675

FISHERIES RESEARCH BOARD OF CANADA

MANUSCRIPT REPORT SERIES

(BIOLOGICAL)

No. 675

TITLE

Survey of Canadian fisheries

AUTHORSHIP

Biologists of the Fisheries Research Board of Canada
and of the Provinces of British Columbia, Alberta,
Saskatchewan, Manitoba, Ontario, Quebec and Newfoundland

Compiled and edited by W. E. Ricker

Establishment

Office of the Chairman (Editor's Office)

Dated April, 1959

CONTENTS

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

INTRODUCTION

The pages to follow attempt to answer request for information on the present state, and the probable future development, of Canada's fisheries. Neither question is easy to answer.

Present Supplies

It is only for a few of the more intensively used fish stocks that a good estimate of the present supply can be made. However the present-day catch usually affords a firm basis on which some kind of estimate or guess can be constructed.

1. The usual method of estimating stock size is to obtain the best available estimate of the rate of removal of fish from the population. Divided into the catch, this provides a figure for total stock. For example, if the catch is 10 million pounds, and rate of exploitation is 25 per cent, the stock is 10/0.25 = 40 million pounds. More accurately, this was the stock at the start of the fishing season. If this season is short, then 30 million pounds are left at its end; growth and recruitment during the ensuing year will bring it up again. However, if fishing is done more or less continuously through the year, the stock on hand tends to be of a steady size. In that event, the stock size is estimated as the catch divided by the "instantaneous" rate of fishing.

Estimates of rate of removal (also called rate of exploitation or utilization), and of instantaneous rate of fishing, come from recoveries of tagged or marked fish, or from comparison of catch and escapement (for anadromous fishes, shellfish, etc.), or from cruder information when necessary.

2. When Canadian fishermen fish stocks that other countries also exploit, we usually have estimated the total supply, and have indicated the quantity being taken by the other nations. Although potentially the oceans of the world are open to Canadians, it has been necessary to restrict stock estimates to our coastal waters and adjacent offshore regions, plus any other part of the sea where we actually take the fish in question. On the east coast this has usually meant that statistical Subareas 2, 3 and 4 of the International Commission for the Northwest Atlantic Fisheries (ICNAF) are included. Subarea 5, off the New England coast, is not included except for scallops.

In the west, inshore waters and the region off British Columbia are included in all cases, with larger areas for the following species:

Halibut and blackcod: Willapa Bay, Washington, north and west to the Aleutian Islands (Areas 2 and 3 of the International Pacific Halibut Fisheries Commission).

Sockeye, pink and chum salmon: Waters off the British Columbia coast and the whole of the Strait of Juan de Fuca and Puget Sound. (For coho and spring salmon, see the text.)

Albacore and pilchards: In these British Columbia fisheries, which are currently inactive, our fishermen formerly made catches off Washington (pilchards) and south to central California (albacore).

In the Arctic we include stocks from the Alaska-Yukon boundary east to Cape Chidley and the western half of Davis Strait and Baffin Bay.

3. All commercially-important fish species are dealt with separately, and sometimes separate estimates are given for distinct segments of the stock. For each species, the best estimate of stock comes at the head of the diagnosis. Its basis is given in the text that follows, as are its qualifications, which are often serious. Occasionally we have been forced to run to cover with a qualitative word like "large", usually for pelagic or marginally usable species.

Future Supplies

To project the future is of course more difficult than to describe the present. Half a dozen or so important considerations guide the choice of each estimate of future landings.

1. Most important of all, perhaps, is the fact that a fish stock is decreased in abundance when man begins to use it, and the spawning stock (at least) must remain less numerous as long as an annual crop is to be removed. Without fishing, a stock becomes so dense that growth is slow and mortality is great, especially of eggs and young: growth and reproduction suffice only to compensate for natural losses, and there is no net surplus. A fishery, by reducing the density of the stock, creates the conditions necessary for production of a surplus harvestable annually. It increases rate of reproduction, or rate of growth, or both, by removing most of the large old fish--a process usually called "fishing up the accumulated stock". On the other hand, if the stock is reduced too much, eventually the annual production of a usable surplus declines. The best level of fishing is in between, where "maximum sustained yield" is obtained.

Thus we obtain two fundamental rules of fishery exploitation:

(a) If a stock is being used to less than capacity by reason of underfishing, more fishing will increase the sustained yield and at the same time decrease the size of the stock (or of the spawning stock, at least).

(b) If a stock is being used to less than capacity because of overfishing, less fishing will increase the sustained yield and at the same time increase the size of the stock.

It turns out that for a majority of our fisheries we have to make a prediction which superficially seems paradoxical: in future there will be a greater catch taken from a smaller stock.

2. The above rules define underfishing and overfishing in biological terms, not economic terms. In quite a number of fisheries it is impossible from an economic point of view to increase fishing to the point of maximum sustained yield, because monetary returns per unit cost would fall too low. In that event increased catch in future might arise from use of more economical gear, improved handling, new uses for the product, greater consumer demand, etc., which would be reflected in greater landings per fisherman or an increase in landed value per pound. Equally, a less favourable economic climate can reduce a fishery (e.g. eastern salt cod or western dogfish).

On the other hand, fishing of a preferred species can become intensive enough to reduce annual yield much below the sustainable maximum, without reducing the profitability of the fishery below what is economically bearable. In that event obtaining maximum sustained yield becomes possible only with some kind of non-economic regulation of the amount of fishing done: for example, by closures, size-limits, quotas, or restricted licensing. Granting of leases or property rights has been done in the case of some shellfish, where maximum yield is possible only on a "farming" basis, and the individual can profit in proportion to his own efforts.

3. Rules (a) and (b) under 1. above define the eventual or equilibrium effect of increasing or decreasing fishing. The immediate effect may be different. Increasing fishing always means a greater catch in the current year. Less fishing always decreases the current years's catch. These short-term effects tend to obscure the overall picture. For example, a given increase in fishing effort might give an immediate increase in catch sufficient to more than pay its cost, but after 2 or 3 years the catch--though perhaps still larger than originally--might fall to an equilibrium level that is uneconomic for that amount of fishing. Scarcely less painful is the situation where investigation has shown that less fishing will eventually increase yield, yet this increase can be realized only by reducing effort and, temporarily, catch as well.

4. Variations in climate are an important cause of change in size of fish stocks, hence of catch. Warming of the water along any coast permits invasion and establishment of warm-water species, and favours a retreat northward of cold-water species. Consequently the long-term prospects of some fisheries depend upon the ocean temperatures which will prevail 10, 25 or 50 years from now.

No secure predication can be made of the direction of climatic change. On the Atlantic coast there is some basis for believing that about 1960 the sea will begin to cool from its present unprecedented high, to the benefit of cool-water species like cod and salmon, and to the prejudice of summer visitors like tuna and swordfish. On the Pacific coast no basis for predictions is available, but recently mean temperature has risen a little, after falling sharply from 1940 to 1950.

Apart from long-term trends, in some instances the reproductive success of a species from year to year can be associated with the temperature prevailing. This knowledge serves as a basis for predicting catches, in a general way, for as many years ahead as it takes a brood to grow to the age at which it makes its maximum contribution to the fishery.

Whenever we do not understand very well the direction or the extent of the changes in stock to be expected from variation in environmental conditions--which is the usual situation--it is difficult to distinguish such changes from possible effects of fishing.

5. In addition to natural changes in environment, we must take into account man-made modifications: whether for better or for worse. Our anadromous fishes have been most susceptible to damage, and even where the physical cause is removed, it may be many years before stocks are restored to the size which gives maximum yield. The sockeye and pink salmon fisheries of the Fraser River are still far from completely recovered from an obstruction to their migration which dates back

to 1913. In these and similar instances predictions must take into account the future maximum yield and the rate at which it can be achieved. Less spectacular environmental changes due to logging, pollution, etc., have been considered as far as possible.

Not all changes are harmful. For example, domestic sewage, suitably handled, qualifies as a fertilizer and can increase fish stocks in fresh waters.

Man can also sometimes increase fish stocks by direct aids to production. For example, fishways surmounting natural obstacles, improvement of natural spawning facilities, artificial propagation, predator control, etc., will likely play increasing roles in future.

6. One of the greatest unknowns is the extent to which increasing demand, combined with research, enterprise and ingenuity will bring new fisheries into being. The rapid increase in population now taking place the world over cannot fail to produce a long-term increase in the demand for fish. Evidence of the effects of population on exploitation of fishery resources may be seen in the much larger landings made in Europe and Asia than are made in North America. Increasing demand will eventually bring more stocks of fish into use and we can confidently expect to share in such a development. Recent decades provide several examples of previously worthless fish being developed into major industries--for example, the rise of the Atlantic coast redfish fishery. The nature, importance and timing of such advances are, however, impossible to predict with any confidence. They involve the use of stocks about which little is now known, and usually also some break-through of technology (e.g. "fish-sticks") or else some major shift in economic trends. Beyond pointing to some of the currently unused stocks, we are unable to predict what may be very important contributions to our fisheries 25 years hence.

7. Some possibilities exist for introduction of useful new species into various Canadian waters. Likely possibilities will be mentioned briefly, but in general success is too uncertain to set any figure for a probable 1980 catch in the new environment.

Arrangement

The materials to follow are divided geographically into four primary divisions: Atlantic, Pacific, Arctic and Inland. Anadromous or partially anadromous species, some of which are caught both in the ocean and in fresh water, are treated only once--usually in the marine section.

Except for inland waters, the treatment is usually by kind of fish, rather than by fisheries as such; but even in the salt-water sections some minor species are grouped. The treatment of an important species is divided into two or more geographical areas when this seems convenient from the statistical or the biological point of view, but a general summary is always provided.

The statistics quoted usually include the latest figures available at time of writing, though the cut-off may be at the end of 1953, 1954 or 1955, or of some fiscal year in different places. The term "present catch" or "average catch" is to be taken as the 1951-54 average, unless otherwise qualified.

A T L A N T I C R E G I O N

COD - Gadus callarias

Present stock:	6,800,000,000 lb.	Utilization by Canada:	710,000,000 lb.
		" " others:	400,000,000 lb.
Stock in 1980:	6,500,000,000 lb.	Utilization by Canada:	850,000,000 lb.
		" " others:	520,000,000 lb.

The cod occurs along the northwest Atlantic coast and on offshore banks from Baffin Island and West Greenland south to Cape Hatteras. It is most abundant and provides commercial fisheries from Nantucket shores to Northern Labrador, the most important of which are in Subareas 3 and 4 of the International Commission for the Northwest Atlantic Fisheries. It is the most abundant of the groundfish.

Although a bottom feeder, it may be found anywhere from the surface to 250 fathoms. It prefers a definite range of temperature which varies with the locality and season. Best catches are made at bottom temperatures ranging from 32° F. to 40° F. while smaller catches are made in waters of up to 50° F. A great many populations of cod, both resident and migratory, have been recognized from differences in vertebral counts, tagging, rates of growth and incidence of parasitization. Movements of cod schools on- and off-shore and from bank to bank are seasonal, and may be due in large part to temperature influences, the presence or absence of food and the search for suitable spawning conditions.

Spawning takes place in inshore waters and over the banks in the late winter and spring months, except in the Gulf of St. Lawrence where it is in the summer months. A single female may produce as many as 10,000,000 eggs which float and develop at or near the surface. Growth is faster in the warmer waters to the south and slower in the colder waters to the north.

Cod enter the commercial fishery in quantity at about 4 years of age. Greatest proportion of the commercial catch in Canadian Atlantic waters is made up of cod 4 to 9 years of age.

