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FISHERIES RESEARCH BOARD OF CANADA

TECHNICAL REPORT NO. 19

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A SUMMARY REPORT OF THE BRITISH COLUMBIA TRAWL FISHERY IN 1966 AND SOME ASPECTS OF ITS INVESTIGATION

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Biological Station, Nanaimo, B. C.

May, 1967

INTRODUCTION

Research on the groundfish resource of the Pacific coast of Canada, as conducted by the Fisheries Research Board of Canada, is divided into two main sections. One of these, the distant-seas investigation, is concerned with resources in deep water, particularly Pacific ocean perch which is the principal target of the expanding fisheries of the USSR and Japan in the northeastern Pacific. The other, the near-seas investigation, is concerned with the dynamics of species such as cod and flatfish which contribute to the long-standing domestic trawl fishery of British Columbia, mainly on the shallow coastal banks. While the latter section is oriented more to questions on management and the former to projects of an exploratory nature, it is neither possible nor desirable to make the two mutually exclusive.

This manuscript is concerned only with the domestic fishery as investigated by the near-seas group. However, the report on progress in publication of results (page 29) includes all recent material by both phases of the investigation.

Prior to 1966, reports summarizing events in the fisheries and progress of research appeared in appendices to the Annual Report of the Nanaimo Station. Starting in 1966 the material was published in a separate report (Manuscript Report No. 872).

CATCH STATISTICS OF BRITISH COLUMBIA TRAWLERS

In 1966, detailed information on catch by area, effort expended, depths fished and other pertinent information was collected by port observers who covered 796 of the 1165 trawler landings at Vancouver, Steveston, Prince Rupert and Victoria. Catch recorded from the interviews represented 89% by weight of the total trawl-caught production. Estimates of catch for the 369 landings not covered by observers were obtained from sales-slip records through the cooperation of the Department of Fisheries in Vancouver. These particular sales-slip records were to a large extent concerned with small-boat or day-boat operations conducted in the Strait of Georgia.

Total landings of groundfish (excluding halibut) in British Columbia in 1966 reached a record height of about 57.9 million lb. Otter trawlers landed about 54.6 million lb, an increase of 25% over the previous record catch in 1965, and 86% greater than the mean for the previous 10 years (Table I and Fig. 1). Total effort associated with this catch was just over 28,000 hours, 3% less than in 1965 and 10% greater than in the 1956-65 period. The overall return per hour of trawling (excluding dogfish) in the 1966 fishery was 1927 lb/hr, 28% higher than in 1965 and 86% greater than the mean for the 1956-65 period.

The increased catch in 1966 was partially due to the continued strong fishery for Pacific cod. Landings of this species amounted to 26.8 million lb, 10% higher than in 1965 and 2.7 times the mean landing for the 1956-65 period.

Table I. Statistics of the British Columbia trawl fishery (landings in 1000's lb; effort in hours).

Species	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	Mean 1956-65	1966
English sole	2,007	1,080	1,320	1,664	2,140	2,075	1,556	1,295	1,447	1,335	1,592	1,243
Rock sole	4,175	4,200	4,566	1,904	4,049	2,888	3,262	2,977	2,638	3,077	3,374	7,235
Petrale sole	620	1,059	923	841	988	923	1,107	937	1,225	1,288	991	1,302
Dover sole	375	448	272	180	219	204	384	397	501	434	341	504
Rex sole	52	40	30	9	12	27	19	9	21	19	24	21
Starry flounder	254	195	135	106	197	265	211	203	149	169	188	153
Other flatfish	777	1,303	511	224	124	66	108	171	275	583	414	457
Total flatfish	8,259	8,325	7,757	4,928	7,731	6,447	6,647	5,989	6,256	6,905	6,924	10,915
Pac. true cod	5,154	8,505	10,057	9,187	6,891	4,547	5,934	8,919	15,541	24,466	9,920	26,803
Lingcod	2,446	2,173	2,131	2,469	2,422	2,912	2,095	1,433	2,826	3,840	2,475	4,337
Sablefish	82	104	259	128	143	216	251	143	276	577	218	684
Pac. ocean perch	339	200	703	545	786	272	1,178	1,002	1,039	3,075	914	5,217
Other rockfish	188	275	236	654	194	317	719	365	782	642	437	542
Misc. species	596	600	253	152	170	156	375	423	598	380	370	834
Total foodfish	17,063	20,182	21,396	18,064	18,336	14,867	17,199	18,273	27,318	39,886	21,258	49,332
Dogfish	1,592	4,364	2,913	4,849	2,938	7,344	683	373	109	223	2,539	370
Animal food	10,568	3,982	3,031	4,178	5,809	7,634	7,224	3,738	4,836	3,812	5,481	4,849
Total landing	29,223	28,528	27,340	27,091	27,083	29,845	25,106	22,384	32,262	43,920	29,278	54,551
Total hours	30,773	26,283	22,934	21,677	25,960	23,329	25,407	23,243	27,703	29,029	25,634	28,124
Catch/Effort (lb/hr) exc. dogfish	898	919	1,065	1,026	930	965	961	947	1,161	1,505	1,038	1,927

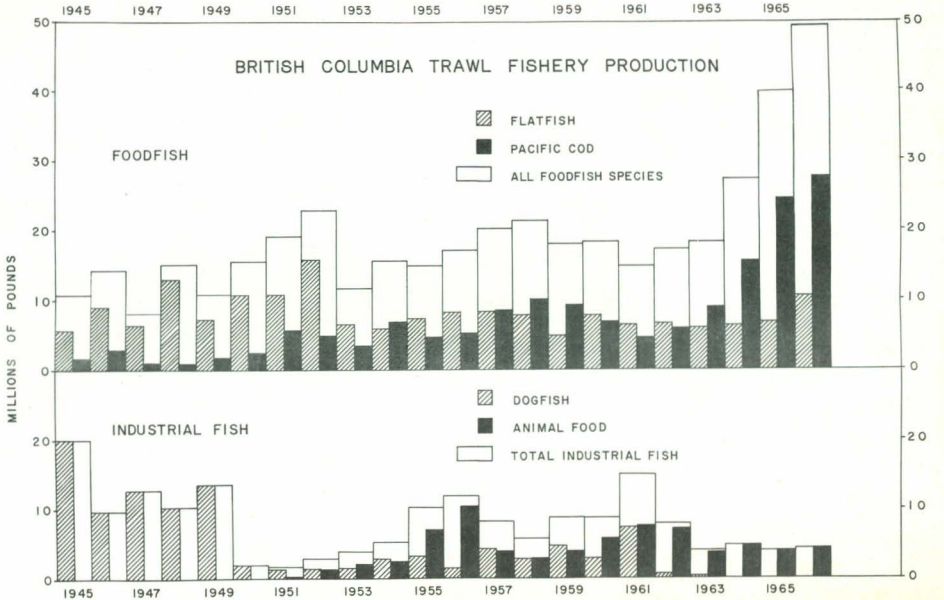
BRITISH COLUMBIA TRAWL FISHERY PRODUCTION
FOODFISH
FLATFISH
PACIFIC COD
ALL FOODFISH SPECIES
INDUSTRIAL FISH
DOGFISH
ANIMAL FOOD
TOTAL INDUSTRIAL FISH
MILLIONS OF POUNDS
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
0
10
20
30
40
50

Figure 1

Main landings of Pacific cod were, as in previous years, from Hecate Strait waters. The growing, but still moderate interest in the fishery for Pacific ocean perch by Canadian vessels resulted in landings of over 5.2 million lb in 1966, an increase of over 40% above the 1965 landings. The bulk (98%) of the Pacific ocean perch catch was taken from grounds in Queen Charlotte Sound. Landings of flatfish by British Columbia trawlers in 1966, at 10.9 million lb, were 58% greater than in 1965 and the increase was due entirely to increased landings of rock sole, total catch of which was 7.2 million lb. Total catch of trawl-caught lingcod, at 4.3 million lb was the highest ever taken by the trawl fleet and was taken primarily from grounds off the west coast of Vancouver Island. Landings of species of fish used for animal food, at 4.8 million lb, were slightly above the level which prevailed in the preceding three years, but slightly below the mean landing for the 1956-65 period. Catch by species, for major geographic divisions in 1966, is shown in Table II (see Fig. 2 for boundaries of divisions).

