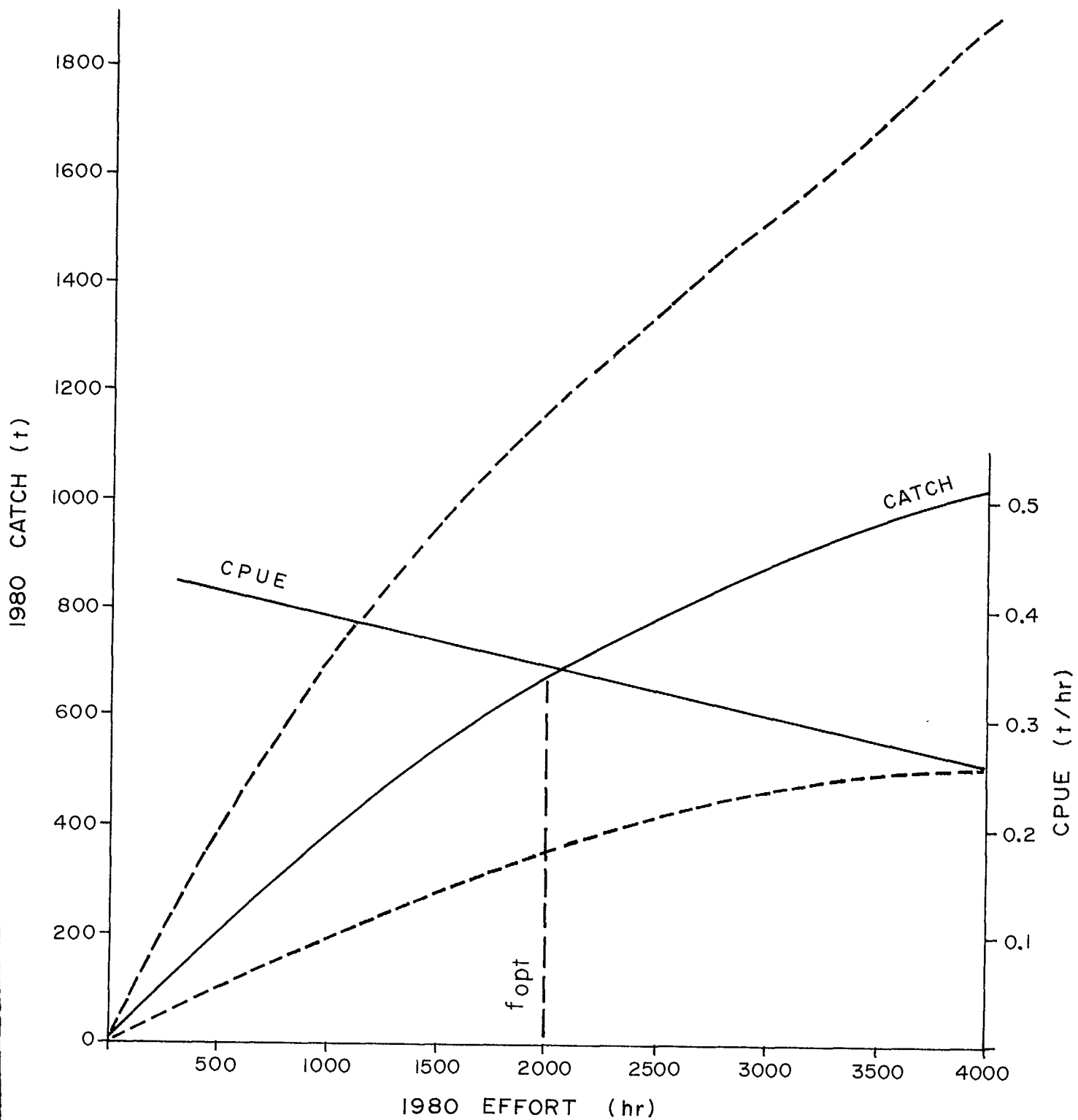


Fig. 9.2. Predicted 1980 catch (t) (\pm 95% CI) and CPUE (t/hr) for given effort levels for North Hecate Strait English sole.

10. PETRALE SOLE STOCK ASSESSMENT

10.1 Introduction

Petrale sole (Eopsetta jordani) is a southern flounder whose northern limit of commercial range occurs at the latitude of Dixon Entrance. It is the most valuable of trawl-caught flatfish and in 1948 accounted for 40% of all groundfish (including dogfish) landed by Canadian trawlers. From a peak of 6,200 t in 1948 production by Canadian and U.S. trawlers operating in British Columbia waters followed a long downward trend to less than 500 t in 1970. Since that time landings have averaged about 1,100 t.

10.2 Definition of stocks

As a result of extensive tagging, Ketchen and Forrester (1966) identified two major stocks, one which spawned in deep water off the Washington coast (Cape Flattery Spit -- at the southern extremity of Area 3C) and spent its spring to autumn feeding period farther to the north in shallower water of the Canadian portion of Area 3C. This was called the "southern stock". The other, the "northern stock", spawned in deep water near the southern boundary of Area 3D adjacent to Estevan Point and spent its inshore months in Area 3D, Queen Charlotte Sound (Areas 5A and 5B) and Hecate Strait (Areas 5C and 5D).

In a more recent study, Pedersen (1975) confirmed the existence of the northern stock but concluded that the southern stock, during its summer, inshore period in Area 3C, consisted of a mixture of stocks which spawned from the Cape Flattery Spit south to the so-called Willapa Deep.

Further studies also suggest the existence of a separate northern stock of petrale sole of small magnitude, based on observations of catches by the Japanese deepwater trawl fishery off Dixon Entrance (1977), and the total non-return from tagging conducted in the shallow water of McIntyre Bay (Dixon Entrance) in 1954 (Ketchen, personal communication).

10.3 Production and abundance trends

10.3.1 The southern stock

In their study of the fishery from its inception in the late 1930s to 1962, Ketchen and Forrester (1966) noted that both landings and CPUE reached a peak in the late 1940s and thereafter followed an irregular decline, accompanied by a progressive increase in average size (and age) to about 1956. The latter phenomenon was associated with passage through the fishery of about 4 consecutively strong year-classes (1940-43) followed by a long succession of relatively weak year-classes (Table 10.1). The relationship of year-class strength to environmental conditions, together with evidence that fishery on the strong year-classes had not been excessive in terms of yield per recruitment, led to the conclusion that success of the fishery during the 1940s and its subsequent decline were due largely to

trends in recruitment, and further that recovery of the fishery would be dependent on the return of strong recruitment.

Subsequent to the Ketchen and Forrester analysis, a study of the Washington fishery by Pedersen (1975) arrived at essentially the same conclusion, viz. there appeared to be no need for regulation of the summer fishery, and the effects of winter fishing (on spawning concentrations) appeared to be over-shadowed by environmentally induced variations in the production of recruits. This conclusion supports the Ketchen and Forrester hypothesis concerning the importance of recruitment but further verification is required. Granted there have been two surges in production since 1956, one centering around 1961 and the other around 1974, both may have been only partly the result of the exceptionally favourable (warm) years which produced the 1958-62 and 1970 year-classes.

10.3.2 The northern stock

Essentially the same events transpired in the fishery on the northern stock. The exceptionally high yield in 1948 consisted of the same strong 1940-43 year-classes. Subsequently production and CPUE collapsed, with the former to be arrested briefly in 1954 by discovery of the spawning ground in the Estevan Deep and by its heavy exploitation in 1957 by the U.S. fleet. Landings reached a low point in 1960 (425 t) and subsequently recovered to 993 t in 1966, slightly out of phase with the surge noted in the fishery on the southern stock (Table 10.2). The second surge coincided with that in the south, but the 1974 peak amounted to less than 600 t.

10.4 Current stock condition

There is no question that the petrale sole stocks are at a relatively low level of abundance, especially in the case of the northern stock, landings from which barely reach 300 t -- entirely incidental to other fisheries. The southern stock fares somewhat better (ca 1,000 t per annum) and maintains its attractiveness only because of high market prices. Still, production is largely incidental to other fisheries (Pacific cod and lingcod).

Although Ketchen and Forrester (1966) could determine no ill effects from the 1954-57 fishery on the spawning stock (and no parent-progeny relationship), their case remains uncorroborated for lack of follow-up analysis. Without an up-dated examination of available data it is impossible to say whether catch limits and/or prohibition of fishing on spawning concentrations would restore the stocks to economically more attractive levels.

10.5 Recommendations

For that part of the so-called southern stock of petrale sole occurring in the Canadian portion of Area 3C, a TAC of 500 t is recommended. In regard to the northern stock it is recommended that a TAC of 100 t be applied to the first three months of the calendar year. Thereafter in that area and in Areas 5A-5D throughout the year free fishing should be permitted.

Table 10.1. Canada-U.S. landings (t) of petrale sole from southwest Vancouver Island (Area 3C) -- the area occupied by the "southern stock", 1942-78.