ICNAF Subareas 2 and 3

Present stock:	5,600,000,000 lb.	Utilization by Canada:	500,000,000 lb.
		" " others:	300,000,000 lb.
Stock in 1980:	5,000,000,000 lb.	Utilization by Canada:	600,000,000 lb.
		" " others:	400,000,000 lb.

History

The cod fishery of the Newfoundland and Labrador banks is the oldest non-indigenous fishery in Canada, or in America. Figures for Newfoundland exports of salt cod show a fairly large production already about 1800 (600,000 dried quintals, corresponding to about 300 million pounds of round fish). There was gradual rise through the 19th century to a peak of nearly 1,800,000 quintals during World War I, and a decline since that time almost to the level of 1800.

Participation by European countries in the Subarea 3 fishery has increased rapidly since World War II, so that they now take about half the catch. Since 1951 they have also taken considerable quantities in Subarea 2, whereas Canada has largely withdrawn from there.

Formerly the European fleet fished entirely in the offshore area. In the past three or four years European boats have increasingly fished the Newfoundland inshore areas in spring and fall. Here the three-mile limit offers very little protection at these seasons. Increased European fishing on the newly-discovered longlining grounds of the Newfoundland northeast coast is to be expected. The first serious inroads of this fleet on these grounds occurred in the Trinity Bay area in the autumn of 1955.

Average yearly production by Canada and by other countries since 1930 is shown below, in millions of pounds round weight:

	Subarea 2			Subarea 3			Both
	Canada	Others	Total	Canada	Others	Total	Subareas
1931-35	140	0.2	140	465	96	561	701
1936-40	145	..	145	433	126	559	704
1941-45	95	..	95	454	23	477	572
1946-50	76	..	76	550	238	788	864
1951	62	8	70	501	289	790	860
1952	38	125	163	462	327	789	952
1953	25	223	248	469	315	784	1032
1954	26	14	40	559	225	884	924

The Newfoundland portion of the Canadian landings for 1931-35 is actually for the period July 1, 1930 to June 30, 1935, the Newfoundland statistics for this period having been compiled by fiscal years. The totals for "Others", Subarea 3, are estimates in some cases. For some years, European statistics had no area totals, so that breakdowns have been made on the basis of known years.

The great bulk of the Canadian catch is landed in Newfoundland; mainland landings from these Subareas in recent years have been 40-60 million pounds, practically all from Subarea 3.

Present Status

In recent years both the Newfoundland catch and the whole Canadian catch in Subareas 2 and 3 have continued to decline in total amount, and also in importance relative to the European catches--which have been increasing. A rise in the Canadian catch in 1954 was purely temporary, due to unusually favourable hydrographic conditions in the inshore area in that year. The catch in 1955 has declined.

The decrease in our cod catch has been due to a fall in the production of salt cod. The fresh fish fishery has increased, but not as rapidly as salt fish industry has declined. European nations have a lower wage and cost standard, and have many ways of subsidizing the fishermen and the ships so as to maintain their fishing crews and fleet. Having control of their imports of salted fish, and with

salt fish a very important part of their protein diet, they regulate imports and the price of salt fish to the advantage of their own salt fish producers and consumers, and to the disadvantage of other producing countries.

As regards supplies, the stocks adjacent to Newfoundland and on the Subarea 3 banks are probably only moderately exploited at present, even by all the nations involved. Preliminary evidence from age determinations suggests a total mortality rate of 35 per cent per year. About half of this, say 18 per cent, may be fishing mortality, or 0.22 on the instantaneous basis. Applying this to the Subarea 3 catch gives an estimated stock of 800/0.22 = 3600 million pounds.

In Subarea 2 the rate of exploitation is much less, say 6 per cent recently, at a guess. Applied to an average catch of 130 million pounds in 1951-54, this implies a stock of about 2,000 million pounds.

Future Prospects

Since the production of salted fish by present methods is only possible on the basis of a very low landed value for the raw material, it is probable that the production of salted fish and particularly of light-salted fish in the Newfoundland area will continue to decline in the immediate future. On the other hand, production of fresh fish, and of salt fish with the assistance of mechanical driers, is expected to increase.

There is no likelihood of overutilization of these cod stocks within 25 years, though we cannot foresee the plans of other nations. Various European countries have the will and the means to subsidize the production of salted cod, directly and indirectly, so that it is likely their production of cod in the area will be maintained or will increase. Canadian policy on salted fish has not yet applied an effective brake to declining production. Traditional methods of handling the fish are too laborious to provide reasonable income to fishermen, without subsidies. Some mechanization of the industry has started, but this is not yet a very important factor in production.

Judging by haddock and by the cod in the Norwegian area, it is possible that the Subarea 3 cod fishery could be maintained at at least twice the present yield, with a total mortality rate of up to 50 per cent or more per year. This, however, would result in some reduction in size of the stock and also in the size of the individual fish. Cod of the smaller sizes would be suitable for filleting, but are not quite so suitable for salting as are larger ones.

If markets were available, if landed price were a little higher, if the Labrador stocks were used fully, and if Canadians entered the offshore fishery vigorously, the present total Canadian catch in Subareas 2 and 3 could be doubled. However this seems unlikely to happen within 25 years. The most realistic prediction is that our catch will at first decline somewhat due to the reduction in fish salted, and then gradually come back and rise to say 20 per cent above the present level by 1980, mainly because of increased use of cod for filleting. This forecast presupposes that the competition of the European fleet does not become too much greater than at present.

ICNAF Subarea 4

Present stock:	1,200,000,000 lb.	Utilization by Canada:	210,000,000 lb.
		" " others:	100,000,000 lb.
		(based on 1953-54)	
Stock in 1980:	1,500,000,000 lb.	Utilization by Canada:	250,000,000 lb.
		" " others:	120,000,000 lb.

History and Present Status

In Subarea 4, cod are common at the mouth of the Bay of Fundy, on inshore and offshore Nova Scotian grounds, and throughout the Gulf of St. Lawrence. The southern populations off western Nova Scotia have rapid growth and high fishing mortality. The northern populations in the Gulf of St. Lawrence have slower growth and lower fishing mortality.

Best available statistics of the Subarea 4 catch are from (6), in millions of pounds:

	Canada		Others		
	Mainland	Nfld.	U.S.A.	Europe	Total
1931-35	183(33-35)	18	47	?	248+
1936-40	172	10	55	?	237+
1941-45	246	16	43	?	305+
1946-50	275	17	18	?	310+
1951	225	26	10	?	261+
1952	227	39	13	?	279+
1953	166	38	8	115	327
1954	177	38	8	80	303

The annual yield has varied from 210 to 430 million pounds (all countries). In 1954, the yield was 300 million pounds. The high landings in 1945 (430 million) were taken from a stock of cod which had increased in weight because of reduced fishing during war years. The post-war decrease in landings is attributed to a reduced stock of cod resulting from increased use of otter trawlers, and in lesser degree, probably, to higher water temperatures.

The Canadian share of the catch has varied from 145 to 350 million pounds during the period 1933 to 1954. Canada took most of the catch during war years. In 1954, European and United States trawlers reported 80 and 8 million pounds, respectively, and Canadian landings were only 215 million pounds. However there is a possibility that reported catches by one or more European countries are substantially higher than their actual catches.

The stock of cod in Subarea 4 is estimated to be approximately 1,200 million pounds, corresponding to an average rate of utilization of 25 per cent in 1954. About 300 million pounds could be taken annually on a sustained yield basis.

Future Prospects

It is predicted that the cod stock in Subarea 4 will increase about 15 per cent during the next 25 years. A reversal of the trend towards higher temperatures will help to reverse the current downward trend in stock and landings. Wise use of the resource through large-mesh trawls and limited fishing intensity will also result in a larger stock. Landings of about 370 million pounds may be anticipated 25 years from now. By improving fishing methods and quality of products, Canada should continue to take the greatest share of the catch. Canadian landings of about 250 million pounds may be expected 25 years from now.

References

(1) Martin, W.R. 1953. Identification of major groundfish stocks in Subarea 4 of Northwest Atlantic Convention Area. ICNAF, Annual Proceedings, 3: 57-62.

(2) McKenzie, R.A. 1956 (in press). Atlantic cod tagging off the southern Canadian mainland. Bull. Fish. Res. Bd. Canada.

(3) McKenzie, R.A., and G.F.M. Smith. 1955. Atlantic cod populations along the southern Canadian mainland as shown by vertebral count studies. J. Fish. Res. Bd. Canada, 12(5): 698-705.

(4) Thompson, Harold. 1943. A biological and economic study of cod (*Gadus callarias*, L.) in the Newfoundland area. Newfoundland Biol. Sta., Res. Bull. No. 14, 160 pp.

(5) Sette, Oscar E. 1928. Statistics of the catch of cod off the east coast of North America to 1926. U.S. Bureau of Fisheries, Document No. 1034.

(6) Statistical Reports of the International Commission for the Northwest Atlantic Fisheries.

HADDOCK - Melanogrammus aeglefinus

Present stock:	480,000,000 lb.	Utilization by Canada:	112,000,000 lb.
		" " others:	90,000,000 lb.
		(1953-54 basis)	
Stock in 1980:	340,000,000 lb.	Utilization by Canada:	95,000,000 lb.
		" " others:	70,000,000 lb.

The haddock is common along the northwest Atlantic coast from the southern part of the Grand Banks to Cape Cod. It is normally found in quantities in warmer waters than cod.

The centre of abundance and of the commercial fishery in Canadian Atlantic waters is in the inshore and offshore waters of Nova Scotia. In the Gulf of St. Lawrence it is only found in very small quantities in the southwestern portion. It is more restricted to the bottom than cod. This tends to delimit the various haddock populations even more sharply than cod populations in Canadian Atlantic waters (1, 3, 4, 6). Growth is faster in the southern area than in the northern. Relative strength of year-classes varies widely in haddock, causing fluctuations in the stocks. Maturity is reached at 4 and 5 years of age. The fishery is made up mainly of 4 to 7 year olds.

Subarea 3

Present stock:	240,000,000 lb.	Utilization by Canada:	50,000,000 lb.
		" " others:	50,000,000 lb.
		(1953-54 basis)	
Stock in 1980:	120,000,000 lb.	Utilization by Canada:	25,000,000 lb.
		" " others:	25,000,000 lb.

History

Haddock are at the northern limit of their occurrence in commercial quantities in the southern part of Subarea 3. Consequently their abundance is to a considerable extent at the mercy of climatic trends.

To-day there are two haddock stocks of commercial importance in Subarea 3--the Grand Bank and the St. Pierre Bank stock. The fishery on both of these grew to significant proportions about 1946, though earlier small quantities had been landed. The peak catch was 147 million pounds in 1949. Recent figures, in millions of pounds round weight, are as follows, mostly from (2):

	Average yearly landings		
	Canada	Others	Total
1927-30	0.3	5	5.3
1931-35	1	5	6
1936-40	1	1	2
1941-45	1	4	5
1946-50	23	67	90
1951	9	84	93
1952	17	71	88
1953	31	52	83
1954	73	49	122

The Newfoundland portion of the Canadian landings up to 1935 are exports for the fiscal years ending June 30; from 1936 onward they are for the calendar year. Some of the totals for "Others" are not exact, for the European statistics had not been compiled by area and breakdowns were made on the basis of known years.

Although it seems clear that haddock have become more numerous in recent years, the catches taken in the 1930's do not reflect the size of the stock available then. At that time most interest in Newfoundland centered around salt fish. Haddock were considered too small to make a good salted product, and were not fished intensively.