Routine sampling of groundfish landings at various ports continued to be an important function of the near-seas investigation. In all, 441 samples were taken in 1966 and these consisted of approximately 38,200 otoliths with length measurements and sex, and a further 64,900 length measurements alone. Details of the sampling by species by area are shown in Table III. An inventory of sampling conducted during the years 1946-65 by the investigation has been published in a circular (Statistical Series No. 24). The inventory showed that about 1.1 million fish had been sampled in this 20-year period, with emphasis on species of major importance.

COORDINATION OF CATCH AND EFFORT STATISTICS OF THE PACIFIC COAST

Statistics of catch and effort for the Pacific coast trawl fishery are exchanged with United States agencies on the Pacific coast through the Technical Sub-Committee of the International Trawl Fishery Committee. The statistics are subsequently published by the Pacific Marine Fisheries Commission according to major geographic divisions which, for the British Columbia coast, are shown in Fig. 2. However, catch by nationals in each area is not separated in PMFC statistics and United States statistics must be obtained either by subtraction of Canadian data from the total or through the cooperation of State agencies. A circular (Statistical Series No. 28) has been prepared showing comparative Canadian and United States trawl catches for the years 1954-65 from the areas jointly exploited.

In 1965, the total trawl catch by Canadian and United States vessels from Areas 3B to 5D inclusive was about 97 million lb or about 47% above the 1954-64 average. Contributing greatly to this increased catch were landings of Pacific cod which exceeded 34 million lb in 1965, almost double the mean catch for this species for the 12-year period.

During the period 1954-63 inclusive, Canada's share of the production from the grounds jointly exploited averaged about 24.5 million lb (36% of

Table II. Landings of trawl-caught groundfish in British Columbia in 1966 by species, by major geographic areas (in 1,000's of pounds).

Species	Strait of Georgia	Lower west coast Vancouver Is.	Upper west coast Vancouver Is.	Lower Queen Charlotte Sd.	Upper Queen Charlotte Sd.	Lower Hecate St.	Upper Hecate St.	West coast Queen Charlotte Is.	Alaska	Total
	4B	3C	3D	5A	5B	5C	5D	5E	6	
English sole	408.5	23.5	1.0	7.5	7.0	70.5	725.0	..	..	1,243.0
Rock sole	66.5	314.0	130.0	576.5	607.0	2,171.0	3,369.5	..	..	7,234.5
Petrale sole	3.5	260.5	122.0	169.5	174.0	391.5	181.0	..	..	1,302.0
Dover sole	255.5	7.5	1.5	40.0	50.0	3.5	145.5	..	..	503.5
Rex sole	6.0	10.0	..	0.5	0.5	1.0	3.0	..	..	21.0
Starry flounder	35.0	50.0	2.0	..	0.5	2.5	63.0	..	..	153.0
Other flatfish	7.0	50.0	..	52.5	..	..	348.0	..	..	457.5
Pacific true cod	649.5	3,949.5	997.5	888.5	492.0	9,394.0	10,432.0	..	..	26,803.0
Lingcod	117.0	1,559.5	1,103.5	596.0	388.0	338.0	234.5	..	..	4,336.5
Sablefish	12.5	203.5	5.0	26.5	40.0	7.0	388.5	..	1.0	684.0
Pacific ocean perch	2.0	5.0	..	1,721.5	3,484.5	1.0	1.5	0.5	1.0	5,217.0
Other rockfish	132.0	45.5	24.0	119.5	167.5	8.0	45.0	..	..	541.5
Misc. species	48.0	41.5	2.0	5.5	1.0	9.5	43.5	..	..	151.0
Dogfish	369.0	1.0	..	..	..	..	..	..	..	370.0
Animal food	1,042.5	252.0	31.0	407.5	128.5	249.0	2,739.0	..	tr	4,849.5
Reduction	..	9.0	..	28.5	188.0	396.5	61.5	..	..	683.5
Total landing	3,154.5	6,782.0	2,419.5	4,640.0	5,728.5	13,043.0	18,780.5	0.5	2.0	54,550.5
1956-65 mean	4,660.0	4,206.0	542.0	3,024.0	2,709.0	2,750.0	9,743.0	..	..	27,634.0
Total hours	5,246	5,495	1,393	2,526	2,223	3,722	7,500	1	18	28,124
1956-65 mean effort	10,589	3,881	551	2,266	1,987	1,214	5,084	..	..	25,572

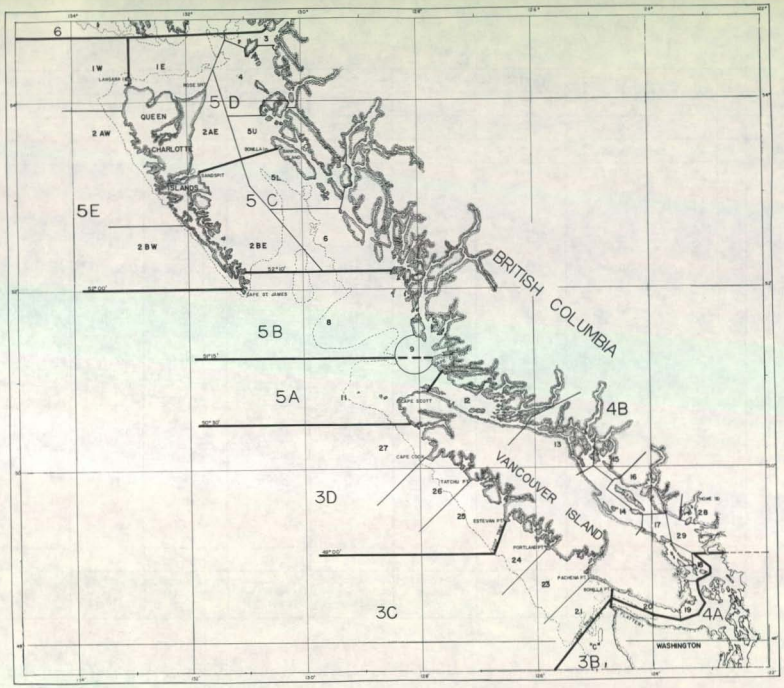

Fig. 2. Statistical areas fished by Canadian and United States vessels off the British Columbia coast.

Table III. Number of samples collected from British Columbia trawl landings in 1966 and in 1965 (brackets).