Year	Flattery Spit	Northern section Area 3C	Total Area 3C	Year	Flattery Spit	Northern section Area 3C	Total Area 3C
1942	?	-	1,561				
1943	?	-	2,264	1961	375	734	1,109
1944	?	-	1,489	1962	215	636	851
1945	?	-	718	1963	90	656	746
1946	?	-	906	1964	71	529	600
1947	?	-	627	1965	140	645	785
1948	?	-	1,321	1966	118	508	626
1949	?	-	1,178	1967	106	256	362
1950	?	-	854	1968	114	232	346
1951	?	-	794	1969	255	142	397
1952	?	-	948	1970	80	143	273
1953	?	-	748	1971	74	518	592
1954	?	-	664	1972	22	756	778
1955	?	-	415	1973	211	452	663
1956	40	520	560	1974	230	675	905
1957	9	612	621	1975	474	465	939
1958	19	494	513	1976	304	452	756
1959	33	939	972	1977	157	301	458
1960	233	746	979	1978	?	?	395

Table 10.2. Canada-U.S. landings (t) of petrale sole from northwest Vancouver Island, Queen Charlotte Sound and Hecate Strait (Areas 3D, 5A-5B) -- the area occupied by the "northern stock", 1942-78.

Year	Area 3D	Areas 5A-5B	Areas 5C-5D	Total	Year	Area 3D	Areas 5A-5B	Areas 5C-5D	Total
1942	-	-	-	-	1961	277	171	102	550
1943	-	-	-	-	1962	295	343	165	803
1944	499	303	-	802	1963	202	537	82	821
1945	270	1,535	193	1,998	1964	183	421	163	767
1946	623	1,258	494	2,375	1965	300	418	202	920
1947	469	986	769	2,224	1966	264	469	260	993
1948	943	920	3,011	4,874	1967	169	485	176	830
1949	316	429	1,644	2,390	1968	293	266	137	696
1950	694	569	700	1,963	1969	262	114	22	398
1951	305	326	642	1,273	1970	136	56	22	214
1952	265	305	574	1,144	1971	127	97	55	280
1953	235	450	46	731	1972	50	154	33	237
1954	712	234	300	1,237	1973	197	211	24	432
1955	452	462	94	1,008	1974	196	283	14	493
1956	291	528	53	872	1975	234	156	27	417
1957	1,320	333	216	1,869	1976	153	132	30	315
1958	174	227	171	572	1977	58	73	24	155
1959	227	160	216	603	1978	21	63	13	97
1960	93	212	120	425					

11. ARROWTOOTH FLOUNDER (TURBOT) STOCK ASSESSMENT

11.1 Introduction

The arrowtooth flounder, or turbot, (Atheresthes stomias) until about 1972 had never found a place on the foodfish market despite frequent attempts, dating from the early 1940s, to overcome processing problems. From those early days until about 1951, with the emergence of a market as minkfood, turbot were almost always avoided or discarded at sea.

The species has a ubiquitous distribution along the British Columbia coast and is encountered in quantity over a wide range of depths from surface waters to 500 fathoms (900 m). Little is known of the turbot's biology and life history and nothing is known of its movements. For present purposes it will be presumed that independent stocks occur in each of the major statistical areas along the coast.

11.2 Catch statistics

Significant landings of turbot as animal food began in 1951, rising rapidly to a peak of 2,500 t in 1956 when most of the production originated from grounds off southwest Vancouver Island (Area 3C) and on the Cape Scott grounds (Area 5A) (Table 11.1). Thereafter landings fluctuated widely. Peaks occurring in 1961, 1967, and 1969 were primarily from Area 5A and northern Hecate Strait (Area 5D). A sharp drop in demand for animal food drove the catch to a low level between 1970 and 1972.

With the development of a foodfish market, production recovered rapidly and was still rising in 1978 at 2,300 t. Although the fishery expanded in all areas (except 4B), the main rise occurred in northern Hecate Strait (Area 5D) which accounted for more than half of landings over the 7-year period (Table 11.2). Production from that area reached a peak of 1,295 t in 1978, but still appears to be primarily a function of fishing effort.

11.3 Condition of the resource

There is nothing to indicate that the "stocks" of turbot are as yet fully utilized. It is not yet known to what degree turbot can be fished selectively, avoiding incidental catches of other species for which catch limitations are, or may be, required. Accordingly, unrestricted development of the turbot fishery is deemed undesirable.

11.4 Recommendations

The following TACs are recommended: Area 4B -- 50 t; Area 3C -- 200 t; Area 3D -- 200 t; Areas 5A and 5B -- 500 t; Area 5C -- 100 t; Area 5D -- 2,000 t; Area 5E -- 100 t.

Table 11.1. Historical record of landings (t) of arrowtooth flounder by Canadian trawlers operating along the British Columbia coast, 1948-78.

Year	Landing (t)		Year	Landing (t)	
	Animal food	Foodfish ^a		Animal food	Foodfish ^a
1948	2	-	1964	830	2
1949	20	-	1965	578	99
1950	9	-	1966	687	27
1951	102	-	1967	1,675	-
1952	429	-	1968	933	4
1953	434	-	1969	2,017	-
1954	499	-	1970	316	7
1955	1,518	-	1971	106	-
1956	2,499	-	1972	172	130
1957	578	-	1973	36	539
1958	399	-	1974	-	364
1959	851	-	1975	-	953
1960	1,114	-	1976	-	1,205
1961	2,360	-	1977	-	1,591
1962	1,482	6	1978	-	2,317
1963	668	5			

^aHuman consumption.

Table 11.2. Canadian landings (t) and calculated effort^a (hr) for arrowtooth flounder, by area, 1972-78.

Year	4B		3C		3D		5A		5B		5C		5D		Total	
	Landing	Effort	Landing	Effort	Landing	Effort	Landing	Effort	Landing	Effort	Landing	Effort	Landing	Effort	Landing	Effort
1972	50	625	4	400	-	-	37	128	-	-	Tr ^b	10	210	1,750	301	2,913
1973	14	31	47	42	Tr	8	37	142	21	-	20	166	437	2,185	576	2,574
1974	4	57	19	380	-	-	9	225	62	443	18	360	251	1,673	363	3,138
1975	18	225	89	212	10	6	147	245	58	341	40	667	591	3,110	953	4,806
1976	3	300	122	488	10	56	47	361	86	115	69	209	981	4,087	1,318	5,616
1977	5	459	278	842	5	27	151	103	98	288	35	125	988	3,407	1,560	5,251
1978	36	600	220	550	7	14	405	844	262	771	80	160	1,295	3,500	2,305	6,439

^aCalculated effort = landings \div CPUE, at 0% qualification level.

^bTr=trace.

12. WALLEYE POLLOCK STOCK ASSESSMENT

12.1 Introduction

Annual coastwide landings of walleye pollock (Theragra chalcogramma) from B.C. coastal waters reached an all-time maximum of 2,411 t in 1978 (Fig. 12.1). A roe fishery, which developed in the period January to March of that year to supply the Japanese market, accounted for 35% of the total catch. The roe fishery continued to develop in 1979. During the first quarter, bottom and midwater trawl landings were 685 t in Area 5D and 1,095 t in Area 4B, compared to 532 and 319 t for these areas in the same period in 1978. Nearly all of the pollock processed for roe were taken from these two areas. Since March, landings have continued, primarily from Areas 5A-5D (Table 12.1) to meet the demand for fillets. The total catch in 1979 to July 20 amounted to 2,231 t.

12.2 Definition of stocks

Stock boundaries for walleye pollock in Canadian waters have not been clearly defined. Evidence of differences in growth rate and spawning localities strongly supports the view that there are several different populations along the coast. Stock identity is of particular concern in Dixon Entrance and the Strait of Georgia, where intensive fisheries have developed in relatively small locations. Information to date suggests there may be more than one stock in each of these areas. No major pollock fishery has developed in Queen Charlotte Sound (Areas 5A-5B), southern Hecate Strait (Area 5C), off the west coast of Vancouver Island (Areas 3C-3D), or off the west coast of the Queen Charlotte Islands (Area 5E). Although concentrations of pollock are found within these regions, little is known about their abundance or movements therefore, as last year, each of these regions will be regarded as a homogeneous stock zone. Significant concentrations of pollock have also been found in some coastal inlets: Dana, Cumsheewa and Selwyn Inlets on Moresby Island, and Observatory Inlet off Chatham Sound. Little is known at present about relationships between the inlet stocks and those found offshore, however preliminary evidence indicates that they may be different. It may be necessary to treat such stocks separately for management purposes, in the future.

12.3 TAC calculations

Gulland proposed (Alverson and Pereyra 1969, Troadec 1978) that for virgin fisheries, where little data are available, the relation

$$MSY = (0.5)(M)(B_0)$$

can be used to predict maximum sustainable yield (MSY) from estimates of virgin biomass (B_0) and the instantaneous rate of natural mortality (M).

A simple approach to MSY theory has been questioned in recent years, largely because, in its earliest conception, the model

unrealistically assumes stability in population characteristics, such as recruitment. Pollock stocks spawn in the midwater and are probably subject to large fluctuations in annual recruitment. Since we cannot at this time predict either such fluctuations, or other biological responses to the increasing fishing pressure, and since our surveys may have included different stocks from those now fished, the TACs have been set at 75% of the MSY level calculated here.