Present Status

The principal countries which harvest haddock in Subarea 3 are Canada and Spain. Until the past year or two Spanish vessels caught most of the haddock in the area. However, in 1954 and 1955 the Canadian trade, particularly in Newfoundland, by machine filleting was able to utilize smaller haddock and there was an exceedingly abundant stock of haddock on St. Pierre Bank, close to the Newfoundland plants. A further economy consisted of landing most of these small haddock round. The Canadian catch rose in 1953 to 38 per cent and in 1954 to 60 per cent of the total, and in 1955 there was a further increase.

Most of the Canadian catch is landed in Newfoundland, but an appreciable portion (17,000,000 lb. in 1954) goes to mainland ports.

The rate of total mortality of vulnerable (full-recruited) fish in these stocks is about 50 per cent per year, about 30 per cent from fishing and 20 per cent natural. On an instantaneous basis the total is 0.70 and the rate of fishing 0.42. Applying the latter to an average catch of 100 million pounds means that the stock present recently has been about 240 million pounds. However both the St. Pierre and Grand Bank stocks receive important new year-classes of recruits only every 3 or 4 years, and recent catches have been almost entirely from the very large 1949 year-class. So far, each year's removals and losses have largely been made up by growth of the survivors, but the end is in sight for this brood.

Future Prospects

The 1949 year-class will yield at a decreasing rate for a few years more. In addition to the decrease in stock density, the individual fish are now large enough for the Spanish fleet to catch considerable amounts, and they will probably take an increasing share in 1956 and 1957. Hence the Canadian harvest will likely decrease somewhat in the years immediately ahead, until a new major year-class enters the fishery.

In general, if stocks remain as in the past decade, the amounts caught by Canada will largely depend on mesh sizes and the possibility of utilization of small fish. If very large mesh sizes are prescribed, the advantage will return to the Spanish salt-fishing fleet. Another complication is the continued presence in the area, and concentrating on haddock, of the Scottish factory ship the Fairtry. Any considerable economic success of this kind of fishing, followed by an increase in factory ships, would present formidable new competition.

Over a longer period, the prospects for Subarea 3 haddock are for moderate but fluctuating yield. It is likely, though not proven, that much of the increase in haddock stocks in Subarea 3 was a result of warming of the ocean since the late 1920's. The immediate prediction of a few more warm years will probably permit one or two additional excellent spawnings. However, the subsequent return to cooler temperatures, if it does occur and if it continues to 1980, could reduce the stock and catch considerably. For our best forecast we have taken the moderate view that average supplies will be reduced by 1980, but only to 120 million pounds --about half of the present, and that Canada will then take half of the harvest, or 25 million pounds.

Subarea 4

Present stock:	240,000,000 lb.	Utilization by Canada:	62,000,000 lb.
		" " others:	40,000,000 lb.
		(1953-54 basis)	
Stock in 1980:	220,000,000 lb.	Utilization by Canada:	70,000,000 lb.
		" " others:	45,000,000 lb.

History

Haddock has long been a popular food fish in eastern Canada and the United States. It ranks second in importance among the groundfish of Subarea 4. It is found in the Bay of Fundy, on inshore and offshore Nova Scotia grounds, and in the southern part of the Gulf of St. Lawrence. A number of stocks of haddock are found in Subarea 4, all distinct from those of Subareas 3 and 5, and largely distinct from each other. About 75 per cent of to-day's landings are taken by otter trawl, but line fishing for haddock continues to be important in Canada.

Landings in the recent period are shown below, in millions of pounds round weight:

	Canada	U.S.A.	European	Total
1931-35	40	67	?	107+
1936-40	46	54	?	100+
1941-45	34	29	?	63+
1946-50	48	37	?	85+
1951	64	37	?	101+
1952	60	54	?	114+
1953	56	40	1	97
1954	69	39	0	108

European catches have always been small.

The total annual yield has varied from 50 to 155 million pounds during the past 25 years. During the long early history of line fishing, Canadian landings exceeded those of the United States. In the early 1930's an accumulated stock of haddock was removed when the United States trawler fleet expanded rapidly, and

their catch at that time exceeded ours. With reduced fishing during war years, landings of both countries dropped to a lower level. Increasing landings during the post-war period are attributed to a growing fleet of Canadian otter trawlers, and to an increase in the size of the stocks resulting (probably) from more favourable water temperatures. Canadian landings again surpassed those of the United States during this period.

Present Status

Haddock were tagged extensively in the 1930's (6), and also in recent years. While returns show much variability, and are greater closer to shore, an overall figure for rate of exploitation is about 30 per cent, and natural mortality is apparently about 20 per cent, so that instantaneous rate of fishing is 0.42, much as in Subarea 3. The stock therefore is about 100,000,000/0.42 = 240,000,000 pounds.

Future Prospects

Indications are that the haddock stock in Subarea 4 will decrease by about 10 per cent during the next 25 years. The predicted decrease in water temperatures will reduce the grounds available to haddock, particularly in the southern Gulf of St. Lawrence. Also, increased stocks of cod may reduce haddock abundance through predation. On the other hand, present dragging practices are wasteful of small haddock in Subarea 4, and it is anticipated that better utilization will be achieved through international agreement. The first step in a program of mesh regulation has already been recommended by ICNAF. Landings of about 115 million pounds may be anticipated 25 years from now, Canadian landings being about 70 million pounds.

References

(1) Thompson, Harold. 1939. The occurrence and biological features of haddock in the Newfoundland area. Newfoundland Biol. Sta., Res. Bull. No. 6, 31 pp.

(2) International Commission for the Northwest Atlantic Fisheries, Statistical Bulletins.

(3) Martin, W.R. 1953. Identification of major groundfish stocks in Subarea 4 of Northwest Atlantic Convention Area. ICNAF, Annual Proceedings, Vol. 3, pp. 57-62.

(4) Needler, A.W.H. 1930. The migrations of haddock and the inter-relationship of haddock populations in North American waters. Contr. Canadian Biol. and Fish., N.S. 6(10): 243-313.

(5) Needler, A.W.H. 1929. Studies on the life-history of the haddock (Melanogrammus aeglefinus L.). Contr. Canadian Biol. and Fish., N.S. 4(20): 267-285.

(6) McKenzie, R.A. MS. Haddock tagging off the southern Canadian mainland. Bull. Fish. Res. Bd. Canada. (In preparation for publication.)

REDFISH - Sebastes marinus

Present stock:	2,200,000,000 lb.	Utilization by Canada:	38,000,000 lb.
		" " others:	124,000,000 lb.
		(1952-54 basis)	
Stock in 1980:	1,350,000,000 lb.	Utilization by Canada:	70,000,000 lb.
		" " others:	70,000,000 lb.

Redfish occur as far south as New Jersey, but are most abundant in the Gulf of Maine and off Nova Scotia. Recent explorations carried out by the Newfoundland Biological Station and later by the Fisheries Research Board of Canada, from the Grand Banks to the northern extremity of Labrador, indicate additional and as yet untapped stocks in depths increasing to the northward. Redfish prefer cold waters, ranging from 35° F. to 50° F. They are on the bottom in the daytime and rise from it at night.

Unlike other common commercial fishes, the young are born alive. The female produces from 25,000 to 40,000 young each year. Redfish do not become sexually mature until they are about 10 years of age. Growth is slow everywhere, and many of the fish in the commercial catches are more than 20 years of age. There are apparently no special spawning grounds.

Stocks of redfish are localized, with no movement between Subareas, and not much within them (1, 2).

Redfish have only recently become marketable, so the fishery is largely a wartime and post-war development. The fish are taken by trawling in fairly deep water. The catch is taken almost wholly by Canada and the United States, since European nations have not yet been able to salt this fish in a form acceptable to their consumers.

Redfish dragging was started by United States trawlers during the 1930's in the Georges Bank region (Subarea 5), and extended northward as the local supplies were reduced. Canadian landings did not become large until about 1945.

ICNAF Subareas 2 and 3

Present stock:	1,700,000,000 lb.	Utilization by Canada:	24,000,000 lb.
		" " others:	69,000,000 lb.
		(1952-54 basis)	
Stock in 1980:	1,000,000,000 lb.	Utilization by Canada:	45,000,000 lb.
		" " others:	45,000,000 lb.

History

In Subarea 3 the redfish fishery is a post-war development. There is no catch in Subarea 2. The average landings, in millions of pounds, have been as follows:

	Canada	Others	Total
1942-45	0.1	..	0.1
1946-50	11.5	0.1	11.6
1951	38.2	29.9	68.1
1952	32.4	69.4	101.8
1953	27.5	73.0	100.5
1954	12.8	65.0	77.8

The Canadian catch rose rapidly to a peak of 38 million pounds in 1951 and has since declined to 13 million pounds. The decline has been largely due to a concentration of the Canadian fleet on haddock, and some transfer of Newfoundland effort in redfish fishing to the Gulf of St. Lawrence. Redfish have also not been as abundant as previously on the Newfoundland redfish fishing grounds on the eastern slope of the Grand Bank. Meanwhile the United States fleet has been obtaining several times this catch in Subarea 3, so that in 1954 the Canadian redfish catch in the Subarea was only 16 per cent of the total. The United States catch has been fairly stable. The United States fishermen utilize the abundant smaller redfish of the southwest slope of the Grand Bank as well as the larger redfish on the eastern slope of the Bank.

Present Status

The redfish fishery in Subarea 3 is still in an early stage of development: that of the "removal of accumulated stock". In some areas sufficient fish have been removed that stocks are now noticeably scarcer. Other more remote stocks are not yet being exploited. Because redfish become fishable first at 10 years or so of age, there has not yet been time for the exploited stocks to respond to fishing by increasing recruitment. We have no clear idea of what their sustained yield will prove to be, but it will almost certainly be less than the initial removals. For the whole of Subareas 2 and 3, we guess that present utilization is about 5 per cent of the stock per year.

Future Prospects

On the whole, it is likely that stocks now fished will not sustain the present rate of utilization definitely. On the other hand, by bringing other stocks of Subarea 3 and (eventually) Subarea 2 into production, the catch can probably be maintained at about its present level. Whether Canada will obtain a greater portion of the catch is a question of economics, and the level of United States tariffs on the fillets will be a major factor. At the present time Canadian vessels can make more trips but the landed value per pound is only half the landed value in the United States.

Theoretically there may exist very great pelagic stocks of redfish, of which the populations now fished are only a fringe. However, at present there is no evidence for such stocks, so we have made predictions on the basis of known supplies.

Our best estimate is that total redfish production from Subareas 2 and 3 will be about the same in 1980 as at present. Present areas will give less yield as the old mature stock is removed, but addition of new grounds will compensate for this. Since Canada's advantage of location will increase as more

northern stocks are used, the Canadian share is predicted to become 50 per cent of the total, or about 45 million pounds.

ICNAF Subarea 4

Present stock:	500,000,000 lb.	Utilization by Canada :	
		1952-54 av.:	14,000,000 lb.
		1954 only :	36,000,000 lb.
		Utilization by others :	
		1952-54 av.:	55,000,000 lb.
Stock in 1980:	350,000,000 lb.	Utilization by Canada :	25,000,000 lb.
		" " others :	25,000,000 lb.

History

Redfish occur commonly throughout Subarea 4, in deeper water than cod and haddock. They are caught commercially between Nova Scotia banks and inshore grounds, and along the deep channels of the Gulf of St. Lawrence. Redfish are caught by otter trawlers and marketed in fresh and frozen products. The fishery, which is only 20 years old, has depended on a large number of populations of old, slow-growing fish. Each accumulated population is rapidly reduced by fishing, and consequently the fleet has moved farther east each year in search of new grounds.