Species \ Area	4B	3C	3D	5A	5B	5C	5D	Total
Pac. true cod	11(13)	44(21)	27 (9)	22 (7)	4 (8)	30(25)	41(55)	179(138)
English sole	19(14)	..	1	1	..	1	9(11)	31 (25)
Rock sole	1 (2)	1	6 (2)	18 (7)	10 (8)	20(12)	30 (2)	86 (33)
Petrale sole	..	7(12)	8 (7)	6 (2)	3 (3)	3 (6)	2 (3)	29 (33)
Butter sole	..	..	..	..	..	..	2 (4)	2 (4)
Other flatfish	(2)	2 (2)	..	..	..	..	3 (1)	5 (5)
Starry flounder	3	3	..	..	..	..	2	8
Turbot	..	2 (1)	..	2 (3)	..	..	1	5 (4)
Sablefish	(2)	7 (6)	4 (3)	2	..	..	8(13)*	21 (24)
Lingcod	3 (4)	16(17)	15(11)	12 (4)	5 (4)	2	2	55 (40)
Pac. ocean perch	(1)	..	..	6 (6)	12(12)	..	..	18 (19)
Dogfish	2	..	..	..	..	..	..	2
Dover sole	(3)	..	..	..	..	..	(1)	(4)
Total	39(41)	82(59)	61(32)	69(29)	34(35)	56(43)	100(90)	441(329)

*Most of these taken in Area 6 by line vessels.

the total). In 1964 and 1965 Canadian landings increased markedly over those in the preceding 10 years and her share of total production rose to 43% and 45% respectively (Table IV and Fig. 3). Canadian trawl production in 1966 has reached a new record high of 54.6 million lb and may help bring total production in 1966 from grounds off the British Columbia coast to a higher level than in 1965.

THE CONTROLLED TRAWL FISHERY OF THE STRAIT OF GEORGIA

The total catch of foodfish from areas in the Strait of Georgia where trawling periods are restricted by regulation amounted to 561,000 lb in the 1966-67 season. This catch was about 10% lower than the mean catch taken during the period from 1956-57 to 1965-66. Effort expended was 1052 hours, again less than for the previous 10 years. Catch per unit of effort of foodfish from the regulated areas in 1966-67 was 533 lb/hr as compared with the mean of 357 lb/hr in the previous 10 years.

Catch on specific grounds within the regulated areas during the October-March season of 1966-67 is shown in Table V. A large measure of the increased catch/effort in 1966-67 was due to increased abundance and availability of Pacific cod at Nanoose Bay. Total catch of cod from Nanoose Bay in February and March 1967 was about 219,000 lb and would have been much higher had there not been market limitations for that particular species. Despite the limitation the catch was the highest since 1959-60 and was accomplished with the lowest effort since the winter of 1948-49 (excluding 1965-66 when there was in effect no fishing at Nanoose Bay). Catch/effort of Pacific cod taken from Nanoose Bay in 1967 was 982 lb/hr, a substantially higher return than in any year for which there is record. In Union Bay, catch of English or lemon sole in 1966-67 (Oct.-Dec. 1966) was 55,400 lb, slightly greater than the 50,000 lb established as the desirable sustainable yield. Catch per unit of effort of English sole in that season, at 513 lb/hr was about the same as in 1965-66 and almost 50% greater than the mean for the preceding 5 years. Length-frequency distribution of English sole taken in the commercial fishery suggest that there was a slight increase in recruitment prior to the 1966 fishery.

At Cape Lazo, catches of English sole and Pacific cod during the 1966-67 open season were 75,000 lb and 50,000 lb respectively. These catches were close to the mean catch which prevailed in this area in the preceding five years.

CATCH AND CATCH/EFFORT FOR PARTICULAR SPECIES

1. Petrale sole

(a) Southern stock. Canadian catch of petrale sole from the stock off the lower west coast of Vancouver Island (Area 3C) in 1966 was 260,500 lb,

Table IV. Canadian and United States otter trawl production from waters adjacent to British Columbia (catch in 1000 lb).

Year	Canada	United States	Total	Percent Canadian
1954	20,017	39,052	59,069	33.9
1955	23,839	42,091	65,930	36.2
1956	28,079	47,114	75,193	37.3
1957	25,142	39,298	64,440	39.0
1958	25,739	42,330	68,069	37.8
1959	24,170	50,289	74,459	32.5
1960	25,989	42,685	68,674	37.8
1961	25,809	41,737	67,546	38.2
1962	24,457	44,829	69,286	35.3
1963	22,031	49,283	71,314	30.9
1964	32,262	42,933	75,195	42.9
1965	43,920	53,307	97,227	45.2
Mean 1954-64	25,231	43,786	69,016	36.5

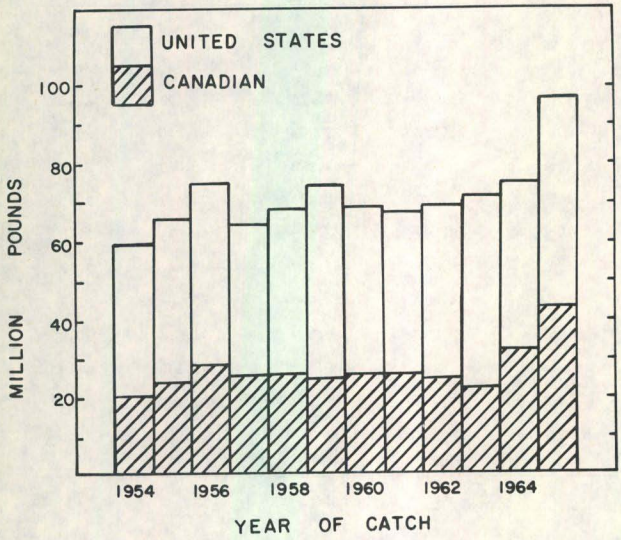

Fig. 3. Total production of trawl-caught groundfish by Canadian and United States vessels from Statistical areas 3B to 5D inclusive during the years 1954 to 1965.

Table V. Otter trawl landings (lb) from experimental areas in the Strait of Georgia
October 1966 to March 1967

Species / Hours of fishing	Cape Lazo	Union Bay	Yellow Rock	Qualicum Parksville	Nanoose Bay	Total
	469	108	225	27	223	1,052
English or lemon sole	75,261	55,448	33,322	3,600	1,940	169,571
Rock sole	19,470		13,866	2,400	877	36,613
Petrale sole	154		276	431		861
Starry flounder	1,063	1,221	14,054	2,780		19,118
Pacific cod	50,499	4,448	6,523	221	219,011	280,702
Lingcod	11,115	1,312	2,676	2,976	1,960	20,039
Sablefish	21				879	900
Rockfish	3,944	6,951	162	3,911	1,358	16,326
Dogfish	4,116		1,114		2,335	7,565
Other fish	3,979	1,666	2,508	441	628	9,222
Total foodfish	169,622	71,046	74,501	16,760	228,988	560,917
Catch per hour foodfish (lb)	362	658	331	621	1,027	533

little more than half that taken in 1965 and 33% less than the mean for the preceding 10 years. Average catch per effort, based on the performance of double-gear vessels (25-49 tons) during the period May to August, was 67 lb/hr, substantially lower than the 110 lb/hr observed in 1965 and the mean of 171 lb/hr for the previous 10 years (Table VI). Average length of female petrale sole in samples from the fishery decreased slightly in 1966.

(b) Northern stock. Landings of petrale sole from the northern stock (Areas 3D, 5A-5D) in 1966 at 1,038,000 lb were about 20% higher than in 1965 and almost double the mean catch for the preceding 10 years.