Virgin biomass was measured in the Strait of Georgia (Area 4B) and on the west coast of Vancouver Island (Area 3C) by hydroacoustic surveys during 1974-76, before major fisheries developed. However, in northern Hecate Strait and Dixon Entrance the 1978 and 1979 hydroacoustic surveys were made after there had been appreciable fishing (since 1976; Table 12.1). The biomass estimates from these surveys thus can no longer be considered to represent virgin biomass. An approximation of virgin biomass can be obtained by adding the catches back to 1976 to the hydroacoustic estimates. Estimates of stock size were obtained for the other three regions (5A-B, 5C, and 5E) by comparing catch rates of pollock with other species during commercial operations and biological surveys, and by extrapolating from the results of hydroacoustic surveys carried out elsewhere on the coast. Preliminary estimates of the instantaneous rate of natural mortality (M) range from 0.5 to 1.0, which correspond to annual mortality rates of 39-63%. The TAC calculations were based on $M = 0.6$. The pollock TAC for each region was therefore calculated from:

$$TAC = (.75)(.5)(.6)B_0 = (0.23)B_0$$

12.3.1 Georgia Strait and Juan de Fuca Strait (Area 4B)

Annual landings from Area 4B in 1978 totalled 380 t, most of which was taken during the first quarter roe fishery (Table 12.1). At that time American vessels landed more than 500 t of pollock from the vicinity of Point Roberts. Very little pollock was landed by Canada from Area 4B in 1978 after the roe fishery.

In anticipation of a roe fishery by both nations in 1979, a joint Canada-U.S. TAC of 1,500 t was set for the area between Point Roberts and Active Pass. It was recommended that the balance (2,500 t) of the 1979 TAC (4,000 t) be applied to the remainder of Area 4B. An intensive Canadian roe fishery developed in Georgia Strait during 1979. First quarter landings in 1979 were 1,096 t. Most (83%) of the Canadian catch was taken in the open Strait north of Point Roberts while the remainder was landed from Swanson Channel. Only 29 t was taken by Canada from the Canadian portion of the trans-boundary area between Point Roberts and Active Pass, while landings by both nations from this area amounted to only 435 t, much less than the recommended TAC of 1,500 t.

The 1979 Area 4B TAC was split because maturity data collected during research cruises in 1978 suggested that spawning peaked 4 weeks earlier in northern and central Georgia Strait than in the area between Point Roberts and Active Pass (Thompson and Beamish 1979). It was concluded therefore that at least two separate stocks may spawn in the open Strait. Maturity data collected in 1979 have reinforced the two-stock spawning

theory (Table 12.2). Thompson and Beamish (1979) estimated pelagic fish biomass east of Mayne Island by studying sounder paper collected in March 1978. Pollock biomass was estimated to be approximately 4,800 t, from which a TAC of 1,500 t was estimated ($TAC = 0.6 \times 0.5 \times B_0$). On March 28-29 1979, Washington State Department of Fisheries (M. G. Pedersen and N. Lemberg, personal communication) surveyed a smaller portion of the ground with more sophisticated equipment, obtaining an estimated pollock biomass of 2,700 t. Ignoring 1979 catches, which were 435 t and taken in part after the 1979 survey, virgin biomass for this spawning stock could be estimated as the sum of the 1978 Canada-U.S. landings (500 t) and the 1979 estimate of 2,700 t, for a total of 3,200 t. This is likely to be conservative, since some pollock were very close to the bottom and were not counted in the survey, so it is reasonable to assume $B_0 = 4,000$ t for the pollock stock that is available to trawlers between Active Pass and Point Roberts in March and April.

Since pollock in Swanson Channel appear to be larger at age than in the open Strait of Georgia (Weir et al. 1978; Cass et al. 1978) and since length frequencies of Juan de Fuca pollock contain proportionately more longer fish than those from the open Strait, the December-February fisheries in these areas may target on a stock distinct from those in Georgia Strait. In 1978 the landing from Minor Areas 19 and 20 and Swanson Channel amounted to 182 t, just over half the maximum of 302 t recorded in 1955 but much larger than the low 1960-76 landings. The removal from this region in the first quarter of 1979 was 165 t (Table 12.3).

Virgin biomass was estimated from 1975-76 hydroacoustic surveys to be 22,000 t for the entire Strait of Georgia but it became apparent from reconsiderations of the technique that the estimate could range from 15,000 to 22,000 t. Stock sizes for Johnstone and Queen Charlotte Straits (Minor Areas 12 and 13) have not been determined. The Juan de Fuca-Swanson Channel stock has not been surveyed hydroacoustically, therefore the TAC was estimated from historical commercial catch rates (Table 12.3).

12.3.1.1 Recommendations

A TAC of 3,400 t is recommended for Area 4B, of which not more than 300 t should be taken in combined Minor Areas 19 and 20 (Juan de Fuca Strait), and the Gulf Island Channels of Minor Areas 17 and 18, and not more than 900 t should be taken in the combined Minor Area 18 (east of Mayne Is.) and Washington Department of Fisheries Statistical Area 20A. The remaining 2,200 t is recommended for the remainder of Area 4B.

12.3.2 West coast Vancouver Island (Areas 3C and 3D)

There has never been a significant commercial fishery for walleye pollock off the west coast of Vancouver Island (Table 12.1). Results of research trawl surveys showed that pollock appeared irregularly in these waters, and were available to both midwater and bottom trawls, but catch rates were generally low. The incidental catch of walleye pollock was low in the foreign fishery for hake in Area 3C in 1977 and 1978.

Five hydroacoustic surveys carried out in the southern half of Area 3C during 1974-76 suggested that the biomass of pollock was about 500-2,000 t or 0.4-5.2% of the total biomass of pelagic and semi-pelagic fish in the area surveyed. These surveys included only the continental shelf from the southwest corner of La Pérouse Bank to Juan de Fuca Canyon. Two other surveys extended north of Amphitrite Point to Kyuquot. Pollock were less common in the northern part of the area, which is consistent with the experience of commercial trawlers. In Area 3C, the virgin biomass is estimated to be 2,000 t (upper limit of the hydroacoustic surveys) and the biomass in Area 3D is assumed to be 1,000 t.

12.3.2.1 Recommendation

A TAC of 700 t is recommended for walleye pollock in combined Areas 3C and 3D.

12.3.3 Queen Charlotte Sound (Areas 5A and 5B)

Combined landings of pollock from Areas 5A and 5B in 1976, 1977, and 1978 were 469, 236, and 293 t, respectively, or 18, 27, and 12%, respectively of the coastwide pollock landings (Table 12.1). Catch data from both research cruises and commercial operations do not yet indicate a predictable pattern of seasonal and geographical distribution of this species in the region. Landings peaked during August-October in all three years, but since pollock was not searched for with the same intensity at other times of the year and over the whole extent of the region, it is possible that many components of the stock have not been discovered.

To estimate biomass for this region, it was assumed that pollock density in Area 5A-5B was similar in water more than 50 fm deep to that in Dixon Entrance. The estimated stock size was the product of this density and the volume of water more than 50 fm deep. Two estimates of density were used. One assumed concentrations of pollock like those found in Dixon Entrance would be encountered, and so included the density values from such concentrations in Dixon Entrance. The other assumed that no concentrations occurred, and so excluded the higher density values found in Dixon Entrance. Both estimates assumed that all the fish encountered were pollock, an assumption that would obviously lead to overestimation. On the basis of the first assumption, the pollock stocks were estimated at 2,300 and 6,700 t in Areas 5A and 5B respectively, for a total of 9,000 t, and on the basis of the second assumption, stock size was estimated to be 1,500 and 4,300 t respectively, for a total of 5,800 t.

12.3.3.1 Recommendation

A TAC of 1,300 t is recommended for walleye pollock in combined Areas 5A and 5B.

12.3.4 Southern Hecate Strait (Area 5C)

In 1976, 1977, and 1978 pollock landings from Area 5C amounted to 193, 16, and 11 t, respectively (Table 12.1). No regular substantial

pollock fishery exists here, although from research cruises it is clear that juvenile and adult pollock inhabit the area. The extrapolation technique used to estimate stock size in Areas 5A and 5B (Section 12.3.3) gave estimates of 3,400 and 5,400 t for Area 5C. During a research cruise in March 1979, a large number of adult pollock were found spawning in Dana and Selwyn Inlets, on the east coast of Moresby Island. It is not known whether these pollock stay in the inlets all year, or are found offshore in Hecate Strait at times. Nothing is known about the possible relationship between pollock stocks of Area 5C and those to the south in Queen Charlotte Sound, or those to the north in Area 5D.

12.3.4.1 Recommendation

A TAC of 800 t is recommended for walleye pollock in Area 5C.

12.3.5 Dixon Entrance and northern Hecate Strait (Area 5D)

The 1979 TAC for pollock in Area 5D was derived from a hydroacoustic survey of Dixon Entrance, Chatham Sound, and northern Hecate Strait made in July 1978. This survey found pollock widely distributed throughout Dixon Entrance. Commercially exploitable concentrations were found in the Two Peaks-Dundas Island area, and off Cape Chacon. Few fish were found in the area south and west of Zayas Island. A small concentration was located near Boston Rocks in northern Chatham Sound. The estimated biomass by locality is given below:

Two Peaks-Dundas Island-Rose Spit	2,800 t
Langara Island-Masset	1,700 t
Cape Chacon	2,700 t
Cape Muzon	250 t
South Side Dixon Entrance (scattered)	1,600 t
North Side Dixon Entrance (scattered)	1,200 t
Zayas Island	50 t
Boston Rocks	1,400 t
<hr/>	
Total	11,700 t

In the January 1979 acoustic survey few pollock were found generally distributed throughout Dixon Entrance. The concentration off Cape Chacon had disappeared, but concentrations were located again on the Two Peaks-Dundas Island Grounds and in the Zayas Island area. Abundance of pollock was very much reduced compared to July 1978, and further decreased during the course of the cruise. In the last week of January there was estimated to be about 1,000 t of pollock on the Two Peaks-Dundas Island and Zayas Island Grounds and almost none elsewhere in Dixon Entrance. A week later on the same grounds the estimate was only 400 t. Important factors contributing to the decline in abundance at this time were the roe fishery, which accounted for two thirds of the decrease and movement of pollock out of the area to spawning grounds.