Average landings to date have been as follows, in millions of pounds:

	Canada			
	Mainland	Nfld.	U.S.A.	Total
1931-35	0	0	0.3	0.3
1936-40	0.3	0	22	22.3
1941-45	0	0	19	19
1946-50	1	0	117	118
1951	2	0	184	186
1952	3	3	43	49
1953	14	6	43	63
1954	25	11	84	120

Present Status

The total stock of redfish in Subarea 4 appears to be approaching a level of stability well below that of the virgin stock. At a 14 per cent instantaneous rate of removal in 1952-54, the stock is estimated to be about 500 million pounds.

Future Prospects

It is predicted that landings will soon depend on annual recruitment and growth, as all stocks are brought into production. In the Gulf of St. Lawrence

there are only occasional successful year-classes of redfish, which does not suggest a large sustained yield. Neither does the slow growth at the low temperatures where redfish live. In 25 years, the annual landings will probably not exceed 50 million pounds; at the current rate of fishing, the stock would then be 350 million pounds. This rather low rate of removal reflects the slow growth and sporadic recruitment of the species.

Some increase in landings may come from use of better mesh sizes, and reduced wastage of small fish at sea. Improved fishing techniques may be developed to catch redfish wherever they may be concentrated off bottom. However, neither development is expected to result in landings of the size of the late 1940's. In future, Canada will probably take about half the catch, or 25 million pounds per year.

References

(1) Martin, W. R. 1953. Identification of major groundfish stocks in Subarea 4 of Northwest Atlantic Convention area. ICNAF, Annual Proceedings, Vol. 3, pp. 57-62.

(2) Templeman, W. MS. (The redfish in Canadian Atlantic waters.) Fisheries Research Board of Canada, St. John's.

POLLOCK - Pollachius virens

Present stock:	200,000,000 lb.	Utilization by Canada:	32,000,000 lb.
		" " others:	7,000,000 lb.
Stock in 1980:	160,000,000 lb.	Utilization by Canada:	40,000,000 lb.
		" " others:	10,000,000 lb.

History and Present Status

Pollock is a common groundfish in the southern part of ICNAF Subarea 4, and ranges north to the southern Grand Bank and St. Pierre Bank in Subarea 3. The largest catches are made at the mouth of the Bay of Fundy. The stock of pollock is believed to about 200 million pounds. Approximately 60 million pounds could be taken each year under present conditions.

Pollock landings in Subarea 4, in millions of pounds round weight, have been as follows:

	Canada	U.S.A.	Total
1931-35	8	4	12
1936-40	16	8	24
1941-45	20	7	27
1946-50	29	7	36
1951	22	?	22+
1952	34	6	40
1953	37	?	37+
1954	36	?	36+

Landings of pollock have been increasing, mainly because of increased marketability. The United States has taken 6 to 12 million pounds per year since 1930. Annual Canadian landings have increased from about 5 million pounds in the 1920's to about 25 million pounds during the post-war period and 36-37 million pounds in 1953 and 1954.

Future Prospects

Increased utilization will likely increase the pollock catch in the immediate future, possibly to 60 or 70 million pounds. However if the cooler temperatures predicted for 1980 actually occur, there will be some restriction of range and abundance, so that total production then is estimated as only 50 million pounds per year.

HAKE

White hake - *Urophycis tenuis*
Squirrel hake - *Urophycis chuss*

Present stock:	200,000,000 lb.	Utilization by Canada:	30,000,000 lb.
		" " others:	1,000,000 lb.
Stock in 1980:	200,000,000 lb.	Utilization by Canada:	45,000,000 lb.
		" " others:	10,000,000 lb.

History and Present Status

The hake is a common groundfish in the southern part of Subarea 4, and ranges north to the southern edge of the Grand Banks. Catches up to 250,000 pounds a year have at times been landed from the Newfoundland area. The largest catches are taken at the mouth of the Bay of Fundy and in the southern part of the Gulf of St. Lawrence. Elsewhere it is taken incidentally with other groundfish.

The Subarea 4 landings, in millions of pounds round weight, have been as follows:

	Canada	U.S.A.	Total
1931-35	22[a]	2	24
1936-40	28[a]	3	31
1941-45	26	1	27
1946-50	32	1	33
1951	27	?	27+
1952	34	?	34+
1953	28	?	28+

[a] Includes cusk, probably less than 1 million pounds.

Landings have varied between 12 and 35 million pounds during the past 25 years. For ten years now, landings have exceeded 25 million pounds. Unfortunately hake quickly soften under ice, so that demand is low and large quantities are discarded at sea. Canada has taken most of the catch; United States landings having decreased to about a million pounds a year.

Future Prospects

Since rate of utilization is low, the hake stock should yield at least 60,000,000 pounds annually on a sustained basis. We anticipate that demand will increase with a growing number of consumers and improved handling of the catch, so that landings will increase and wastage will be reduced. However the stock will shrink only slightly, if at all, because much of the improvement will be from greater landings rather than increase in catch. It is quite probable that the Canadian take will be about 45 million pounds 25 years from now, and other nations may get an additional 10 million.

SILVER HAKE - Merluccius bilinearis

Present stock: 100,000,000 lb.	Utilization: negligible
Stock in 1980: 60,000,000 lb.	Utilization by Canada: up to 5,000,000 lb. " " others: up to 5,000,000 lb.

History and Present Status

The silver hake or whiting is an abundant groundfish in the southern part of Subarea 4, and in recent years it has been found in some numbers as far north as the southern Grand Bank and St. Pierre Bank in Subarea 3. It is a southern species which moves north during summer months. The recent trend towards higher mean temperatures has increased the abundance of the species on our coast.

We guess that the present stock of silver hake in Subarea 4 is roughly 100 million pounds and that about 25 million pounds could be taken each year. However this fish quickly becomes soft under ice. It has not been exploited by any nation in our waters. United States landings from Subarea 5 have become important during recent years, about 40 million pounds per year have been landed since 1944.

Future Prospects

It is predicted that silver hake will be of little or no commercial importance to Canada during the next 25 years. After 1960 the stock will probably decrease with the lower water temperatures that are forecasted. Total landings from Subarea 4 might be 10 million pounds per year by 1980, and half this amount might be landed in Canada.

HALIBUT - Hippoglossus hippoglossus

Present stock:	60,000,000 lb.	Utilization by Canada:	6,200,000 lb.
		" " others:	200,000 lb.
		(1952-54 basis)	
Stock in 1980:	60,000,000 lb.	Utilization by Canada:	6,500,000 lb.
		" " others:	600,000 lb.

Halibut are found in small numbers along the deep-water edge of cod and haddock grounds. Growth is slow, and no great fluctuation in year-class size has been identified.

Halibut landings consist of (1) fish caught by professional halibut fishermen, using long-lining gear; and (2) fish caught by trawlers incidentally to fishing for cod, haddock, etc. Longliners take most of the catch. Trawlers catch smaller fish as a rule.

Extensive movements of halibut off Nova Scotia and within the Gulf of St. Lawrence have been observed, but no interchange between these regions (1). However one Gulf halibut was retaken on the edge of the Grand Bank, and another off Iceland (2). In spite of this, the Subarea 4 stocks are to a large extent distinct from Subarea 3 or Subarea 2.

Subareas 2 and 3

Present stock:	20,000,000 lb.	Utilization by Canada:	2,000,000 lb.
		" " others:	100,000 lb.
		(1952-54 basis)	
Stock in 1980:	20,000,000 lb.	Utilization by Canada:	2,500,000 lb.
		" " others:	500,000 lb.

History and Present Status

The catches since 1930 in our region have been as follows, in thousands of pounds round weight:

	Subarea 2		Subarea 3	
	Canada	Others	Canada	Others
1931-35	0	277	429	258
1936-40	0	9	650	433
1941-45	0	0	457	6
1946-50	0	39	1386	15
1951	0	481	5712	18
1952	0	48	1789	0
1953	0	0	1391	43
1954	0	0	2659	103

In Subarea 2 halibut occur but the stocks are presumably only of moderate size. In several years between 1935 and 1942 there was a small Newfoundland catch, but the actual amounts are unknown. European vessels have taken sporadic catches in the Labrador region. There were landings reported in 7 years between 1930 and 1954, the maxima being 659,000 pounds in 1933 and 481,000 in 1951. Norwegian fishermen are said to have found good halibut fishing in the northern part of Subarea 2 in 1955.

In Subarea 3 there is regular fishing by the Canadian fleet, consisting of both Newfoundland and Nova Scotia vessels. Most of the catch is landed on the mainland. Except since 1951, the yield figures tabulated above include catches for ICNAF district 4R (west coast of Newfoundland), but these were never large (less than 100,000 pounds per year in 1952-54).

Catches made incidentally by the European salt-fishing fleet are not included in any statistics. Presumably these are discarded at sea, apart from any that may be eaten by the crews.

Canadian landings from Subarea 3 increased greatly in 1950 and 1951 reaching nearly 6 million pounds in 1951. Since 1951 they have declined again to more usual levels. This peak of production principally reflects increased effort applied to stocks which had accumulated during World War II. Halibut fishing is done mostly by vessels which would otherwise fish for cod, so effort expended in halibut fishing responds sensitively to changes in the price differential between the two species and to the catch of halibut per unit of effort expended.

The stock estimate is made on the basis of a rate of utilization similar to that estimated for Subarea 4, below.

Future Prospects

There is no expectation of future catches in Subarea 3 much larger than those taken to-day; say 2,200,000 pounds in 1980. It is possible that a larger stock might be built up and a larger yield eventually taken if capture of small fish were eliminated. However there seems no way of accomplishing this without hardship to the more important round-fish industry.

Some Canadian expansion into Subarea 2 is possible, but the stocks there are probably much less than in Subarea 3. We estimate 300,000 pounds a year taken by Canada from this Subarea in 1980, and possibly as much again by other countries.

Subarea 4

Present stock:	40,000,000 lb.	Utilization by Canada:	4,200,000 lb.
		" " others:	100,000 lb.
		(1952-54 basis)	
Stock in 1980:	40,000,000 lb.	Utilization by Canada:	4,000,000 lb.
		" " others:	100,000 lb.

History and Present Status

The landings of recent years are shown below in thousands of pounds round weight:

	Canada	Others	Total
1933-35	3300	1400	4700
1936-40	4100	1100	5200
1941-45	1800	200	2000
1946-50	4400	100	4500
1951	4900	200	5100
1952	4000	100	4100
1953	4600	100	4700
1954	4000	100	4100

The post-war increase in landings seems to reflect mainly the increase of stock during the war, and its subsequent removal by heavier fishing. At present the catch is back to the pre-war level.

Tagging experiments in 1946 off Anticosti Island and in 1947 off south-western Nova Scotia indicate a rate of recapture of about 10 per cent per year, if allowance is made for failure to report some tags (1, 2), or slightly more on the instantaneous basis. Consequently the Subarea 4 stock is estimated as 4,200,000/0.105 = 40 million pounds.

Future Prospects

We anticipate that halibut landings will remain at about their present level

during the next 25 years: 3 million pounds per year. It is not likely that other nations will enter the fishery on any important scale.

References

(1) Martin, W. R., and F. D. McCracken. 1950. Movement of halibut along the Canadian Atlantic coast. Fish. Res. Bd. Canada, Atlantic Prog. Rept., No. 50, pp. 3-8.

(2) McCracken, F. D., and W. R. Martin. 1955. Recent recoveries of tagged halibut. Ibid., No. 61, p. 4.

FLOUNDERS

American plaice = Hippoglossoides platessoides
Greysole or witch = Glyptocephalus cynoglossus
Winter flounder = Pseudopleuronectes americanus
Yellowtail flounder = Limanda ferruginea

Present stock:	500,000,000 lb.	Utilization by Canada :	65,000,000 lb.
		" " others :	6,000,000 lb.
		(1952-53 basis)	
Stock in 1980:	400,000,000 lb.	Utilization by Canada*:	90,000,000 lb.
		" " others*:	10,000,000 lb.