Catch/effort for the northern stock is obtained by weighting Canadian catch/effort in each of the Areas 5A to 5D by the total Canadian and United States catch in each area. In 1965, the most recent year for which data are available, the weighted average catch/effort of petrale sole was 119 lb/hr, substantially less than that of 1964 (180 lb/hr) and the mean for the previous 10 years (170 lb/hr).

Landings of petrale sole by British Columbia fishermen from the northern and southern stocks totalled 1.3 million lb in 1966, about the same as in 1965 and about one-third greater than the mean catch for the preceding 10 years.

2. Lingcod

Total Canadian trawl catch of lingcod in 1966 was just over 4.3 million lb, which was about one-half million lb greater than in 1965 and 75% greater than the mean for the previous 10 years (Table VII). Over 60% of the trawl catch was taken from grounds off the west coast of Vancouver Island, with 1.6 million lb from Area 3C and 1.1 million lb from Area 3D. The trawl catch of lingcod from Area 3C was almost 50% greater than the mean for the 1956-65 period. Catch/effort, based on catches by all vessels (with the qualification that the lingcod must have been 25% or more of the total landing) was 711 lb/hr in 1966. This was slightly lower than the 786 lb/hr which prevailed in 1965 and only slightly higher than the mean for the preceding 10 years (670 lb/hr). Length frequency distributions for the commercial fishery are shown in Fig. 4.

Catch of trawl-caught lingcod in waters off Cape Scott (Area 5A), at 1.5 million lb, was about 50% greater than in 1965 and 60% greater than the mean for 1956-65 (0.9 million lb).

The proportion of the annual catch of lingcod accounted for by trawlers in 1966 increased slightly to 61.7% (Table VIII).

3. Pacific cod

Pacific cod was again the dominant species in trawl catches in British Columbia in 1966 and total catch was 26.8 million lb - or about 10% greater than in 1965 and 2.7 times the mean catch for the 1956-65 period.

Table VI. Statistics of the petrale sole fishery in Area 3C.

Year	Catch		Catch per hour (Canadian)	Average length Canadian	
	United States and Canadian	Canadian		Males	Females
	(1000 lb)		(lb)	(mm)	(mm)
1956	1235	416	79	409	453
1957	1368	522	132	395	457
1958	1127	410	163	401	446
1959	2142	408	213	394	442
1960	1638	438	161	388	437
1961	2445	453	168	384	433
1962	1876	326	211	389	433
1963	1644	166	195	393	433
1964	1322	377	281	392	446
1965	1730	402	110	391	455
1966		261	67	392	446
Mean 1956-65	1653	392	171	394	444

Table VII. Statistics of the Canadian trawl fishery for lingcod.

Year	Total trawl catch all areas	Trawl catch Area 3C	C/E Area 3C
	(1000 lb)	(1000 lb)	(lb)
1956	2446	1584	696
1957	2173	1220	632
1958	2131	1093	751
1959	2469	797	634
1960	2422	1041	482
1961	2912	1556	643
1962	2095	494	476
1963	1433	435	722
1964	2826	940	878
1965	3840	1686	786
1966	4337	1560	711
Mean 1956-65	2475	1085	670

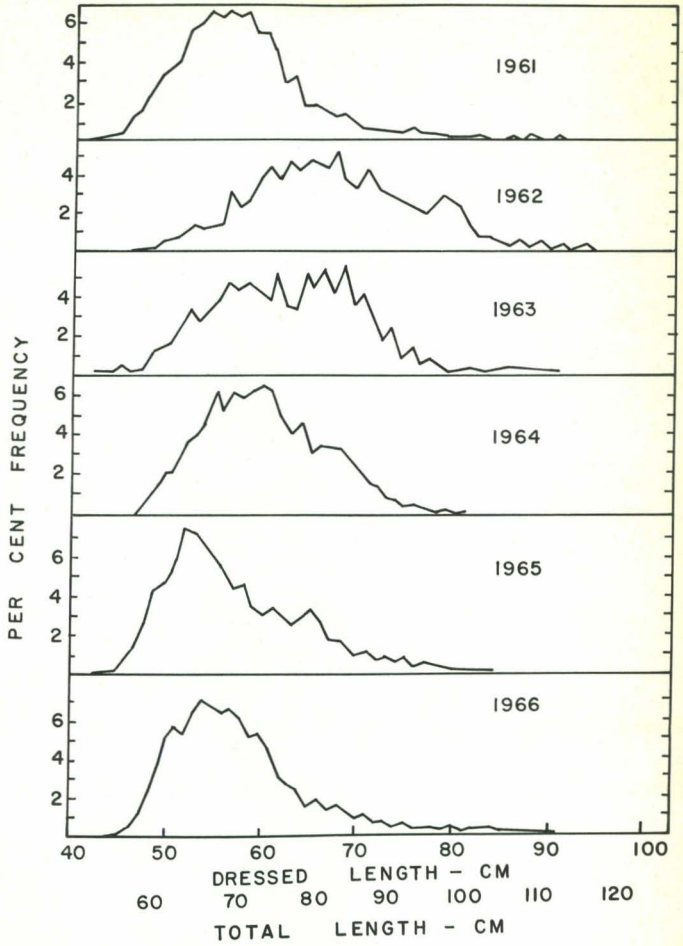

Fig. 4. Length frequency distributions of trawl-caught lingcod taken in Area 3C.

Table VIII. Percentage of lingcod taken by trawl gear as compared to that taken by line and other gear in British Columbia fisheries.

Year	Total catch (1000 lb)	Percentage taken by	
		Trawl gear	Other gear
Mean 1952-56	3896	29.2	70.8
Mean 1957-61	4461	37.8	62.2
1962	4309	34.9	65.1
1963	3196	29.7	70.3
1964	5340	51.8	48.2
1965	6379	60.2	39.8
1966	7028	61.7	38.3

The bulk of the catch, almost 20 million lb, was taken in Areas 5C and 5D and almost 4 million lb was taken in Area 3C.

A review of the trawl fishery for Pacific cod in British Columbia waters to and including 1966 and a forecast for 1967 has been prepared by Ketchen (1967). His summary suggests that annual variations in fishing success for cod on the offshore grounds are dependent on highly variable annual recruitment. Some cod broods (year classes) are much stronger than others and this is reflected in the average sizes of fish which comprise the annual landings. The technique for predicting success of fishing for Pacific cod is based on an observed relationship between size of fish landed in a given year and average fishing success in the succeeding year. Ketchen predicted, tentatively, that fishing success in Hecate Strait during 1967 would be below average to average, while that off the west coast of Vancouver Island would be above average to average. The prospects for the Queen Charlotte Sound cod fishery are uncertain.