In the May-June 1979 hydroacoustic survey, pollock were sparsely distributed throughout Dixon Entrance. Concentrations were found again on the Two Peaks-Dundas Island Grounds and off Cape Chacon. Pollock were found widely but sparsely distributed in Clarence Strait, with evidence of a possibly exploitable concentration near Kasaan Bay. Pollock were less numerous in Revillagigedo Channel than in Clarence Strait. In northern Hecate Strait from Butterworth Rocks to Bonilla Island, the pollock encountered were mainly small immature fish and were mixed with considerably larger numbers of small sablefish.

The hydroacoustic biomass estimates for May-June 1979 were:

Two Peaks-Dundas Island	4,140 t
Rose Spit-Shag Rock	2,340 t
Zayas Island	280 t
<hr/>	
Subtotal	6,760 t
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Cape Chacon	1,380 t
<hr/>	
Total	8,140 t
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The 1979 TAC for pollock in Area 5D was 2,300 t. This was based on the July 1978 hydroacoustic estimate of 11,700 t of pollock in the entire area with an additional 2% added to account for the on-bottom portion of the stock and an allowance of 1,000 t for on-bottom pollock in northern Hecate Strait. The calculation of a TAC based on this amount assumed that all pollock in Dixon Entrance, Chatham Sound and northern Hecate Strait would be available for exploitation on the Two Peaks-Dundas Island fishing grounds. Information obtained from later surveys on the distribution of pollock in Area 5D suggests it might be more realistic to assume that only those pollock found on the Two Peaks-Dundas Island Grounds, and possibly those from the adjacent Langara Island-Masset concentration, contribute significantly to the stock exploited on the Two Peaks-Dundas Island fishing grounds.

If the results of the 1978 and 1979 summer hydroacoustic surveys are adjusted to approximate virgin biomass by the addition of the annual catches (Table 12.1) back to 1976, estimates of 8,190 t and 10,760 t respectively, are obtained for the southern side of the strait, where the fishery occurs. The difference between the two estimates may have been due in part to a difference in the distribution of fish within Dixon Entrance. Perhaps the best estimate of virgin biomass now available will be the average, or 9,500 t. For a stock of this size the MSY would be 2,800 t and the TAC 2,100 t. If the Cape Chacon concentration can be exploited, an additional TAC of 450 t would be possible. This is based on an estimated virgin biomass of 2,000 t for the area (the average of the 1978 and 1979 hydroacoustic estimates).

In northern Hecate Strait from Butterworth Rocks to Bonilla Island, midwater and bottom concentrations of juvenile pollock occur, as well as schools of adult pollock. No separate TAC is suggested for this part of Area 5D. Discards of juvenile pollock occur in Hecate Strait during

the summer bottom-trawl fishery, which targets mainly on flatfish and Pacific cod.

12.3.5.1 Recommendations

The recommended TACs for walleye pollock in Area 5D are 2,100 t for Rose Spit-Two Peaks-Dundas and Zayas Islands area, and 450 t for the Cape Chacon area.

12.3.6 West coast Queen Charlotte Island (Area 5E)

Landings of pollock from Area 5E totalled 0.2 t in 1976, 12 t in 1977, 21 t in 1978, and 44 t to July 1979 (Table 12.1). Commercial and research catches of adult and juvenile pollock have been made in inlets and on the narrow continental shelf. The estimated biomass is 1,000 t. During the summer of 1979 commercial vessels landed about 50 t from a concentration of pollock lying in the Langara Trench between Frederick and Langara Islands. The possibility exists that it may be part of the Dixon Entrance stock. The size of this concentration has not been estimated. For the present purposes the virgin biomass of pollock in Area 5E is guessed to be 3,000 t.

12.3.6.1 Recommendation

The recommended TAC for walleye pollock in Area 5E is 700 t.

Table 12.1. Canadian landings (t) of walleye pollock, by area, 1954-79.

Pollock landing (t)										
Year	Area									Total
	4B	3B	3C	3D	5A	5B	5C	5D	5E	
1954	147	0	3	0	13	1	0	0	0	164
1955	418	0	5	0	1	0	0	3	0	426
1956	380	0	52	0	5	0	0	14	0	451
1957	248	0	4	0	3	0	0	7	0	262
1958	121	0	9	0	0.3	0	0	14	0	145
1959	260	0	8	0	0.4	0	0	2	0	270
1960	95	0	5	0	1	3	0	10	0	114
1961	115	0	0.1	0	1	0	0.3	7	0	123
1962	49	0	6	0	0	0	0	12	0	67
1963	13	0	7	0	6	0	0	4	0	29
1964	33	0	2	0	5	0	0	2	0	42
1965	26	0	10	0	0	0	0	9	0	45
1966	37	0	0.4	0	1	0.1	0.4	82	0	121
1967	33	1	0	0	1	0	7	48	0	90
1968	16	0	2	0	7	0	4	13	0	42
1969	30	0	14	0	33	0	0	47	0	125
1970	45	0	0	0	0	0	0	8	0	52
1971	80	0	5	0	0	0	0	0	0	85
1972	71	0	0.3	0	172	0	0	1	0	244
1973	9	0	0.1	0	62	9	0.4	13	0	93
1974	11	0	0	0	6	6	2	47	0	72
1975	1	0	0	0	21	10	1	70	0	104
1976	26	0	5	2	69	400	193	627	0.2	1,322
1977	50	0	10	0	61	175	16	568	12	891
1978	380	0	6	0.4	106	187	11	1,700	21	2,411
1979 ^a	(1,096)	0	0	0	(9)	(0.1)	(4)	(1,079)	(44)	(2,231)

^aPreliminary data.

Table 12.2. Walleye pollock maturity observations in Area 4B (Georgia Strait) during 1978-79.

Period	Observation	Source
<u>1978</u>		
Feb. 24-25	First appearance of hydrated ova in Area 29.	Vessel observer report (J.M.T.)
March 29-30	Largely spent or recovering west of Texada Is. and from Halibut Bank to Entrance Is.	Thompson and Beamish (1979)
April 11-13	Peak period of spawning between Point Roberts and Active Pass.	Thompson and Beamish (1979)
April 21	Mostly spent, recovering or resting near Halibut Bank.	Thompson and Beamish (1979)
<u>1979</u>		
March 4	First appearance of hydrated ova in Area 29.	Vessel observer report (K.W.)
March 19-20	Start of spawning between Active Pass and Point Roberts (2 spent females, 6 RR males).	Port sample (N.V.)
March 23-25	Peak spawning in Area 29.	Vessel observer report (K.W.)
March 28-29	Just before peak between Active Pass and Point Roberts (similar frequency of maturities to data collected April 5-7 in 1978).	CALIGUS cruise (M.S.S.)

Table 12.3. Canadian trawl landings (t) of walleye pollock in Major Area 4B (1954-79).

Year	Pollock landing (t)				
	Minor Areas 19-20	Minor Area 18		Minor Areas 14-17, 29	Area 4B Total
		Inside Passages	Open Strait		
1954	3	111	14	18	147
1955	1	301	33	16	418
1956	1	241	59	28	380
1957	21	36	88	10	248
1958	7	54	12	9	121
1959	22	127	13	50	260
1960	9	41	14	7	95
1961	10	11	8	4	115
1962	15	3	4	7	49
1963	5	2	0.3	5	13
1964	22	7	0	3	33
1965	20	0	0	1	26
1966	29	0	0	1	37
1967	5	0	0	23	33
1968	2	0	0	9	16
1969	19	0	0	6	30
1970	17	11	14	4	45
1971	51	17	6	6	80
1972	70	0.2	0.4	0	71
1973	3	4	0	2	9
1974	0	9	0	1	11
1975	0	0	0	1	1
1976	23	0.3	0	0.3	26
1977	29	16	1	0.6	50
1978	80	102	11	178	380
1979 ^a	(5)	(160)	(24)	(907)	(1,096)

^aPreliminary estimates to July 20.