*These landings would be about equally divided between Subarea 3 and Subarea 4.

Landings of flounders by Subareas in 1952-54 were as follows (in thousands of pounds round weight):

	Subarea 2	Subarea 3		Subarea 4		Total	
	Canada	Canada	Others	Canada	Others	Canada	Others
1952	0	36,900	200	24,400	3,500	61,300	3,700
1953	20	42,900	100	25,000	7,100	67,900	7,200
1954	few	24,000	?	35,000	?	59,000	?

The four species listed are treated separately below, as far as possible. The American plaice is the most important species, especially in Subarea 3.

References for All Flounders

(1) Huntsman, A. G. 1918. The Canadian plaice. Bull. Biol. Bd. Canada, No. 1, 32 pp.

(2) Templeman, W., and Gertrude L. Andrews. 1956(in press). Jellied condition in the American plaice Hippoglossoides platessoides (Fabricius). J. Fish. Res. Bd. Canada, 13(2).

(3) Dickie, L.M., and F. D. McCracken. 1955. Isopleth diagrams to predict equilibrium yields of a small flounder fishery. J. Fish. Res. Bd. Canada, 12(2): 187-209.

(4) Stewart, T. N. MS, 1956. Danish-seining explorations in Newfoundland and Cape Breton areas. To be published as a Bulletin of the Fisheries Research Board of Canada.

(5) Frost, Nancy. 1940. Newfoundland flatfishes. A popular account of their life histories. Newfoundland Biol. Sta., Service Bull., No. 14, 23 pp.

(6) Scott, D. M. 1954. A comparative study of the yellowtail flounder from three Atlantic fishing areas. J. Fish. Res. Bd. Canada, 11(3): 171-197.

American Plaice

History and Present Status

This plaice occurs on both sides of the Atlantic, being known as long rough dab in England. In America it is found from Long Island to the Arctic, usually from 20 to 100 fathoms. It is abundant over some large areas of the northern and eastern Grand Bank, and is also found in important commercial quantities on the Nova Scotia banks and the southern part of the Gulf of St. Lawrence. Unlike other flounders, it is taken in some numbers by the line fishery, as well as by dragging.

Plaice grow very slowly on the Grand Bank, being similar to redfish in this respect. Farther south growth is faster and the stock younger.

The Canadian landings of plaice in Subarea 3 are as shown below, in millions of pounds:

	Subarea 3
1948	2
1949	5
1950	13
1951	27
1952	31
1953	30
1954	19

Prior to 1948 only small landings were made in Subarea 3, and Canada has taken the only important catches there. The fishery is still in the stage of removal of accumulated old stock. The younger age composition which is approaching will be advantageous in that fewer young fish will have the undesirable "jellied" condition of the flesh (2). The decrease of Area 3 landings in 1954 (and 1955) is mainly a result of diversion of otter trawling effort to the abundant haddock of the southern banks in the Subarea.

The Subarea 4 stocks have been used for a longer period of time, but exact landings figures are unavailable because this species is grouped with other flounders in the statistics.

Future Prospects

An estimate of total landings in 1980 is 35 million pounds from Subarea 3 and possibly 20 million from Subarea 4. The stock will be reduced in size, especially in Subarea 3, but this of course is a favourable development, up to a point.

Greysole or Witch

History and Present Status

This is another species whose fishery dates from the time since World War II. It is a deep water species, taken by draggers or Danish seine.

In Subarea 3 it is taken by Danish seining on a small ground in Fortune Bay, and along with haddock in dragging on the southwestern Grand Bank. Catches landed

in Newfoundland, in thousands of pounds, were as follows (1947-51 based on exports):

	Subarea 3
1947	298
1948	669
1949	1509
1950	2142
1951	2927
1952	2618
1953	6887
1954	5351

In Subarea 4 the witch is taken commonly on both the Atlantic and the Gulf sides of Cape Breton. Witch landings are grouped with other flatfish. The present catch is taken mainly by dragging but grounds suitable for Danish seining have been discovered in that area (4).

Future Prospects

In Subarea 3 an increase in landings of about 50 per cent will probably be possible, to say 10 million pounds per year. If more Danish seining grounds are discovered this might become greater, but recent searching has revealed only rough bottoms in the more likely areas.

Winter Flounder

History and Present Status

Since World War II the winter flounder or blackback has become of some importance to inshore draggers in the southern part of Subarea 4. In St. Mary Bay, Nova Scotia, the catch rose to 1,299,000 pounds in 1950, during the peak of the removal of accumulated old stock, and now seems to be levelling off at about 500,000 pounds per year.

Statistics of winter flounder catches for the whole Subarea are included with those of the other flounders.

Future Prospects

As far as St. Mary Bay is concerned, the fishery appears to have reached a limit beyond which it is not profitable to go within the present price structure (3). Other areas have some possibilities for increased landings but the fishery will probably never be a large one in our waters.

Yellowtail Flounder

The yellowtail is one of the four flounders which contribute to an estimated stock of about 200 million pounds in Subarea 4. They are taken by otter trawlers

on the Nova Scotia banks, usually in water less than 40 fathoms deep. They occur in Subarea 3, but not in significant commercial quantities. Canadian landings in 1946 were about 2 1/2 million pounds (6). See above for flounder prospects in general.

GREENLAND HALIBUT - Reinhardtius hippoglossoides

Present stock:	20,000,000 lb. or more	Utilization:	1,000,000 lb.
Stock in 1980:	no change	Utilization:	1,000,000 lb.

History and Present Status

The Greenland halibut is a northern species, occurring in Subareas 2 and 3. It is found in all deep cold water parts of the Newfoundland area but is only fished in a few of the more accessible parts of the bays, particularly in Trinity Bay. The catch is sold as salted fish. It does not seem particularly attractive as a fresh fish, but there has been some export in the fresh frozen form from Greenland.

Catches in recent years have run between 500,000 and 1,300,000 pounds; the peak was nearly 2,000,000 pounds in 1930. A synopsis of average yearly landings is shown below, in thousands of pounds round weight:

1911-15	131
1916-20	824
1921-25	765
1926-30	1334
1931-35	1102
1936-40	898
1941-45	889
1946-50	871
1951	743
1952	968
1953	1090
1954	1191

Future Prospects

Though supplies are available to support a larger fishery, it is unlikely that landings will increase in the near future since the number of fishermen is declining and the future of the salt fish market remains doubtful. There will however be increased incidental landings from an expanding longline fleet. Best prediction is that these two trends will offset each other and maintain production at about its present level.

SKATES

Barn-door skate	= *Raja laevis*
Big skate	= *Raja ocellata*
Thorny skate	= *Raja radiata*
Spiny-tailed skate	= *Raja spinicauda*

Present stock:	70,000,000 lb.	Present utilization:	negligible
Stock in 1980:	70,000,000 lb.	Utilization by Canada:	4,000,000 lb.
		" " others:	2,000,000 lb.

Present Status

A variety of species of skate are found in Subareas 2, 3 and 4. Large numbers are taken while fishing for other groundfish, principally of the first three species above. They have not been used commercially, except a small amount kept by the Scottish factory ship *Fairtry*. Skate wings are extensively utilized for food in European countries. It is guessed that the total stock of skates is about 70 million pounds and that roughly 15 million pounds could be landed each year.

Future Prospects

Skate wings will doubtless be marketed in North America as demand for protein increases. The remainder could be reduced at appropriate plants. It is predicted that skate landings off our coasts might be 6 million pounds per year 25 years from now, of which Canada may take 4 million pounds.

CUSK - Brosme brosme

Present stock:	30,000,000 lb.	Utilization by Canada:	2,000,000 lb.
		" " others:	300,000 lb.
Stock in 1980:	30,000,000 lb.	Utilization by Canada:	3,000,000 lb.
		" " others:	1,000,000 lb.

History and Present Status

The cusk is of some commercial importance in Subarea 4, but it is rarely encountered farther north. It is an excellent food fish, and is taken on all fishing banks incidentally to catches of other groundfish species. No large concentrations of cusk have been observed. Landings in recent years are as follows, in thousands of pounds round weight:

	Canada	U.S.A.	Total
1931-35	a	2000	2500 (est.)
1936-40	a	3000	3500
1941-45	1000	1000	2000
1946-50	1000	300	1300
1951	2000	?	2000+
1952	2000	300	2300
1953	2000	?	2000+

[a]Probably less than a million pounds. During these years cusk catches were included in published statistics along with hake.

The stock of cusk in Subarea 4 is estimated to be about 30 million pounds. United States landings averaged about 2 million pounds annually from 1900-1945, but have recently declined. Nova Scotian landings have risen in the last few years, and most of the catch is now landed there.

There is no real information on rate of exploitation. However the species is mostly caught incidentally to other fishing operations, and it tends to frequent rocky areas where dragging is difficult, so the rate of utilization is probably low in spite of the good price which it commands. The population estimate of 30 million pounds is on the basis of about 8 per cent utilization in 1951-54.

Future Prospects

Landings may increase to about 4 million pounds 25 years from now, of which at least 3 million pounds may be expected to be taken by Canada.

CATFISH (Wolffish)

Common or striped catfish = Anarhichas lupus
Spotted catfish = Anarhichas minor

Present stock:	110,000,000 lb.	Utilization by Canada:	6,000,000 lb.
		" " others:	1,000,000 lb.
Stock in 1980:	90,000,000 lb.	Utilization by Canada:	14,000,000 lb.
		" " others:	1,000,000 lb.

History and Present Status

Catfish or wolffish are of most importance in Subarea 4. There the spotted catfish is uncommon, but the common catfish is found in large numbers particularly on inshore grounds off southwestern Nova Scotia. Most of the fishing takes place during spring months when catfish are concentrated near shore.

In Subareas 2 and 3 the striped wolffish is most common in the southern areas while the spotted wolffish is the important one north of the Grand Bank. Present landings are mainly of the striped species from off the south coast of Newfoundland. The stock to the northward exists over a very large area and is so little fished that its size can only be guessed. Some information is available from long-lining experiments which in the deep water yielded wolffish, mostly spotted, averaging 2-3 per cent of the deep-water cod catch.

Recent production is as follows, in thousands of pounds round weight:

	Subarea 3	Subarea 4		
	Canada	Canada	U.S.A.	Total
1931-35	few	400	2000[a]	2400
1936-40	few	600	1000	1600
1941-45	87	1000	500	1500
1946-50	138	2000	1000	3000
1951	309	4000	?	4300+
1952	338	6000	1000	7300+
1953	398	6000	?	6400+
1954	327	6000	1000	7300

[a] 1935 only

The stock of catfish in Subarea 4 is estimated to be about 70 million pounds, and approximately 12 million pounds could be landed each year on a sustained yield basis. In Subareas 2 and 3 the total stock may be 40 million pounds or more, but most of this is on deepwater northern grounds not at present fished.

Landings were low during war years but they have increased to 7 million pounds in 1954. Canada took 6 million pounds in that year and United States trawlers took the other million.

Future Prospects

Catfish landings in Subarea 4 may be about 9 million pounds 25 years from now. About 8 million pounds will probably be landed annually in Canada. From Subarea 3, landings on the northeast coast of Newfoundland will increase as long-lining and deepwater fishing increase and as plant facilities are expanded, particularly if some price premium over cod can eventually be offered. However the species is likely to retain an "incidentally-caught" status, rather than becoming the primary object of a fishery, except for a short period of the year on Burgeo Bank. Subarea 3 landings in 1980 may approach 5,000,000 pounds, and the eventual possible take would be greater.