Assessment of the validity of the prediction of 1967 may be made difficult because of two factors: (1) a labour dispute in early spring idled a high proportion of the British Columbia trawl fleet and (2) even before the labour dispute there was some indication of market difficulties when boats were placed on limits for Pacific cod landings.[a]

4. Pacific ocean perch

Landings of Pacific ocean perch by British Columbia trawlers in 1966 were about 5.2 million lb. This was about 70% greater than in 1965 and almost 6 times the mean annual catch taken during the 1956-65 period. The bulk of the catch was taken, as usual, in Queen Charlotte Sound (Areas 5A and 5B). Catch per unit of effort in the Canadian fishery is based on performance of double-gear vessels of 100 gross tons or over whose landing of Pacific ocean perch equalled 50% or more of the total vessel landing. The catch/effort in 1966 was 2800 lb/hr which was not appreciably different from that in 1965 but was almost 30% above the mean for the 1956-65 period. Intraseasonal statistics of the fishery during the past two years suggest that there is no apparent response (decrease) in stock to increasing catch by the Canadian fishery (Table IX). The continuing high catch/effort figures suggest (1) that British Columbia fishermen are still in the process of learning how and where to fish for ocean perch, or (2) that stock size is very large. The latter possibility does not seem improbable. The mean annual catch of Pacific ocean perch from Queen Charlotte Sound by Canadian and United States trawlers during the period 1961-65 has been about 7.0 million lb. However, the impact of this fishery on the resource was not sufficient to prevent the development of an active fishery by vessels from the Soviet Union in 1966 (see Ketchen (1967) for description of foreign fisheries in the northeastern Pacific).

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[a] The labour dispute which was between vessel owners and crew had an effect on trawl landings by mid-March and lasted through mid-July.

Table IX. Statistics of the Pacific ocean perch fishery by Canadians in Queen Charlotte Sound in 1965 and 1966.

Year & Month	Qualifying catch[a] 1000 lb	Number of trips	Hours fished	Days fished	Catch per hour lb	Catch per day lb
1965						
June	280	6	109	13.3	2,570	21,059
July	211	6	59	5.4	3,582	39,133
August	188	3	78	10.7	2,416	17,615
September	395	8	183	20.8	2,160	19,000
October	818	11	221	29.8	3,702	27,458
November	542	7	210	32.0	2,581	16,935
Total	2,434	41	860	112.0	2,832	21,743
1966						
June	759	7	199	22.5	3,812	33,717
July	136	6	65	9.3	2,088	14,592
August	711	10	260	31.1	2,733	22,847
September	735	9	290	33.6	2,534	21,871
October	1,113	12	389	52.9	2,862	21,043
November	599	10	244	34.5	2,456	17,369
Total	4,053	54	1,447	184.0	2,800	22,035

[a]See text for details of qualification.

5. English sole

In the summary report for the 1965 British Columbia trawl fishery, it was shown that the English sole fishery which had traditionally been conducted in northern Hecate Strait during the months of March to June, was becoming one of incidental importance when compared with the whole trawl fishery in that area (Forrester et al. 1966). This trend has continued in 1966 (Table X). Under these circumstances, assessment of the status of stocks is virtually impossible.

6. Rock sole

Catch of rock sole from northern Hecate Strait in 1966 was 3.4 million lb, almost three times the mean catch for the preceding five years. A high percentage (85%) of the catch was taken from the Two Peaks-Butterworth Rocks region of Area 5D. Catch per unit of effort in this region at 19,400 lb per day, was almost 20% higher than that which prevailed during the preceding five years. Catch/effort of rock sole in this particular fishery is estimated from double-gear vessels which fish the area during the period May to October inclusive and have 50% or more of rock sole in their landing for a trip.

TAGGING STUDIES

1. Tagging in 1966

Tagging in 1966 was confined to that conducted during the course of exploratory cruises sponsored by the Industrial Development Service and releases have been noted under special projects.

2. Tagging prior to 1966

Summaries of recoveries from the more recent large-scale taggings of petrale sole and lingcod off the lower west coast of Vancouver Island and Pacific cod in northern Hecate Strait are presented in tabular and pictorial form in Fig. 5-10.

Recoveries from the petrale sole taggings of 1962 and 1964 continue to show more extensive movement southward than to the north, but the bulk of recoveries have been in the general area of tagging. Recoveries from the lingcod tagging of 1964 again have been mainly from the area of tagging but movement where recorded has been predominately northward and one recovery has been returned from lower Hecate Strait. Extensive interchange between grounds has been shown by Pacific cod taggings in 1964 and 1965, but there has been little movement outside the major area of tagging.

A summary of results of English sole tagging in British Columbia waters has been prepared for inclusion in a forthcoming Pacific Marine Fisheries Commission Bulletin which will deal almost exclusively with English sole on the Pacific coast of North America. A summary of the MS follows:

Table X. Statistics of Pacific cod and sole catches in Area 5D.

Year	Effort (hrs)	Catch (1000 lb)			Percent of English sole taken Mar-June in minor area 4[a]
		Pacific cod	Sole species	English sole	
Mean 1955-59	4,200	2,522	3,424	1,022	74%
Mean 1960-64	5,400	3,973	2,868	1,098	62%
1965	6,900	12,321	2,181	751	54%
1966	7,500	10,432	4,835	725	28%

[a]Two Peaks-Butterworth Rocks region of Area 5D.

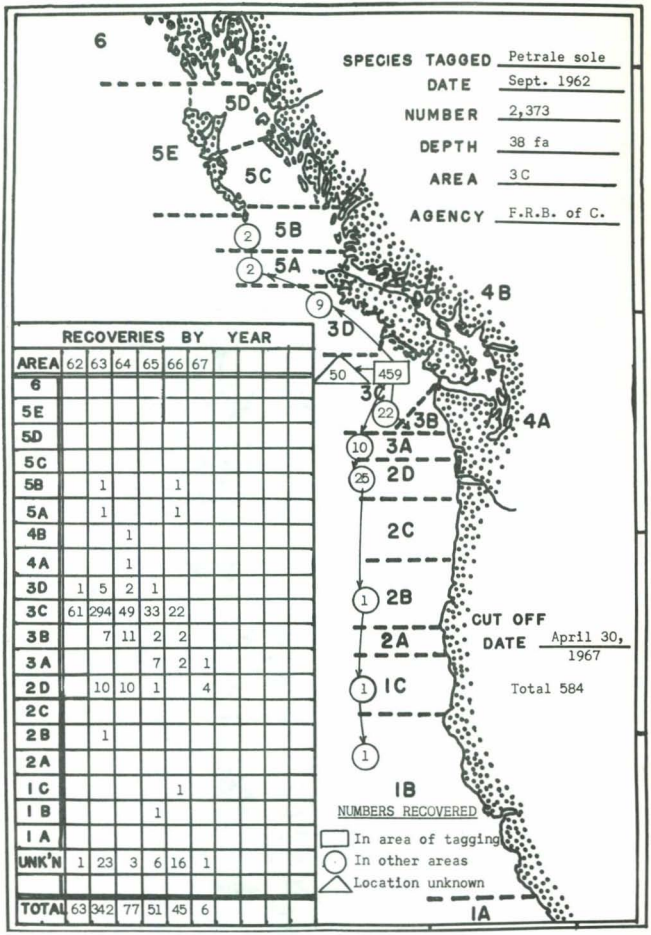


Fig. 5. Recovery pattern from a tagging of petrale sole conducted on the SW Corner of the Big Bank in September 1962.