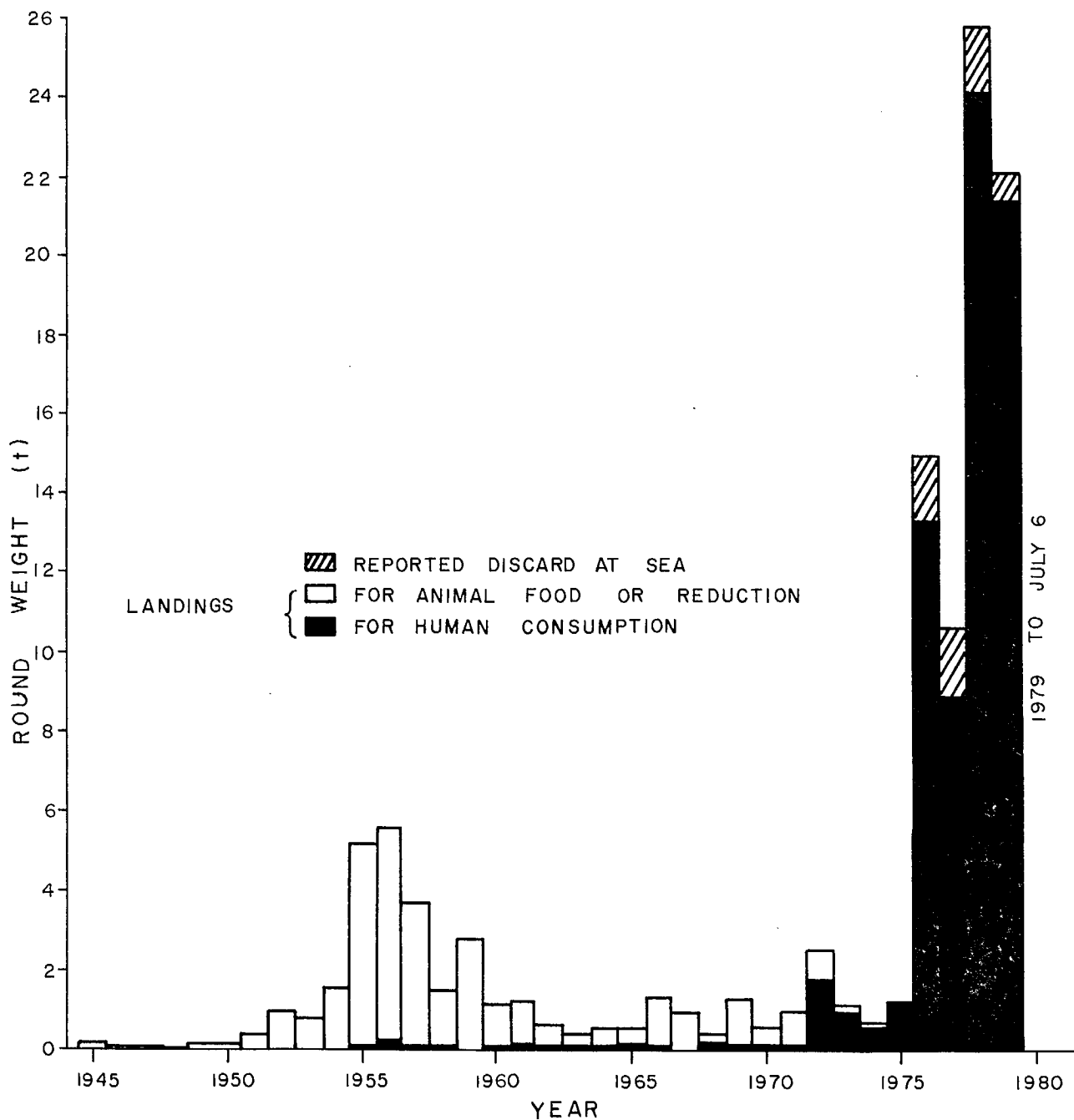


Fig. 12.1. Canadian walleye pollock landings (t) by utilization (1945-July 6, 1979) and reported discards (1976-July 6, 1979) from B.C. coastal waters.

13. PACIFIC HAKE STOCK ASSESSMENT

13.1 Introduction

Pacific hake (Merluccius productus) are now fished by Canadian fishermen, but only a minor amount of the catch is currently sold to North American markets. In 1978, Canadian fishermen caught 1,836 t of Pacific hake from Sub-zone 5-1 as part of the cooperative venture with Polish fishermen. In 1979, 484 t of Pacific hake were caught in the Strait of Georgia as of June 30 and offshore catches of Pacific hake were approximately 500 t as of June 30, 1979. It is expected that the total catch by Canadian fishermen will exceed 10,000 t. Therefore, it appears that Pacific hake is becoming an important fishery and if markets can be developed for Pacific hake products, this species could be landed in quantities in excess of any other groundfish species.

13.2 Assessment of the Strait of Georgia Stock

No review of the hydroacoustic survey data in the Strait of Georgia was conducted during 1979, and the estimate of the biomass remains at 120,000 t. Studies during the commercial fishery for Pacific hake in March and April 1979 indicated that the stocks were large with catches of 10,000-20,000 kg being made in less than 30 minutes. However, we suspect that the estimated biomass is much smaller than 120,000 t and may be only one quarter to one half of this estimate.

Using the age composition of the catch in Table 13.1 and considering only the ages of fully recruited fish from age 4 to 9 (85% of the catch of mature, recruited fish), an instantaneous mortality rate of 0.64 was calculated. Using the Gulland (1970) formula $MSY = 0.5 \times M \times B_0$. MSY estimates ranging from 38,000-10,000 t were calculated using biomass estimates ranging from 120,000-30,000 t. Because the hydroacoustic biomass estimate must be considered to be preliminary, and only a small number of fish have been aged by the new ageing method developed for Strait of Georgia Pacific hake, both the natural mortality estimates and biomass estimates may be in error. Therefore, until resources are available that will allow more time to be spent on studies of the biology and abundance of Pacific hake in the Strait of Georgia, it is recommended that a quota of 10,000 t be established for 1980.

If a fishery develops in 1980 for fillets or for roe some regulations will be required to prevent the discard of carcasses into the Strait of Georgia. It will also be important to regulate the discards of pollock that are caught incidentally in the Pacific hake fishery. Pollock incidence was 23% in the hake catches during March and April, 1979. Thus catches of pollock could be important and regulations should be imposed to prevent the waste of these fish.

13.2.1 Recommendation

A conservative TAC of 10,000 t is recommended for the Strait of Georgia. The discard of hake or pollock directly into the Strait of Georgia should be discouraged, and regulations may be required to prevent the waste of fish.

13.3 Assessment of the offshore stock

The size of the offshore Pacific hake stock and the allowable catch are determined by United States scientists. A TAC for the Canadian zone is established based on the U.S. biomass estimate, and an estimate of the proportion of Pacific hake that move into the Canadian zone. United States scientists have determined that the Pacific hake stocks are healthy and there is no reason at this time to expect that the United States TAC for 1980 will be substantially different from 1979. Therefore, it is quite possible that the recommended TAC in 1980 for offshore hake in the Canadian zone will be 35,000 t. The exact value cannot be determined until the U.S. estimate is obtained, and if a preliminary TAC is required, we suggest 20,000 t be allocated with a 15,000 t reserve.

A survey of Sub-zones 5-1 and 5-2 in early May 1979 did not locate significant concentrations of hake, indicating movement into the Canadian zone probably had not begun. By mid-June concentrations of hake were observed in Sub-zone 5-1 indicating the movement into the Canadian zone probably occurred early in June. Catches as large as 4,700 t of Pacific hake have been reported for foreign vessels fishing in the Canadian zone in May and hake have been observed in the Canadian zone as late as mid-October. Thus offshore hake moving into the Canadian zone may be resident for up to 5 mo. Some local stocks are known to exist, but the size of these stocks is unknown. Pollock are caught with the hake and in some areas incidental pollock catches may be equivalent to 20% of the hake catch.

13.3.1 Recommendation

The recommended TAC for Pacific hake in the Canadian zone is provisionally 20,000 t, with a 15,000 t reserve until the U.S. TAC is known.

Table 13.1. Age composition of Pacific hake from the Strait of Georgia (1979), determined from otolith sections.

Age	n
1	40
2	38
3	42
4	174
5	123
6	32
7	19
8	14
9	7
10	14
11	14
12	6
13	9
14	5
15	5
16	11
17	1
Total	554

14. BUTTER SOLE STOCK ASSESSMENT

14.1 Introduction

The butter sole (Isopsetta isolepis) exists in abundance in the shallow water of the northern Hecate Strait flats. (Minor quantities are to be found off the west coast of Vancouver Island). During the winter months, adults migrate to Skidegate Inlet where they traverse a shallow bar and descend into depths of ca 30 fm where they spawn. During at least one severely cold winter (1949-50), the fish apparently were unable to cross the bar, and spawning presumably occurred in the open waters of the Strait.

The main site of the fishery has normally been in Skidegate Inlet, but in the early days of the fishery (mid 1940s) large catches were made on and around Dogfish Bank, close to Rose Spit on Graham Island. The species was first used for human food, but by 1960 most of the production was diverted to animal food presumably because of the high cost of processing. (Butter sole is a thin flatfish with a relatively low fillet-recovery-to-body-weight ratio).

14.2 Catch statistics

Production of butter sole for human consumption reached a peak of 1,686 t in 1952, but has always varied substantially because of market conditions or variable availability induced by environmental conditions (Table 14.1). During 1955-72, when butter sole was sold in part for human consumption, but more often as animal food, landings ranged from about 200-900 t. The species has been essentially unfished since 1972, because of the collapse of the animal food market and because it no longer finds any demand as human food.

14.3 Stock condition

In the early days of the fishery (prior to 1953) there was concern that the butter sole could be easily overfished because of its high vulnerability to capture on the Skidegate spawning ground. However, the impact of fishing was never clearly demonstrated. High estimates of Z, instantaneous total mortality rate, for females (1.36-1.68) were attributed largely to a high natural death rate (Kutty 1963). Since the stock has been essentially unfished since 1972, it has presumably returned to a primitive level of abundance.