DOGFISH - *Squalus acanthias*

Stock: unknown, but large in some years

Present utilization: none

Utilization in 1980: up to 20,000,000 lb.

History and Present Status

Dogfish are often extremely numerous in summer, north to Newfoundland (1). Formerly they were used for dog feed to a considerable extent in Newfoundland, but this has declined greatly in the past few years, with the passing of dog transport.

There is no commercial fishery at the present time. In Great Britain dogfish are popular in the fish-and-chips trade, but it has apparently never been accepted as an article of human food in America.

Future Prospects

An export market for fillets may conceivably develop within 25 years, or a reduction industry might be possible. Either eventuality would require an important change in technology or price structure, which cannot be forecast at this time.

Reference

(1) Templeman, W. 1944. The life-history of the spiny dogfish (*Squalus acanthias*) and the vitamin A values of dogfish liver oil. Newfoundland Biol. Sta., Res. Bull., No. 15, 102 pp.

HERRING - Clupea harengus

Present stock:	3,800,000,000 lb.	Utilization:	240,000,000 lb.
Stock in 1980:	3,500,000,000 lb.	Utilization:	500,000,000 lb. or more

Herring occur throughout the Canadian Atlantic area from the Bay of Fundy to Hamilton Inlet, Labrador. They are particularly abundant between the parallels 43° and 50° North Latitude. They are caught, chiefly, in a narrow coastal area, occasionally throughout the waters covering the continental shelf and have been reported frequently from areas farther offshore. Herring are almost certainly more numerous than any other commercial species in Canadian waters.

The herring stock as a whole is divided into a number of essentially discrete units. There are at least four major divisions south of the Laurentian Channel, and four around Newfoundland. Known spawnings occur in different areas from late April to mid-September, chiefly from 2 or 3 fathoms down to about 30 fathoms. Herring grow to a length of about 17 inches and to a weight of about 1 1/2 pounds. They are usually found in large schools and are capable of extensive migrations (400 to 500 miles or more). Age analyses indicate total mortalities are low--about 10-20 per cent per year. Herring 10 to 15 years of age are common in commercial catches and those of 15 to 20 years are not unusual.

Catches are made, chiefly, close inshore during spawning seasons when fish are of relatively poor quality. They are used in a variety of ways for canned, pickled and smoked products, for bait and fertilizer and for reduction to meal and oil.

Newfoundland Area (Subareas 2, 3 and 4R)

Present stock:	800,000,000 lb.	Utilization:	50,000,000 lb.
Stock in 1980:	700,000,000 lb.	Utilization:	100,000,000 lb.

History and Present Status

Present catches are very low, about 50 million pounds, compared with a former peak catch of 160 million pounds in 1946 and 100 million pounds in 1918 and do not represent the amounts that could be caught if the available population were utilized. The only occasions when large landings of herring have been made were during and just after the two World Wars when large quantities of thin spawning herring could be sold in the salted condition. Average yearly landings are shown below, in millions of pounds round weight:

1911-15	71
1916-20	87
1921-25	45
1926-30	38
1931-35	25
1936-40	34
1941-45	75
1946-50	99
1951	60
1952	54
1953	37
1954	32

The Labrador herring fishery has always been characterized by an irregular succession of seasons when herring either appear in great abundance or fail to appear at all. This is perhaps related to changes in hydrographic conditions but there are no supporting data. Tibbo (2) concluded that the Labrador herring were a part of the population that spawns in Notre Dame Bay on the east coast of Newfoundland some two or three hundred miles to the south, the Labrador fish consisting of the larger, older and more migratory individuals. Attempts to develop a herring meal and oil industry on the Labrador coast in the 1940's failed because of irregular supplies of raw materials. At present there is little effort expended in the catching of herring in Labrador. The herring that are found there are very large (average length 15 inches) and old (average age 12 yrs.) and of very high quality when they appear on the coast in July and August.

The herring fisheries of the island of Newfoundland are located chiefly in Bay of Islands on the west coast and Fortune Bay on the south coast. Extensive herring fisheries have been carried on in Notre Dame Bay on the northeast coast but are of little importance now. In all areas the herring taken commercially are large (10-14 inches) and old (7 to 10 years). There appear to be only minor variations in year-class abundance and hence overall abundance should remain stable. A large number of year-classes (10-14) are represented in samples from all areas. The herring taken in Fortune Bay and Notre Dame Bay are of poor quality and suitable for low grades of pickled products, for bait, and for reduction to meal and oil. High quality herring are taken in Bay of Islands in November and December but during the spring fishery in that area the landings are also herring of poor quality. An extension of the fishing season to the summer and fall months should provide fat herring that would be suitable for high grade food products.

Future Prospects

The same incentives, and technical and technological advances, will affect future landings in Subarea 3 as in Subarea 4. Catch in 1980 should be at least twice the present, and might be considerably more.

Region South of the Laurentian Channel

Present stock:	3,000,000,000 lb.	Utilization by Canada:	200,000,000 lb.
Stock in 1980:	2,800,000,000 lb.	Utilization by Canada:	400,000,000 lb.

History and Present Status

The long early history of herring and sardine fishing in the Bay of Fundy region has been discussed by Huntsman (4).

The present Canadian catch south of the Laurentian Channel is in the neighbourhood of 200 million pounds annually. Catches increased from 100 million pounds in the early 1930's to 250 million pounds in 1946 and have since fallen off somewhat. The figures below are in millions of pounds round weight:

	Herring	"Sardines"	Total
1920-24	77.6	39.9	117.6
1925-29	93.6	41.7	135.2
1930-34	92.7	23.3	116.0
1935-39	111.3	43.8	155.1
1940-44	124.5	71.6	196.1
1945-49	134.5	84.9	219.4
1950	162.5	68.3	230.8
1951	143.5	64.8	208.3
1952	184.6	54.5	239.1
1953	150.1	37.2	187.3
1954	175.6	33.1	208.8

The herring fisheries in Subarea 4 are located chiefly in the southwestern part of the Gulf of St. Lawrence, from Yarmouth to Halifax on the Atlantic coast of Nova Scotia and in Passamaquoddy Bay in the Bay of Fundy. A special feature of the Subarea 4 fishery is the large weir fishery in and near Passamaquoddy Bay which mostly takes "sardine" herring of ages 0, I and II. The Gulf of St. Lawrence fishery is carried on chiefly during a spring spawning season in late April and May. On the Atlantic coast of Nova Scotia the fishery is for summer and fall spawning herring from July to September. In both of the latter regions landings are governed more by market demand than abundance: the herring taken commercially are large and old and the populations are in general underfished.

Future Prospects

Although present herring landings are greater than those of any other species except cod, catches could be increased considerably. The present catch is probably not more than 5 to 7 per cent of the stock and this could be safely increased to at least 15 per cent, or 400 million pounds annually. Anticipated climatic changes are unlikely to cause marked variations in total abundance in Subarea 4. Increased landings should result from a continued demand for fish meal and increased demand for high quality food products. Improvements in methods of locating and catching are essential, and are already being developed. Expansion of the present fishery to offshore areas, particularly in the Gulf of St. Lawrence during summer and fall months, will provide high quality herring for an expanding food market. The "sardine" industry has probably reached a plateau as regards tonnage, but more of its product may go for purposes other than human food which has been the chief market until now. Recent technological advances have made possible the use of whole fish for the extraction of pearl essence with fish-meal a by-product of the industry. Plant capacity is already large enough to handle more than half the average landings and will probably be increased. There is no indication that the market for canned sardines can be increased substantially.

N.B. The meaning of the term "sardine" has changed within the past ten or fifteen years. It formerly meant small sizes of herring (0, I and II years), but now it means any herring canned for human food. Regardless of size, fish used for fish meal or pet food are described as "herring" now, and the majority of the fish so used are small (0, I and II years of age).

References

(1) Leim, A.H. 1956(in press). Summary of results under Atlantic Herring Investigation Committee. Bull. Fish. Res. Bd. Canada.

(2) Tibbo, S.N. 1956(in press). Populations of herring (Clupea harengus L.) in Newfoundland waters. J. Fish. Res. Bd. Canada, 13(4).

(3) Tibbo, S.N. 1956(in press). The herring of the Chaleur Bay area. Bull. Fish. Res. Bd. Canada.

(4) Huntsman, A. G. 1953. Movements and decline of large Quoddy herring. J. Fish. Res. Bd. Canada, 10(1): 1-50.

MACKEREL - Scomber scombrus

Present stock:	large	Utilization by Canada:	30,000,000 lb.
Stock in 1980:	little change	Utilization by Canada:	60,000,000 lb.

History and Present Status

Mackerel occur throughout the Canadian area from the international boundary to the Strait of Belle Isle. They probably winter in "a narrow band of relatively warm water flanking the continental shelf from abreast Cape Hatteras to the eastern end of Georges Bank and possibly.....to abreast Sable Island" (2). They appear on Canadian and United States coasts in May, and start to disappear from the northern part of the range in September.

Some spawnings occur in the Gulf of St. Lawrence and off Nova Scotia, but the majority are off the coast of the United States. Growth is rapid--a high proportion becoming spawning adults at 2 years of age. They are found during spring, summer and fall in the warm surface layers rarely deeper than 50 to 75 feet.

The mackerel fishery has a long history which exhibits marked fluctuations in catch and apparently in abundance of the fish (3). The largest recent Canadian catch was 52 million pounds in 1939. The record was 70 million in 1880, a time when mackerel were very numerous and penetrated north to the Strait of Belle Isle in commercial quantities. Average catches for recent years have been as follows, in millions of pounds round weight:

Years	Mainland	Years	Newfoundland	Total
1920-24	17.9			
1925-29	14.8			
1930-34	20.1			
1935-39	28.7	1936-40	0.02	28.7
1940-44	34.5	1941-45	0.08	34.6
1945-49	31.1	1946-50	2.4	33.5
1950	27.1	..	..	..
1951	24.7	1951	3.4	28.1
1952	27.1	1952	5.1	32.2
1953	24.1	1953	5.7	29.8
1954	28.2	1954	2.2	30.4

No real estimate of the north Atlantic stock can be given, but it is obviously large in relation to present utilization. Since it replaces itself rapidly, it constitutes one of the larger reservoirs of incompletely exploited fish.

At present considerable quantities of mackerel move north into Subarea 3, especially in autumn. Up to 6 million pounds have been taken in recent years by the Newfoundland fishery. Many more were available, but these autumn fish are fat and spoil easily, and there is lack of suitable boats, seines and shore facilities.

Mackerel are used almost exclusively for food products, but small quantities go for bait and for reduction to oil and meal.

Future Prospects

Mackerel are probably as abundant in Canadian waters as they are in United States waters, but of the total catch in the western Atlantic, only about 25 per cent is taken in Canadian waters. With the use of more efficient catching equipment (e.g., purse-seines) the Canadian catch should at least equal the United States catch (60 to 80 million pounds annually in recent years). Though climatic changes may eventually reduce the overall range somewhat, they will probably have little effect on abundance within the parts of Subarea 4 where most catches are now made. The supplies in Subarea 3 may dwindle after 5 years or so, if predicted temperature trends actually occur, but enough may remain to provide a catch at the present level. Landings will also probably fluctuate considerably due to wide variations in year-class recruitment and hence overall abundance.

Our best estimate of 60 million pounds taken in 1980 is less than the probable potential. Technological improvements which would preserve the excellent flavour and texture of freshly-caught mackerel would boost production and could even make mackerel a premium fish comparable to salmon. At present mackerel in inland stores is rather consistently tough and tasteless.