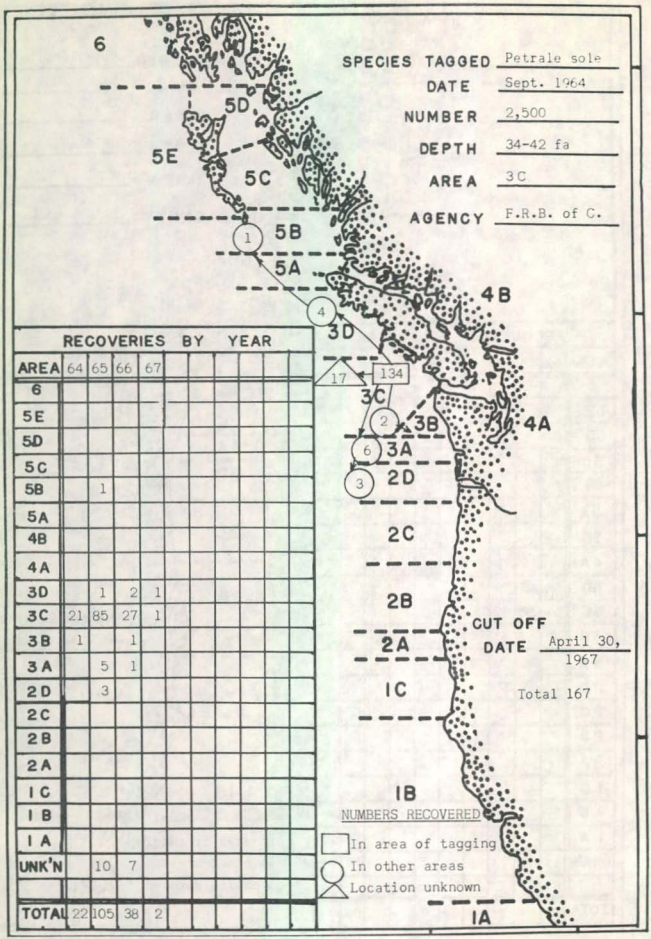
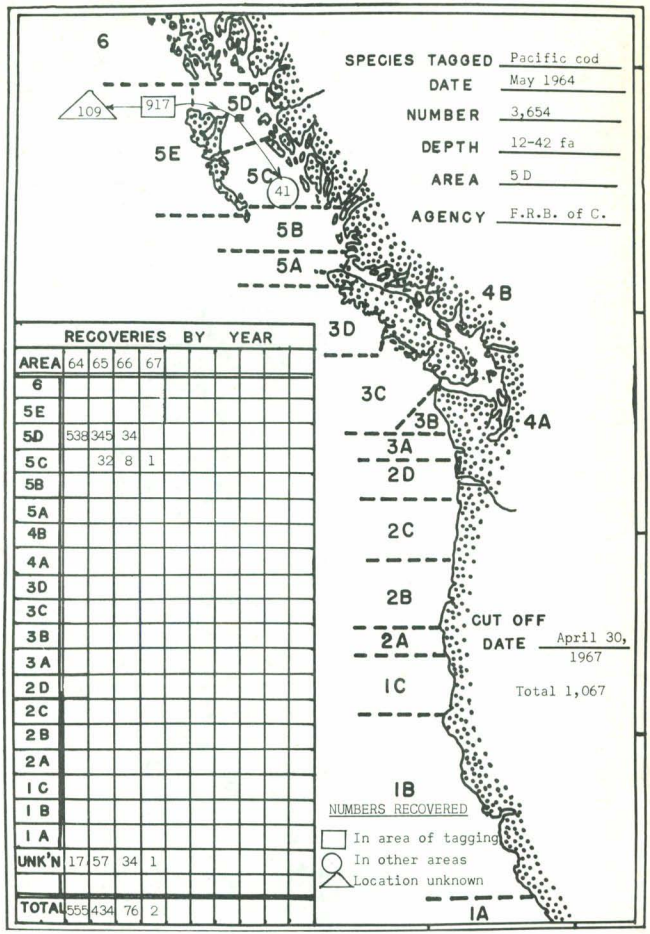


Fig. 6. Recovery pattern from a tagging of petrale sole conducted on the Japanese Island grounds in September 1964.



RECOVERIES BY YEAR

AREA	64	65	66	67
6				
5E				
5D	538	345	34	
5C		32	8	1
5B				
5A				
4B				
4A				
3D				
3C				
3B				
3A				
2D				
2C				
2B				
2A				
1C				
1B				
1A				
UNK'N	17	57	34	1
TOTAL	555	434	76	2

Fig. 7. Recovery pattern from a tagging of Pacific cod conducted in Northern Hecate Strait (Two Peaks-Butterworth Area) in

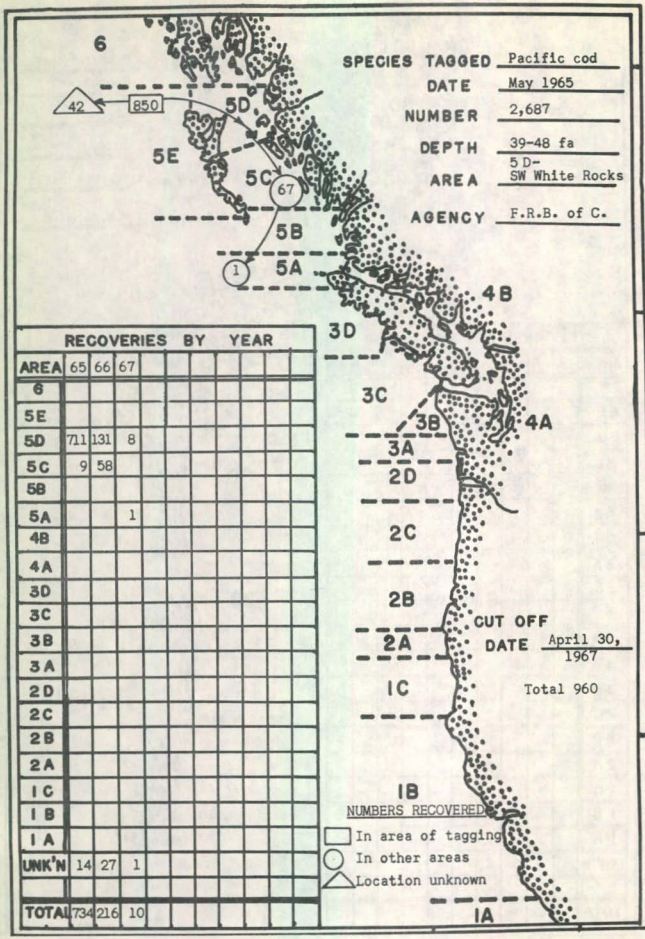


Fig. 8. Recovery pattern from a tagging of Pacific cod conducted in Northern Hecate Strait (SW of White Rocks) in May 1965.

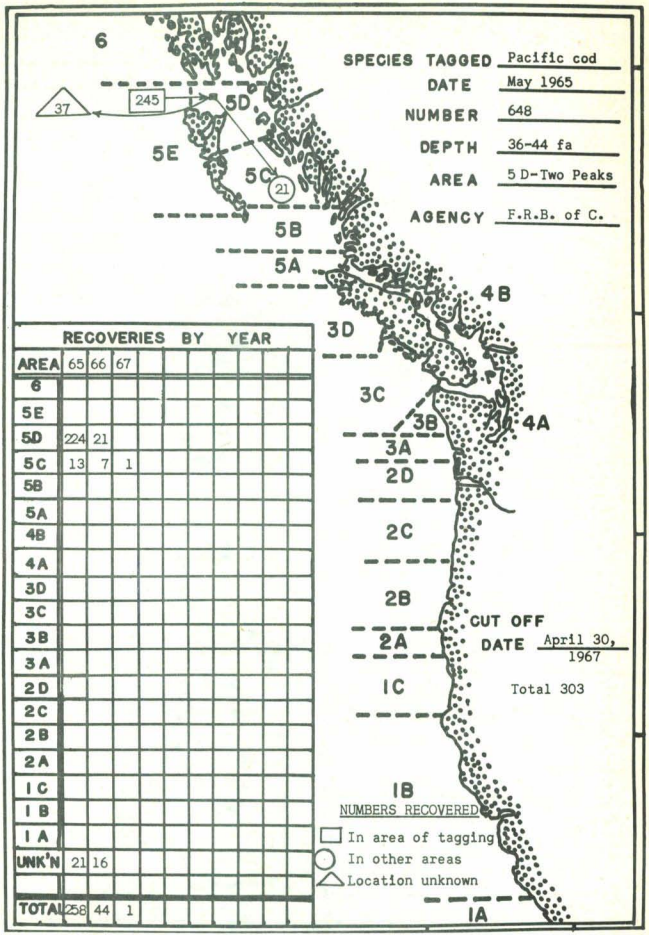


Fig. 9. Recovery pattern from a tagging of Pacific cod conducted in Northern Hecate Strait (Two Peaks) in May 1965.