14.4 Recommendations

No restrictions need be placed on fishing for butter sole as long as it takes place in Skidegate Inlet. There, the stock can be fished to the exclusion of all other commercially valuable species. However, unrestricted fishing on the summer feeding grounds could result in large incidental catches of juvenile rock sole and other species which may require conservation measures.

Table 14.1. Landings (t) of butter sole in British Columbia, 1945-78.

Year	Food-fish ^a	Animal food	Total	Year	Food-fish ^a	Animal food	Total
1945	658	-	658	1962	35	877	912
1946	699	-	699	1963	52	310	362
1947	114	-	114	1964	93	236	329
1948	295	-	295	1965	118	250	368
1949	13	-	13	1966	158	579	737
1950	5	-	5	1967	335	477	812
1951	827	-	827	1968	188	523	711
1952	1,686	-	1,686	1969	174	231	405
1953	170	-	170	1970	573	126	699
1954	96	21	117	1971	199	27	226
1955	213	121	334	1972	122	56	178
1956	314	351	665	1973	10	3	13
1957	586	69	655	1974	tr	-	tr
1958	227	219	446	1975	-	-	-
1959	96	108	204	1976	-	-	-
1960	46	583	629	1977	-	-	-
1961	15	324	339	1978	-	-	-

^aHuman consumption.

15. ALBACORE STOCK ASSESSMENT

15.1 Introduction

The albacore (Thunnus alalunga) is a wide-ranging pelagic species of trans-oceanic distribution in the tropical and sub-tropical waters of the North Pacific. While occurring for the most part in the international sea, it makes seasonal intrusions at various stages of its life-history into the 200-mile zones of Japan, Mexico, U.S.A., and Canada.

15.2 Summary of life history

The albacore spawn in moderately deep water across the breadth of the North Pacific in a band lying between 0° and 10°N. To judge from egg and larval surveys, most of the spawning occurs in the western Pacific. In the first 2 years there is a seasonal south to north movement to the "front" (ca. 35°N) and south again in the fall. Between ages 2 and 3 an east and west movement becomes superimposed on the seasonal south to north movement and is manifested by the annual arrival of juveniles off the North American coast in spring and summer. Those which make their landfall south of San Francisco to Baja California remain throughout the summer and then move southwestward to areas unknown.

Albacore making their landfall north of San Francisco move northward along the Oregon and Washington coasts, and, depending on presence of 14°-16°C water, extend northward off British Columbia to the Queen Charlottes (ca. 54°N). By early autumn the migration shifts south and then westward. Tagging suggests that this northern component traverses the Pacific to the southern coastal waters of Japan (ca. 35°N). By this time the older fish in this highly migratory component of juveniles reach maturity and presumably move southeastward to the 0°-10°N belt of latitude where they proceed to spawn. Behaviour from first spawning through the remainder of adult life is not clearly understood, but on the basis of information on the Japanese fishery their distribution is confined mainly to the west of Hawaii.

15.3 Definition of stocks

There is still some doubt as to the number of stocks present in the North Pacific. The current view is that there is one major stock in the triangle joining San Francisco, Graham Island and southern Honshu. Although some of the juvenile albacore which appear to the south of San Francisco eventually reappear in the fishery close to Japan (6% of tag recaptures), the majority apparently move southwestward from the North American coast and escape further fishing during the remainder of their life.

Thus present information suggests there are at least two stocks in the North Pacific -- one which is vulnerable to exploitation by both the North American and Japanese fisheries and one vulnerable only as juveniles to the North American fishery. This description is perhaps over-simplified. With the advance of knowledge, particularly about age and growth, it is

becoming increasingly apparent that the subject of stock definition is extremely complex.

15.4 Catch and effort statistics

Table 15.1 shows the 1961-77 distribution of albacore catch by country and gear.¹⁴ From an average of 55,000 t in 1961-65, total production rose fairly sharply surpassing the 100,000 t level during the early 1970s. The catch reached an all-time high of 122,000 t in 1976, but fell to less than one-half that amount in 1977, largely because of a relative failure in the Japanese fishery which is explained in part by the failure of the oceanographic "front" to develop in that year directly to the east of southern Honshu. Preliminary information on the 1978 Japanese fishery indicates a higher production than in 1977 but still far below the 1971-76 average.

In contrast, the North American fishery from 1961 to 1976 showed no trend, averaging about 22,000 t, with a peak of 31,000 t in 1973. The catch in 1977 was the lowest since 1961 being less than 12,000 t, but preliminary information on the 1978 fishery indicates that production will be near the 22,000 t average. The poor catch of 1977 was attributed to rough seas and unfavourable oceanographic conditions, including poorer than normal upwelling along the Pacific coast.

The Canadian fishery, consisting largely of vessels which do not venture south to more productive latitudes, has been highly erratic, with catches ranging from virtually 0 (from 1953 to 1965) to a peak of 3,600 t in 1972. Since that time production has fallen to very low levels being only 53 t in 1977 and even less in 1978. Again, oceanographic conditions have been the dominant factor in determining the size of the catch in recent years. However, other factors such as poor prices, and the frequently more attractive troll fishery for salmon, have accounted for some of the historical ups and downs in the Canadian fishery.

Statistics of CPUE are provided in Table 15.2. At the 1978 meeting of the international Working Group on Albacore it was apparent that there are many reservations concerning CPUE as a measure of abundance, particularly in the Japanese fishery. There, the major problem is one of defining effective fishing effort because the fishery for albacore is not clearly distinct from those for other tunas such as bonito and skip-jack. Problems which plague interpretation of North American CPUE include year-to-year differences in distribution and size of schools, the presence or absence of upwelling, strengths of the frontal system, bad weather, etc.

15.5 State of the albacore resource

Japanese scientists have developed several elaborate schemes to measure effective fishing effort for albacore. Applying these statistics

¹⁴Statistical data contained in the present report have been extracted from the second annual report of an international Working Group on Albacore, represented by Japan, U.S.A. and Canada at its 1978 meeting.

and those of catch to a general production model, they conclude that the present catch is at or near MSY, variously estimated to be between 95,000 and 125,000 t. This range of estimates reflects uncertainty as to the true shape of the production curve, as few if any catch-effort points lie to the right of the dome.

In addition to uncertainty concerning the measure of effective effort and the possibility it is increasing rapidly, there are misgivings that the assumptions implicit in the production model are not satisfied. One is the assumption that there is but one stock. The other, which is much more serious, concerns the stability of age structure. The Japanese fishery which formerly depended on fish of age 4+ to 6+ is now concentrating on fish of age 2+ (ca. 50 cm). Yield-per-recruit analysis has clearly indicated that this shift to younger ages is in the wrong direction for maximizing yield.¹⁵

15.6 Recommendation

Until Japan and the United States, the major exploiters of albacore (accounting for 98.8% of the production) issue an international call for controls, it is recommended that no restraints be placed on Canadian fishing power or catch.

¹⁵Continued premature exploitation of juveniles is likely to have substantial impact on the North American fishery north of San Francisco, and may have been felt for the first time in 1978.

Table 15.1. Catches of North Pacific albacore in metric tons, 1961-77^d (dashes indicate no estimate available).

Year	Japan ^a				United States ^b			Canada	
	Pole-and-line	Longline	Other gears	Total	Pole-and-line	Jig	Total	Jig	Total ^c
1961	18,636	15,999	-	34,635	2,837	12,054	14,891	4	49,530
1962	8,729	12,617	-	21,346	1,085	19,753	20,838	1	42,185
1963	26,420	11,445	-	37,865	2,432	25,142	27,574	5	65,444
1964	23,858	11,558	-	35,416	3,411	18,389	21,800	3	57,219
1965	41,491	11,214	121	52,826	417	16,461	16,878	15	69,719
1966	22,830	20,874	585	44,289	1,600	15,169	16,769	44	61,102
1967	30,481	24,374	520	55,375	4,113	17,814	21,927	161	77,463
1968	16,597	19,040	1,109	36,746	4,906	20,441	25,347	1,028	63,121
1969	31,912	18,006	1,480	51,398	2,996	18,826	21,822	1,365	74,585
1970	24,263	15,372	956	40,591	4,416	21,039	25,455	354	66,400
1971	52,957	10,915	1,262	65,134	2,071	22,196	24,267	1,587	90,988
1972	60,591	12,622	922	74,135	3,750	23,600	27,350	3,558	105,043
1973	69,640	16,000	1,922	87,562	2,236	15,652	17,888	1,720	107,170
1974	73,576	12,952	1,289	87,817	4,777	20,177	24,954	1,207	113,978
1975	52,157	9,931	568	62,656	3,243	18,926	22,169	101	84,926
1966	85,336	15,738	2,464	103,538	2,780	16,314	19,094	252	122,804
1977 ^d	31,934	15,512	1,727	49,173	1,497	10,012	11,509	53	60,682

^aJapanese longline catch for 1961-68 excludes minor amount taken by vessels under 20 gross tons. Longline catch in weight is estimated by multiplying annual number of fish caught by an average weight statistic.

^bUnited States pole-and-line catch excludes minor amount taken by vessels not submitting logbooks to IATTC: this amount is included in the jig catch.