References

(1) Sette, O. E. 1943. Biology of the Atlantic mackerel (Scomber scombrus) of North America. Part I. Early life history, including growth, drift and mortality of the egg and larval populations. U.S. Fish and Wildlife Service, Fish. Bull.,No. 38, pp. 149-237.

(2) Sette, O. E. 1950. Biology of the Atlantic mackerel (Scomber scombrus) of North America. Part II. Migrations and habits. U.S. Fish and Wildlife Service, Fish. Bull., No. 49, pp. 249-350.

(3) Sette, O. E., and A. W. H. Needler. 1934. Statistics of the mackerel fishery of the east coast of North America, 1804 to 1930. U.S. Bureau of Fisheries, Investigational Rept. No. 19, 48 pp.

ATLANTIC SALMON - Salmo salar

Present stock:	9,500,000 lb.	Commercial utilization:	4,500,000 lb.
		Utilization by anglers:	500,000 lb.
Stock in 1980:	20,000,000 lb.	Commercial utilization:	10,000,000 lb.
		Utilization by anglers:	1,000,000 lb.

History

Salmon occur from southern New Brunswick to Ungava Bay. They are anadromous fish, spawning in late autumn wherever water depths and bottom gravel are suitable in rivers and brooks. The eggs hatch in the spring and the young remain in fresh water for two to four years or more. They then descend to the sea, where some individuals, if not all, range widely. They remain at sea for one year to become "grilse", or longer to produce "salmon". There is a notable tendency for maturing fish to return to their river of origin to spawn. Spawned-out salmon are known as "kelts". Some 5 or 10 per cent of them survive to spawn again, and another 5 or 10 per cent are taken by the fishery.

The bottle-neck in Atlantic salmon production appears to lie in the available river habitat for production of smolts (3).

The various Canadian salmon stocks cannot be treated discretely. Salmon captured off eastern and northeastern Newfoundland include fish bound for rivers in Labrador, the island of Newfoundland, Quebec and the Maritime Provinces, including even the Bay of Fundy region. Similarly, catches in northern New Brunswick include fish bound for the St. Lawrence rivers, Nova Scotia and the Fundy region, as well as local fish. This extensive mixture of stocks on the fishing grounds was indicated first by the widespread recapture, by fishermen, of kelts tagged in New Brunswick, Nova Scotia and Quebec (1), and of fresh salmon tagged off Newfoundland and New Brunswick (4, 5). It has recently been confirmed by returns of salmon marked as smolts in the Miramichi and Petitcodiac River systems. In spite of this mixture of stocks in the fisheries, all available evidence suggests that the fish eventually reach "home" in a great majority of cases, even seeking out the same tributary that they had left as smolts (2).

Estimates of catches since 1890 are shown in Table A. Records of catches for individual mainland areas are available over longer periods (3), while the Newfoundland export figures varied between 0.8 and 2.5 million pounds, without any consistent trend, between 1852 and 1920. Since the turn of the century, the catch averaged 4 or 5 million pounds a year up to 1920, rose to 8 1/2 million a year in 1926-30 (the top was 14 million pounds in 1930), and since 1940 has fallen to 4 or 5 million a year once more. This does not include the angling catch, which is estimated to have been about 500,000 pounds a year since 1950.

The distribution of average catch by regions since 1950 is approximately as follows:

	Commercial catch (lb.)	Anglers' catch (fish)
Labrador	800,000	1,000 (est.)
Island of Newfoundland	2,200,000	14,000
North shore of Gulf of St. Lawrence	200,000	5,000
Remainder of Gulf	1,000,000	45,000
Atlantic coast of Nova Scotia	90,000	5,000
Bay of Fundy	210,000	5,000
Totals		75,000 fish
	4,500,000 lb.	or 525,000 lb.

Table A. Average yearly commercial catch of Atlantic salmon, in thousands of pounds, round fresh.

	Quebec, N.B., N.S., P.E.I.	Newfoundland (incl. Labrador)	Total
1871-5	4063	1727	5790
1876-80	2962	1804	4766
1881-85	2327	1399	3726
1886-90	2441	1525	3966
1891-95	3216	1343	4559
1896-1900	2966	1709	4675
1901-5	3031	1654	4685
1906-10	3478	1251	4729
1911-15	3536	3060	6596
1916-20	3168	2472	5640
1921-25	4618	3744	8362
1926-30	4564	5111	9675
1931-35	4069	4778	8847
1936-40	2846	4927	7773
1941-45	2543	3723	6266
1946-50	2184	4004	6188
1951	1744	3351	5095
1952	1667	3415	5082
1953	1493	3089	4582
1954	1551	2354	3905
1955	..	1747	..

Sources: For Newfoundland, Customs export figures are used to 1910 adjusted to round weight basis; from 1911, estimates by the Department of Fisheries Markets and Economics Division, St. John's office, including estimated local consumption of commercial fish, but not anglers' catches. For other provinces, figures are those of the Dominion Bureau of Statistics through 1950; from 1951 the figures compiled by the Halifax office of the Department of Fisheries and the published Quebec statistics are used.

In Newfoundland grilse are taken in nets as well as by angling, and may comprise up to half the commercial catch, by weight. Elsewhere grilse are reserved for anglers. In some New Brunswick streams kelts may be taken by angling, and about 8,000 a year are harvested.

Present Status

The rate of utilization of Atlantic salmon is fairly large, but it has not been exactly determined. In the late 1930's Belding and associates tagged fish from the drift-net fisheries at Port aux Basques and off the Miramichi, and at various shore sites, and obtained returns of from 13 to 38 per cent (4). However their greatest rates of return were from fish tagged from shore nets, when the salmon did not move far from the point of tagging, and had been tagged only after much of their chance for exposure to commercial fishing was over. This suggests that the drift-net fish, which dispersed much more widely, gave far too low a return: either because fish caught in drift nets suffer excessive tagging mortality, or because the tags were not very secure and worked loose on the longer journeys, or because facilities for reporting tags from a distance were not as good.

Blair (5) reports an experiment done at Bonavista in 1940, in the heart of the Newfoundland trap-fishing area. He obtained 36 per cent first-year returns for grilse and 41 per cent for "salmon" (2 or more years in the sea). The "salmon", but not the grilse, were tagged only toward the end of their season at Bonavista, and Blair believed that this tended to make returns low: a considerably higher rate of return would be expected for the larger fish, because commercial fishing everywhere favours them over grilse.

Another consideration in assessing tag recoveries is that any tagging from a commercial fishery tends to give too low a result because a part of the fish's opportunity to be caught, in the current year, is past. And of course the return of tags is never complete. On the other hand, some mainland salmon may not come within range of the Newfoundland fishery before making landfall, though the relatively large representation of marked Miramichi and Petitcodiac fish found in that fishery does not support this view (2).

All in all, the average commercial rate of capture of "salmon" by the various Canadian fisheries can scarcely be less than 50 per cent, and might be greater. For grilse it is estimated as 40 per cent. If we apply these figures to the 1951-54 average catches of 4,500,000 pounds, considering 1/3 of the catch of Newfoundland and Labrador to be grilse, the total stock is estimated as 2.5 million pounds of grilse and 7 million pounds of "salmon", or 9.5 million pounds in all.

Future Prospects

(a) Without additional conservation measures. Estimation of future trends in salmon stocks depends on knowing the causes of past changes. From the very beginning, the history of salmon fishing has been one of marked fluctuation in catches. At least for New Brunswick rivers, a good case has been made for associating this with fluctuations in rainfall (3, 6), which produced ups and downs having important highs at an average period of 9 or 10 years, as a rule. (The year-to-year picture is complicated by predation of older parr upon younger ones, so that every third year tended to have a strong population in some rivers.)

However these effects do not easily account for long-term trends in catch, which are especially apparent in the present century.

More recently it has been found that there is an inverse relationship between average annual ocean temperatures and commercial salmon catches. This has been true since 1921 when the temperature records were started. Since 1940 temperatures have increased steadily and in the past few years have been from 2 to 3° F. above normal. Salmon catches have declined correspondingly. In most cases the years with the highest average water temperatures had the lowest salmon catches. Assuming this is more than a coincidence, the causal connection between ocean temperature and catch is not certainly known. Perhaps the increased temperature affects the habits of salmon at sea so they avoid the netting areas, in which event the size of the stock would remain unaffected. Alternatively, the stock may actually decrease because of reduced survival of smolts in the sea when temperatures are high. Or high ocean temperatures may be associated with high air temperature and/or low rainfall on land, which factors presumably reduce salmon parr habitat and so reduce stocks at that stage.

Whatever the true association, oceanographers tentatively forecast that sea temperatures will remain as at present for about 5 years; then in the following 20 years decline to the lower level of the early 1940's. If other conditions remain as at present, we might expect a recovery of the salmon catches by 1980 to something like the level of 1926-30, when 9.7 million pounds a year were caught commercially (round weight basis).

(b) Catch with new management procedures.

1. Control of mergansers which prey upon young salmon has been found a very promising method of increasing smolt production, in experiments now being conducted on several rivers (7). If after a few years this is adopted as a widespread management procedure, we estimate that the production of young salmon can be doubled or tripled on the rivers affected, with a corresponding increase in the stock of adults.

2. Dams or natural obstacles which now deny extensive areas of some rivers to spawning salmon may be removed or ameliorated. Some old mill dams, now becoming redundant, may be removed entirely, but usually it is a matter of providing effective fishways. For example, the producing area of the St. John River system would be greatly increased by permitting spawning above Grand Falls, N.B. In Quebec, Newfoundland and Labrador many rivers are blocked to ascent of salmon (9), so that only about half of the potential smolt-rearing area there is used. Some fishways have already been provided, and there will doubtless be more built during the decades immediately ahead. A survey of all the eastern provinces is in progress by the Department of Fisheries, to determine the potentialities and practicability of various sites.

Some falls, of course, are too great for a fishway to be provided, or are situated in areas which at present are so remote that construction and maintenance costs would be excessive. However we anticipate that, over the years, the Canadian salmon stock can be increased by up to 50 per cent in this manner.

3. In areas which must remain inaccessible to spawners, salmon production can be initiated and maintained by stocking on a continuing basis from hatcheries. The only disadvantage of this procedure is that it is relatively expensive. Hatchery techniques can also be used to establish runs rapidly in parts of rivers above new fishways.

(c) Adverse factors. Increased use of other resources will almost unavoidably have some ill effect upon salmon production. Power developments have already blocked some rivers. Even where effective fishways are provided, there is a loss of the producing river area which is flooded by the reservoir, and usually some smolt loss in going over the dam or through the turbines.

Increased lumbering activity will reduce shading of streams, raise temperatures, decrease summer flow, increase erosion and silting, and hence decrease smolt production. Chemical spraying of forests has recently caused serious salmon losses in the St. John and Miramichi drainages, and these can be expected wherever this activity continues.

Potential pollution from mines, factories and urban development will tend to increase, but can probably be held below danger levels by remedial measures.

On the whole, factors detrimental to salmon production though partly unavoidable, will probably not decrease potential production by more than 10 per cent in 25 years, if all possible precautions are taken.

Taking all the above into account, our best estimate of the salmon stocks that will be available in 1980 is 50 per cent above the "natural" production of that time. This implies extensive use of available management procedures, and hence the expenditure of considerable sums annually. Eventually, up to twice the natural production may be achieved, but it will take time to build up runs in newly-opened rivers, even after fishways are built; and the latter will itself be a fairly long process.

If the ocean cools off as predicted, the natural unassisted production should itself be considerably greater than the present; and it is on this higher natural level that the results of intensified management will be built. However, production will continue to vary considerably from year to year from natural causes. Our best prediction, with intensified management and a somewhat more favourable environment, is for an average commercial catch of 10-12 million pounds in 1980 if fishing regulations remain about the same, varying between say 6 and 17 million.