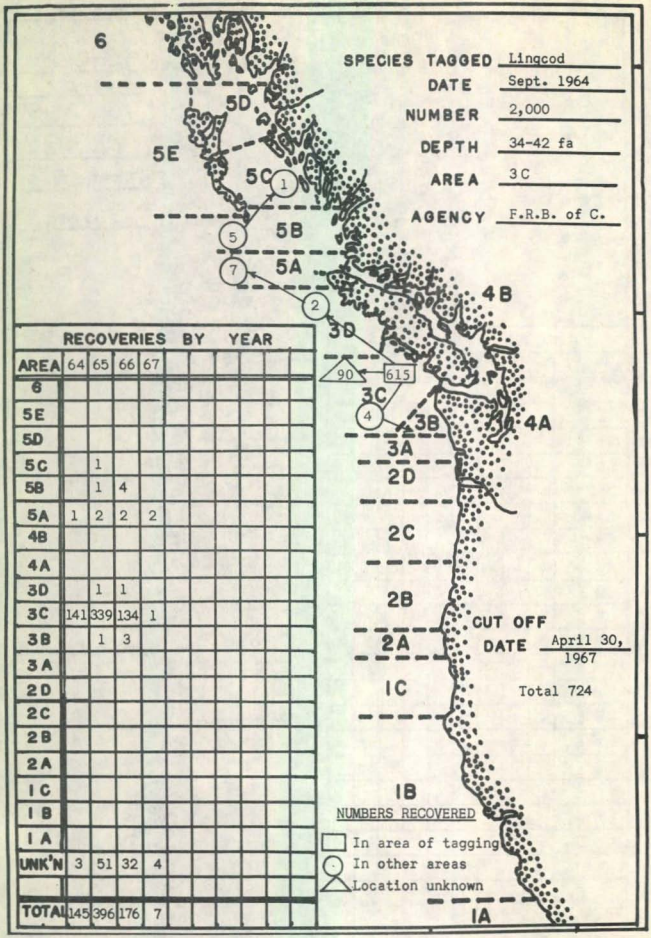


Fig. 10. Recovery pattern from a tagging of lingcod conducted on the Leppard Island grounds in September 1964.

a) Between 1944 and 1961, approximately 25,000 English sole were tagged and released in British Columbia waters. Most of the tagging took place in the Strait of Georgia and northern Hecate Strait, the principal areas for English sole.

b) Approximately 6500 recaptures (with usable information on locality) have been reported. Of these only 1.1% indicated movement to waters off the United States coast (exclusive of recoveries in the Strait of Georgia). Taggings conducted near the international boundary yielded the highest returns from United States waters, but none of these were in localities supporting significant Canadian fisheries.

c) Most of the recaptures off the open coast of the United States were in the region between Cape Flattery and Destruction Island, Washington, where spawning is known to occur in winter months.

d) Tagging results, supported by results of meristic studies and the geographical distribution of catch, suggest there are two major stocks of English sole in British Columbia waters: one in Hecate Strait and the other in the Strait of Georgia. Within the latter area there appear to be three substocks or populations. Minor populations occur in other regions of the coast, such as Queen Charlotte Sound and various coastal inlets.

e) In light of available information on water circulation, there is support in the tagging results for the hypothesis that the English sole engages in contranatant (upstream) migrations to various spawning areas.

LABORATORY EXPERIMENTS

In cooperation with the environmental changes investigation, further laboratory work was done on the embryonic development of certain groundfish species. Work on Pacific cod eggs in 1966 involved development as affected by variations in salinity, temperature and dissolved oxygen. Conditions for optimum response with respect to salinity and temperature were found to be about 19 °/oo S and 6 C. An optimum was not found for levels of dissolved oxygen, but it would appear to be at about saturation level. The study of development of English sole eggs as affected by salinity and temperature was completed in 1966 and results submitted for publication: an abstract of the MS (by Alderdice and Forrester) follows:

> Eggs of the English sole were incubated at a number of salinity-temperature conditions within the ranges of 10-40 °/oo S and 2-12 C. Temperatures of 2 C were lethal in all cases. Development time from fertilization to 50% hatch ranged from 3.5 days (12 C) to 11.8 days (4 C) and was shortest at salinities around 25 °/oo between 6-12 C. Larvae were classified as viable (normal) or abnormal on the basis of several subjective criteria.

Response surfaces were computed and salinity-temperature conditions were estimated at which responses were optimized, namely: larval size, 28.1 ‰, 7.9 C; total hatch, 25.6 ‰, 9.0 C; viable hatch, 25.9 ‰, 8.4 C. In general, optimum conditions for survival appear to be associated with salinities and temperatures of 25-28 ‰ and 8-9 C. Temperatures associated with the production of 50% viable hatch at optimum salinity conditions (25.9 ‰) are calculated to be about 4.5 and 12.5 C.

Incidental observations were obtained in several cases on egg density and oxygen consumption. At 30 ‰ S, 6 C, eggs floated for about 93% of the incubation period and sank prior to hatching. Salinities of neutral buoyancy of these eggs rose from 27.8 ‰ at fertilization to 30.8 ‰ at hatching. On the basis of oxygen consumption tests and calculation of rates of oxygen transfer to the eggs, it was concluded that rates of development were independent of oxygen availability in all tests.

Several inferences are drawn from the experimental evidence regarding effects of salinity and temperature on year-class strength. Over the geographic range of the species, salinity would appear to have little influence on egg viability. Temperature, however, may limit abundance at the north-south boundaries of the range of commercial exploitation and act as a lethal factor at the boundaries of geographic distribution.

Early in 1967 an attempt was made to hatch eggs of the petrale sole (Eopsetta jordani) obtained from fish which congregate for spawning in the "Estevan Deep" region off the west coast of Vancouver Island. Ripe eggs were fertilized on the west coast and transported to the laboratory at Nanaimo. Embryonic development was difficult to follow at all stages and while hatching did occur it was limited. Newly hatched larvae, which were about 2.9 mm in length, were virtually free of pigmentation. It is planned to continue the experiments in 1968.

SPECIAL PROJECTS

In 1966, the near-seas investigation undertook the planning and execution of an exploratory fishing program which was an extension of that conducted in 1965 and was sponsored by the Industrial Development Service of the Department of Fisheries. In conjunction with this program, investigators tagged approximately 650 petrale sole, 435 rock sole, 320 Pacific cod and 50 lingcod captured on grounds in Hecate Strait and Queen Charlotte Sound. A report on the results of this program in 1966 is being prepared for distribution to the industry.