^cOmitted are unknown but minor catches by United States sport fishermen and by longline and pole-and-line vessels of the Republic of Korea and Taiwan.

^dData from report of the Third North Pacific Albacore Workshop, Honolulu, Hawaii. Feb. 1979.

Table 15.2. Catch per unit of effort (CPUE) of North Pacific albacore by fishery.

Year	U.S.A. Jig ^a	Japan	
		Pole-and-line ^b	Longline ^c
1961	69.17	4.40	0.25
1962	124.59	7.22	0.30
1963	132.09	6.29	0.32
1964	97.61	6.86	0.40
1965	89.07	6.26	0.33
1966	90.45	5.94	0.54
1967	126.83	6.09	0.40
1968	135.23	5.34	0.38
1969	112.57	4.95	0.28
1970	127.39	6.13	0.31
1971	96.68	6.94	0.21
1972	61.08	6.25	0.30
1973	82.89	5.49	0.38
1974	105.17	7.81	0.34
1975	99.81	5.95	0.23
1976	69.22	6.13	0.30
1977	59.90	2.49	

^aNumber of fish per standardized boat-day.

^bMetric tons per standardized fishing day.

^cNumber per thousand standardized hooks.

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APPENDIX 1. SPECIAL REGULATIONS FOR PACIFIC COD IN AREA 3C

Introduction

Since 1976, increasing concern has been expressed by trawl captains and processors with respect to the expanding and evolving fishery for spawning Pacific cod on Amphitrite Bank during January-March. They have contended that the new trawling techniques catch an excessive proportion of the spawning cod, and hence jeopardize the stock(s). Since Amphitrite Bank is the only known major spawning ground for Pacific cod in Area 3C, the entire cod resource in Area 3C is jeopardized.

Although no proof of this hypothesis is currently available (nor likely to be in the near future), plausibility is evident to those who have observed the new fishing techniques. As a precautionary measure, logic suggests that the January-March fishery be restricted, or closed, during years when Pacific cod abundance is at a cyclic low level. A predictor of these low-abundance periods is required to provide management and the industry with adequate advance warning.

To satisfy this need, predictors were developed which would give 3 and 6 months notice as to the abundance of spawning Pacific cod on Amphitrite Bank each year. The predictors were the Canadian landings of Pacific cod during April-June (Quarter II) and July-September (Quarter III), respectively, in the year preceding the spawning season. The general validity of these predictors is based on two facts. First, age composition of Pacific cod landings from Area 3C are principally age-2 fish during Quarters II and III, and age-3 fish (same year-class) in Quarter I of the following year. Age composition of landings during Quarter II are less consistent, perhaps because in some years relatively more age-3 and age-4 fish survive past spawning. Second, Canada-U.S. landings and Canada catch rates (t landed/hr trawled) were reasonably well correlated as follows:

Ground	Time	r
Amphitrite Bank	Qtr I	0.911
Big Bank	Qtr II	0.407
	Qtr III	0.575

Both predictors have biases which may affect their accuracy. The predictor based on Quarter II landings will overestimate the Quarter I landings, if the landings contain too many representatives of the older cod which will not be equally abundant during the next spawning season. The predictor based on Qtr III landings will tend to underestimate the Quarter I landings when dogfish are sufficiently abundant in Area 3C to inhibit trawling for cod. A counteracting bias in 1978 may have been the abnormally high water temperature (Douglas and Wickett 1979) which may well have caused a reduction in availability of cod to the trawl fishery.

Prediction and recommendation

Both predictors were employed to estimate the abundance of Pacific cod in Area 3C during January-March 1978, and indicated abundance would be relatively low -- Canadian landings = 476 t (Qtr II predictor) or 856 t (Qtr III predictor) (Appendix Table 1). Accordingly, Area 3C was closed to all trawling for the period February 22-April 3. The estimated Canadian landings for January-March, had there been no closure, was 604 t -- slightly less than the mean estimate (666 t). Actual Canadian landings (January-February) totalled 574 t.

For January-March 1979, Canadian landings were estimated to be 840 t (Qtr II predictor) or 432 t (Qtr III predictor) (Appendix Table 1). Mean estimate was 636 t, slightly less than the mean estimate for 1978 (666 t). Although, a closure to trawling was imposed for February 1-March 31, in the Canadian section of Areas 3C-3D (south of Maquinna Point, and shallower than 100 fm), Pacific cod landings from the January fishery totalled 279 t. Thus, approximately 357 t (636 less 279) of Pacific cod were "saved" for spawning by the February-March closure.

In 1979, the April-June Canadian landings of Pacific cod totalled 644 t, which projects the January-March 1980 landings to be 1,207 t (Appendix Table 1). July-September landings are not available at this time (July 1979). A complete prediction for January-March 1980 landings will be available in early November.

Appendix Table 1. Relationship between Canadian landings (t) of Pacific cod from Area 3C during Quarters II and III of year i with those during Qtr. I of year i+1, 1968-76.

Year (i)	Canada Landings (t)		
	Qtr.II (i)	Qtr.III (i)	Qtr.I (i+1)
1967	344	138	420
1968	126	33	344
1969	200	67	343
1970	277	176	516
1971	1,076 ^b	468	1,544
1972	2,031 ^b	706	1,425
1973	566	369	1,263
1974	692	536	1,463
1975	734	358	1,362
1976	652	326	944
<u>Predictor Parameters</u>			
N	8 ^a	10	
r	0.950	0.911	
a	-21.0	294.	
b	1.929	2.136	
S _{yx}	164.	222.	
1977 ^b	259	268	574 (476/856) ^c
1978 ^b	556	140	279 (840/432) ^c
1979 ^b	644	-	- (1,207/-) ^c

^aOmitting 1971 and 1972.

^bNot included in regression formula.

^cEstimates. (Qtr.II/Qtr.III).

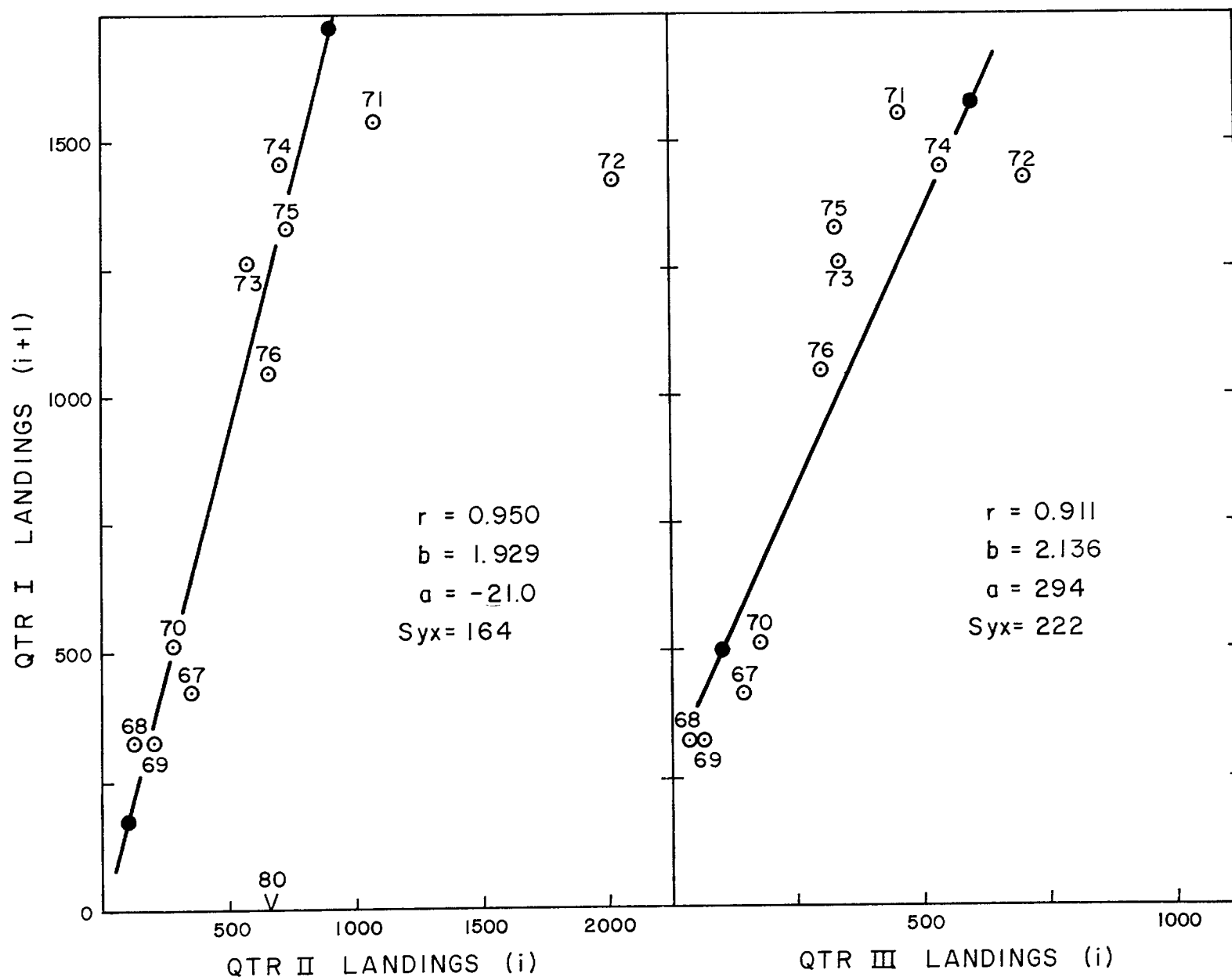


Fig. 1. Relationship between Canadian landings of Pacific Cod from Area 3C (Canadian portion) during Quarter II (April-June) and Quarter III (July-September) in year i with those during Quarter I (January-March) in year i+1, 1967-76.