PROGRESS IN PUBLICATION OF RESULTS

1. Published in 1966 and 1967 (up to May 1)

Allen, K. R., and C. R. Forrester. 1966. Observations on the appropriate size limit for the lemon sole (Parophrys vetulus) in the Strait of Georgia. J. Fish. Res. Bd. Canada 23(4): 511-520.

Davenport, D. 1966. Colour variant of bocaccio (Sebastodes paucispinis) in British Columbia waters. J. Fish. Res. Bd. Canada, 23(12): 1981.

Forrester, C. R. 1966. Length and age composition of petrale sole (Eopsetta jordani) in western Canadian waters. 1. Lower west coast of Vancouver Island (PMFC Area 3C). Circ. Stat. Ser. No. 17, Fish. Res. Bd. Canada, Nanaimo, B. C.

1966. Length and age composition of rock sole (Lepidopsetta bilineata) in western Canadian waters. 1. The Butterworth-Warrior area of Hecate Strait (PMFC Area 5D). Circ. Stat. Ser. No. 18, Fish. Res. Bd. Canada, Nanaimo, B. C.

1967. Trawl production by Canadian and United States vessels from grounds adjacent to British Columbia during the years 1954-65 inclusive. Circ. Stat. Ser. No. 28, Fish. Res. Bd. Canada, Nanaimo, B. C.

Forrester, C. R., and D. F. Alderdice. 1966. Some effects of salinity and temperature on embryonic development of the Pacific cod (Gadus macrocephalus). J. Fish. Res. Bd. Canada, 23(3): 319-340.

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Forrester, C. R., J. A. Thomson, and D. M. Holmberg. 1966. A summary report of the British Columbia trawl fishery in 1965 and some aspects of its investigation. MS. Rept. Biol., No. 872, 29 p.

Harling, W. R. 1966. Northern range extension record for the pygmy rockfish (Sebastodes wilsoni). J. Fish. Res. Bd. Canada, 23(12): 1967-1968.

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Holmberg, D. M. 1967. Catch and effort statistics of the British Columbia trawl fishery in 1966. Fish. Res. Bd. Canada, Tech. Rept. No. 7.

Ketchen, K. S. 1966. Fishery expert warns B.C. crisis looming. Financial Post, May 14.

1967. Recent developments in the domestic and foreign fisheries for groundfish in the northeast Pacific. Fish. Res. Bd. Canada, Nanaimo, B.C., Circ. No. 79, 7 p.

1967. A review of the trawl fishery for Pacific cod with a forecast for 1967. Fish. Res. Bd. Canada, Nanaimo, B. C., Circ. No. 78, 22 p.

Ketchen, K. S., and C. R. Forrester. 1966. Population dynamics of the petrale sole (Eopsetta jordani) in waters off Western Canada. Bull. Fish. Res. Bd. Canada, No. 153, 195 p.

Thomson, J. A., and D. M. Holmberg. 1966. British Columbia landings of trawl-caught groundfish by month, by major and minor statistical area, and total hours of effort by month, by major area. Vol. 14, 1965. Circ. Stat. Ser. No. 19, Fish. Res. Bd. Canada, Nanaimo, B. C.

Westrheim, S. J. 1966. Catch rates, size composition, and sex ratio of Pacific ocean perch (Sebastodes alutus) caught in the eastern north Pacific Ocean (Cape Spencer, Alaska, to Cape Blanco, Oregon) by the G.B. Reed, August-September, 1965. MS Rept. Biol. No. 867, 28 p.

1966. Catch rates, size composition, and sex ratio of Pacific ocean perch (Sebastodes alutus) caught in the eastern North Pacific Ocean by the G.B. Reed, January-March, 1963-65. MS Rept. Biol. No. 869, 17 p.

1966. Northern range extension records for two rockfish species (Sebastodes caurinus and S. elongatus). J. Fish. Res. Bd. Canada, 23(9): 1455-1456.

1966. Northern range extensions for three species of rockfish (Sebastodes flavidus, S. paucispinis, and S. pinniger) in the North Pacific Ocean. J. Fish. Res. Bd. Canada, 23(9): 1469-1471.

1966. Report on the trawling operations of the Canadian research vessel G.B. Reed from Queen Charlotte Sound, British Columbia, to Cape Spencer, Alaska, August 23 to September 7, 1965. Fish. Res. Bd. Canada, MS Rept. Biol. No. 890, 3 p.

1966. Report on the trawling operations of the Canadian research vessel G.B. Reed from Queen Charlotte Sound, British Columbia, to Sitka Sound, Alaska, August 24 to September 15, 1966. Fish. Res. Bd. Canada, MS Rept. Biol. No. 891, 3 p.

Westrheim, S. J., and T. F. Pletcher. 1966. First records of the twoline eelpout, Bothrocara brunneum, Greenland halibut, Reinhardtius hippoglossoides, and shortbelly rockfish, Sebastodes jordani, in British Columbia waters. J. Fish. Res. Bd. Canada, 23(2): 309-312.

2. Manuscripts in press or submitted for publication

Alderdice, D. F., and C. R. Forrester. Some effects of salinity and temperature on early development and survival of the English sole (Parophrys vetulus). Submitted: J. Fish. Res. Bd. Canada.

Forrester, C. R. English sole tagging in British Columbia waters. Submitted: Bull. Pac. Mar. Fish. Comm.

In press. The shrinkage factor in measurements of groundfish. J. Fish. Res. Bd. Canada.

Ketchen, K. S. In press. Length composition of Pacific cod (Gadus macrocephalus) in landings by Canadian trawlers, 1951-1966. Circ. Stat. Ser., Fish. Res. Bd. Canada, Nanaimo, B. C.

Ketchen, K. S., and D. M. Holmberg. In press. Catch statistics of the Canadian and United States trawl fishery for Pacific cod (Gadus macrocephalus), 1954-1965. Circ. Stat. Ser., Fish. Res. Bd. Canada, Nanaimo, B.C.

Lippa, E. J. R. In press. British Columbia trawlers and trawl gear (to 1964). MS Rept., Fish. Res. Bd. Canada.

Westrheim, S. J. In press. Groundfish cruise reports for the G.B. Reed, 1963-1966. Tech. Rept., Fish. Res. Bd. Canada.

In press. Research vessel trawl-caught sampling at sea. J. Fish. Res. Bd. Canada.

3. Manuscripts in preparation

Forrester, C. R., and J. A. Thomson. Studies of a stock of rock sole (Lepidopsetta bilineata) inhabiting northern Hecate Strait, British Columbia.

Ketchen, K. S. A comprehensive review of the dogfish in British Columbia waters. Bull. Fish. Res. Bd. Canada.

Thomson, J. A. Distribution of catch and effort in the British Columbia trawl fishery. MS Rept.

Results of exploratory fishing for groundfish in 1966. Fish. Res. Bd. Canada, Nanaimo, Circ.

Westrheim, S. J. Distribution, abundance and size composition of Pacific ocean perch (Sebastodes alutus) in the northeastern Pacific Ocean. J. Fish. Res. Bd. Canada.

Age determination, growth and mortality of Pacific ocean perch (Sebastodes alutus) in the northeastern Pacific. J. Fish. Res. Bd. Canada.

Westrheim, S. J., and H. Tsuyuki. Morphological and electrophoretic description of Sebastodes reedi, a new scorpoenid fish in the northeastern Pacific. J. Fish. Res. Bd. Canada.