APPENDIX 2. ROCKFISH FISHERY IN AREA 5E

The distinct multispecies nature of the rockfish fishery in Area 5E has made the successful optimization of total yield of the rockfishes difficult to achieve. The differences in stock sizes and biological parameters, and subsequent TACs, among species has resulted in premature closure of the fishery in previous years when one TAC was reached, while others were substantially undersubscribed. In an effort to avoid this truncation of species' fisheries, data from the commercial fishery during 1977-79 were segregated by species, ground, month and year to determine if there were sufficient distinctions to allow some differential exploitation by species.

Appendix Table 2 presents these data for four major fishing grounds, segregated to landings of Sebastes alutus, S. reedi, and all other rockfishes. It is apparent when evaluating this table, that there are locations and times of year when landings are largely composed of only one of the major species and as such, they represent opportunities for management focus. Since the optimization problem has been primarily concerned with S. reedi it would be desirable to restrict landings of S. alutus at some time of year in order to permit greater landings of S. reedi. Also to be considered is the total effort being applied to any one ground.

The months of April and March are relatively similar in that the majority of the catches are composed of S. alutus or species other than S. reedi. Since this situation is common to all grounds during these months it is possible that all grounds in Area 5E, south of 54°00'N could be closed to directed fishing for rockfishes. Past data indicate that such a closure would decrease the annual total landings of S. alutus by approximately 25%. It is further suggested, should the TAC for S. alutus be approached later in the year, while other TACs have not, that the Anthony Island Ground (52°00'-52°10'N) be closed to rockfish fishing. The latter is suggested because this ground has yielded almost exclusively S. alutus in previous years and could be closed with relatively little consequent effects on yields of S. reedi.

Recommendations

To optimize yields of all rockfishes in Area 5E, south of 54°00'N it is recommended that all of this area be closed to directed fishing for rockfishes during the months of March and April. This recommendation is made in order to provide some deferral of S. alutus harvest until later in the year when S. reedi comprises a larger component of the rockfish catch. It is further recommended that the Anthony Island area (52°00'N-52°10'N) be closed to directed fishing for rockfishes should the S. alutus TAC be reached while that for S. reedi has not.

Appendix Table 2. Rockfish fishery in Area 5E. Landings (t) of Sebastes alutus, S. reedi and other rockfishes by month, by ground and by year, 1977-79.

		January	February	March	April
		<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>
Rennell Sound	'77	78.9/54.4/14.5	33.6/ - / 4.5	- / - / -	143.8/ 5.4/ 4.1
	'78	68.4/85.1/40.7	- / 0.2/ 0.2	- / - / -	11.8/ 10.9/ -
	'79	0.4/ 2.7/ 1.5	2.9/ <u>107.0</u> /17.7	11.9/6.4/ 6.4	73.0/ 90.7/31.1
Buck Point	'77	- / - / -	- / - / -	- / - / -	162.4/ - / 4.1
	'78	- / - / -	9.1/ - / -	- / - / -	130.9/ 9.5/34.0
	'79	<u>39.9</u> / - / 2.2	2.7/ - / 1.7	<u>35.8</u> /1.8/ 5.5	<u>49.9</u> / - /16.6
Fred Spot	'77	- / - / -	- / - / -	- / - / -	- / - / -
	'78	<u>75.9</u> / - / 1.6	28.6/ - / -	- / - / -	19.5/ 11.6/ 0.8
	'79	<u>4.5</u> / 0.1/ 0.2	- / - / -	- / - / -	59.9/ 23.1/23.4
Anthony Island	'77	<u>102.1</u> / - / 1.4	- / - / -	- / - / -	4.1/ - / -
	'78	- / - / -	- / - / -	- / - / -	- / - / -
	'79	34.7/ 6.7/ 8.4	<u>120.4</u> / 6.4/ 0.5	- / - / -	<u>90.3</u> / 3.2/ 2.4
Total	'77	181.0/54.4/15.9	33.6/ - / 4.5	- / - / -	310.3/ 5.4/ 8.2
	'78	<u>144.3</u> /85.1/42.3	<u>37.7</u> / 0.2/ 0.2	- / - / -	<u>162.2</u> / 32.0/34.8
	'79	<u>79.5</u> / 9.5/12.3	<u>126.0</u> /113.4/19.9	47.7/8.2/11.9	<u>273.1</u> /117.0/73.5

Appendix Table 2 (cont'd)

		May	June	July	August
		<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>
Rennell Sound	'77	46.7/151.5/ 9.5	303.9/132.9/22.7	140.6/289.4/45.8	15.4/103.4/30.8
	'78	25.2/183.3/67.5	126.8/ 53.0/17.4	1.8/ - / -	86.6/118.4/30.7
	'79	0.7/ 8.2/ 3.2	1.4/ 11.8/13.4		
Buck Point	'77	71.7/ - / 7.7	10.9/ - / 0.5	42.6/ 6.4/14.1	- / - / -
	'78	15.4/ - / -	17.2/ - / 4.1	- / - / -	2.2/ - / 9.1
	'79	7.7/ - / -	1.9/ 10.3/ 0.7		
Fred Spot	'77	- / - / -	- / - / -	- / - / -	- / - / -
	'78	6.4/ - / -	- / - / -	- / - / -	- / - / -
	'79	- / - / -	- / - / -		
Anthony Island	'77	10.0/ - / -	1.4/ - / -	- / - / -	- / - / -
	'78	53.4/ - / -	4.1/ 48.5/ 5.9	298.7/ 66.5/ 9.4	353.2/ 56.6/13.8
	'79	18.9/ 7.0/ 2.7	91.2/ 58.4/ 4.8		
Total	'77	128.4/151.5/17.2	316.2/132.9/23.2	183.2/295.8/59.9	15.4/103.4/30.8
	'78	100.4/183.3/67.5	148.1/101.5/27.4	300.5/ 66.5/ 9.4	442.0/175.0/53.6
	'79	27.3/ 15.2/ 8.9	94.5/ 80.5/18.9		

Appendix Table 2 (cont'd)

		September	October	November	December
		<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>	<u>alutus/reedi/other</u>
Rennell Sound	'77	12.3/ <u>79.8</u> /13.2	25.4/ <u>167.4</u> / 72.1	52.6/ <u>183.7</u> /22.2	- / - / -
	'78	11.3/ <u>64.9</u> /17.2	72.4/ <u>166.6</u> / 90.4	4.8/ <u>7.5</u> / 6.7	3.2/24.2/18.6
	'79				
Buck Point	'77	1.4/ - / 0.5	1.4/ 10.0/ 1.4	4.1/ 14.1/ 2.3	- / - / -
	'78	3.4/ - / -	26.3/ - / 0.1	14.9/ 6.4/ 3.0	5.1/ 0.1/ 3.0
	'79				
Fred Spot	'77	- / - / -	- / - / -	- / - / -	- / - / -
	'78	- / - / -	5.0/ - / -	- / - / -	6.8/ - / -
	'79				
Anthony Island	'77	- / - / -	- / - / -	- / - / -	- / - / -
	'78	- / - / -	<u>521.5</u> / 81.3/ 22.3	<u>177.8</u> / 26.8/ 1.6	<u>85.4</u> /17.0/21.7
	'79				
Total	'77	13.7/79.8/13.7	26.8/ <u>177.4</u> / 73.5	56.7/ <u>197.8</u> /24.5	- / - / -
	'78	14.7/64.9/17.2	<u>625.2</u> / <u>247.9</u> /112.8	<u>197.5</u> / 40.7/11.3	<u>100.5</u> /41.3/43.3
	'79				

OTHER RECOMMENDATIONS

It is recommended that a minimum size regulation of 55 cm in fork length for sablefish be implemented for all areas adjacent to Canada's west coast. It is further recommended that regulations requiring escape devices on trap gear be implemented by January 1, 1981.

It is recommended that the present regulation preventing the retention of lingcod less than 58 cm in total length by the commercial fishery be expanded to include removals by the recreational fishery in the Strait of Georgia and vicinity (Area 4B).

It is recommended that trawling in the portion of Zone 5 north of 54° latitude be limited to a permit fishery to allow close monitoring of rockfish catches.

It is recommended that rockfish fishing in Canadian waters adjacent to Queen Charlotte Sound seaward of the fishery closing line, from Cape St. James to Triangle Island, be restricted to the months of June-September inclusive (see Addendum to sec. 2.11).

It is recommended that Area 3C shallower than 100 fm be closed to all trawl fishing during January 1-April 1 to protect spawning stocks of Pacific cod.

It is recommended that an all-gear lingcod fishing closure be in effect during November 15-April 15 for waters adjacent to the west coast of Vancouver Island (Areas 3C and 3D) and the inside waters of Vancouver Island (Area 4B).

DATE DE RETOUR _____

FEB 17 1982

21/12/88