Angling will benefit from increased stocks, along with net fishing. However, the catch made by anglers depends not only upon improvement of stocks in the rivers, but also on summer weather conditions and on maintenance of angling effort and skill. The number of salmon anglers is increasing now, and if this trend continues there is a possibility that the catch per unit of angling effort will fall owing to congestion at the pools, where constant whipping of the water by amateurs may seriously disturb the salmon. However the total catch by anglers cannot fail to rise substantially, and should be at least twice the present level in 1980. This will come partly from larger catches on accessible streams, and partly from more fishing of rivers that are now difficult to reach, particularly in Newfoundland, Labrador and the north shore of the Gulf of St. Lawrence.

References

(1) Huntsman, A.G. 1938. Sea movements of Canadian Atlantic salmon kelts. J. Fish. Res. Bd. Canada, 4(2): 96-135. (This includes work previously reported by J.A. Rodd and others in Department of Fisheries Annual Reports.)

(2) Kerswill, C. J. 1955. Recent developments in Atlantic salmon research. Atlantic Salmon Journal for 1955, No. 1, pp. 26-30. (Fish. Res. Bd. Canada Studies, No. 398).

(3) Huntsman, A. G. 1931. The Maritime salmon of Canada. Biol. Bd. Canada, Bull. No. 21, 99 pp.

(4) Belding, D. L. 1939. The Atlantic salmon of the Gulf of St. Lawrence. Am. Assn. Advancement Sci., Special Pub., No. 8, pp. 26-31.

(5) Blair, A. A. 1956. Atlantic salmon tagged in east coast Newfoundland waters off Bonavista. J. Fish. Res. Bd. Canada, 13(2): in press.

(6) Huntsman, A. G. 1937. The cause of periodic scarcity in Atlantic salmon. Trans. Royal Soc. Canada (V), 31: 17-27. (Fish. Res. Bd. Canada Studies, No. 175).

(7) Elson, P.F. 1950. Increasing salmon stocks by control of mergansers and kingfishers. Fish. Res. Bd. Canada, Atlantic Prog. Repts., No. 51, pp. 12-15.

(8) Lindsay, Sheila T., and Harold Thompson. 1932. Biology of the salmon (Salmo salar L.) taken in Newfoundland waters in 1931. Newfoundland Biol. Sta., Res. Bull. No. 1, 80 pp.

(9) Blair, A.A. 1943. Salmon investigations. 1. Obstructions in Newfoundland and Labrador rivers. Newfoundland Biol. Sta., Res. Bull. No. 12, 50 pp.

ARCTIC CHAR or SEA-TROUT - Salvelinus alpinus

Present stock:	5,000,000 lb.	Utilization:	270,000 lb. (commercial) 50,000 lb. (domestic)
Stock in 1980:	5,000,000 lb.	Utilization:	400,000 lb.

History and Present Status

This species occurs along the northern half of the Labrador coast (and northward). Typically it spawns and spends the winter in fresh water, going to sea for feeding in summer. Growth is slow, especially northward.

The subsistence fishery is of course very old. Most commercial fish in recent years have been taken by Labrador residents, near the major settlements, but a schooner fishery also occasionally operates from Newfoundland. The catch is marketed in "pickled" form. The average commercial harvest has been as below, in thousands of pounds round weight:

1928-30	320
1931-35	159
1936-40	188
1941-45	64
1946-50	186
1951	122
1952	310
1953	377
1954	276

Present fishing levels have probably not greatly reduced the overall stock, though repeated visits of a schooner to one area have resulted in a decline in catch per unit effort to an unprofitable figure. Since growth is slow, and on the whole the fishery seems to be in balance, it is probably taking less than 10 per cent of the total stock per year, but the actual figure given for stock is quite speculative.

Future Prospects

Some increase in this fishery can take place by using additional local stocks, and if this is done there should be little if any general reduction in supply. However past experience gives no hope of really large production. An eventual take of 300,000-500,000 pounds can be envisaged.

SHAD - *Alosa sapidissima*

Present stock: 8,000,000 lb. Utilization: 2,000,000 lb.

Stock in 1980: 7,000,000 lb. Utilization: 2,000,000 lb.

History and Present Status

The shad is anadromous, spawning in rivers in Nova Scotia, New Brunswick, and Quebec in May and June each year. The resultant fry and small shad descend to salt water by late summer and they remain in the sea until maturity. They may return to spawn several times. Most shad are caught in the tidal portions of rivers while on their ascent to the spawning grounds. Smaller catches are made in weirs and traps along shore in summer when a better quality of fish is taken, i.e., fish that contain more fat.

During the period 1944 to 1952 the eastern Canadian catch of shad has varied from 1 1/2 to 2 1/2 million pounds yearly. Average yearly figures are as follows, in thousands of pounds round weight:

1921-25	564	
1926-30	695	
1931-35	1288	
1936-40	2125	
1941-45	1770	
1946-50	1647	
1951	2333	
1952	2444	
1953	2214	(Plus Quebec catch)[a]
1954	1562	(Plus Quebec catch)[a]

[a]Quebec figures not available for 1953 and 1954.

The maximum catch appears to have occurred in 1875, when 3 1/3 million pounds were caught.

Future Prospects

As Canada is at the northern limit of the distribution of shad on this continent, stocks have probably varied somewhat with trends in water temperature. Further increase would likely be favourable, but a lowering of temperatures in 25 years to the 1940 level should not be too serious, judging by past history. Pollution of the streams is the greatest danger to the eggs and early stages. Such pollution is likely to increase gradually, and natural conditions where the shad spawn are likely to deteriorate more and more, but we anticipate that substantial spawning grounds can be spared. Since the shad does not ascend rivers very far above tide, except in small numbers, serious interference with shad migration by power dams is not very probable, though changes in flow patterns might be unfavourable.

The above unfavourable factors will likely be counteracted by better understanding and more careful regulation of fishing effort. Hence we predict that the average production of shad will remain near the two million pound level for the next 25 years, with fluctuations up and down such as have occurred in the past.

Reference

(1) Leim, A. H. 1924. The life-history of the shad (Alosa sapidissima (Wilson)) with special reference to the factors limiting its abundance. Contr. Canadian Biol., N.S., 2(11): 161-284.

ALEWIVES or GASPEREAU - Pomolobus pseudoharengus and Pomolobus aestivalis

Present stock:	100,000,000 lb.	Utilization:	33,000,000 lb.
Stock in 1980:	80,000,000 lb.	Utilization:	30,000,000 lb.

History and Present Status

The alewives are anadromous fish that ascend rivers in the Maritime Provinces on which there are lakes. They are rarely seen in Newfoundland. Spawning takes place chiefly in lakes, although some may occur in the sluggish portion of streams. Spawning occurs in the late spring and the progeny descend to the sea in late summer and early autumn, remaining there until maturity is reached.

Very similar to shad in appearance, alewives are much smaller and less valued on the market. The fishery is carried on in rivers and near their mouths when the alewives are returning to the spawning grounds. The major catches are in New Brunswick; none are reported from Quebec.

In the period 1944 to 1954 the total yearly catch in the three Maritime Provinces varied from 9 to 41 million pounds. Average yearly catches since 1921 were as follows, in thousands of pounds:

1921-25	4337
1926-30	6055
1931-35	7067
1936-40	9085
1941-45	9344
1946-50	16885
1951	29057
1952	41056
1953	34091
1954	29380
1955	26412

The recent period is one of large landings, resulting partly from increased supplies which presumably result from more favourable temperatures.

Future Prospects

It is probable that the catch of alewives in the rivers can be increased if markets improve. As spawning is chiefly in lakes, pollution is not likely to have much adverse influence on the success of reproduction. There has been some reduction in available spawning grounds in Nova Scotia, caused by the construction of power dams, but no really serious trouble from this source is anticipated. The annual catch of alewives in 25 years may average about 30 million pounds, and it will probably be taken from a somewhat smaller stock than to-day's, because of predicted cooler temperatures.

EEL - Anguilla rostata

Present stock:	large	Utilization:	320,000 lb.
Stock in 1980:	no important change	Utilization:	2,000,000 lb.

History and Present Status

Eels spend 8-12 years in lakes and then migrate to deep ocean waters to spawn and die. The young migrate up the rivers. They occur in commercial quantities north to Newfoundland. Mainland catches per year have been as below, in thousands of pounds.

1936-40	194
1941-45	161
1946-50	261
1951	297
1952	294
1953	353
1954	333

Large numbers of eels can be taken in fall by trapping the seaward-migrating maturing fish, and immature fish which are moving to "hibernating" areas. The fishery would be largely seasonal.

Future Prospects

Potential markets for eels are: (1) north European countries, where they are highly esteemed as food and the local supply does meet the demand; (2) domestic and United States markets to fill increasing demands from people of north European origin and from such "natives" as can be taught to appreciate this delicious fish.

A catch of at least 10,000,000 pounds would likely be available, but possibly only 2,000,000 pounds will be marketed by 1980.

Modern dams may interfere locally with upstream migration of young, but eels are adept in passing obstructions even through small leaks of water. They readily use fishways.

CAPELIN - *Mallotus villosus*

Present stock: large

Utilization : 35,000,000 lb. (mostly non-commercial)

Utilization in 1980: 100,000,000 lb.

History and Present Status

Capelin are extremely abundant in Newfoundland waters and the northern mainland area, but at present are used mainly for bait, fertilizer and dog food, and to some extent for reduction. They are also salted or smoked for human use, but on a very small scale. Estimates below are the average yearly catch for ICNAF Subareas 3 and 4, in millions of pounds:

Years	Subarea 3 and 4R	Subarea 4 (except 4R)
1947-50	38	1
1951	42	2
1952	34	1
1953	32	?
1954	32	?

Future Prospects

Meal plants for capelin alone would not at present be profitable from the shortness of the capelin season, several weeks to a month in any one area. They can be used in herring reduction plants but at present there is only one of these in the Newfoundland area and that is on the west coast of the island where capelin are not as plentiful as on the east coast. At a guess, several hundred thousand tons per year could probably be taken, but it is not easy to see how such a quantity would be utilized. It is a good food fish in the fresh or frozen condition and apart from its unfamiliarity could compete with smelts. It is abundantly available, however, only at the season when the cod also come close to the shore in great quantities, in pursuit of the capelin. At this time plants and people are working day and night to process the cod so that there is little labour or plant space remaining to deal with capelin.

For our best estimate, we consider that some facilities for capelin will be available in 1980, but that the resource will not yet be fully utilized.

Reference

(1) Templeman, W. 1947. Life history of the capelin (*Mallotus villosus* O.F. Müller) in Newfoundland waters. Newfoundland Biol. Sta., Res. Bull. No. 17, 151 pp.

SMELT - Osmerus mordax

Present stock: 40,000,000 lb. Utilization: 6,000,000 lb.

Stock in 1980: 35,000,000 lb. Utilization: 5,000,000 lb.

History and Present Status

The smelt is a small anadromous fish, spawning during spring in small tributaries. In salt water they have never been found more than a mile or so from the outlets of their spawning streams. Smelt occur abundantly in northern New Brunswick, Quebec and in several areas along the west coast of Newfoundland. They are also present on the north and east coast of Newfoundland in modest amounts. Trap nets, gill nets, and seines are used in the commercial fishery during the autumn and winter. Over one-third of the total Canadian catch is taken from the Miramichi River system in New Brunswick.

Average catches are as shown below in thousands of pounds.

	Mainland	Newfoundland	Total
1936-40	7740	349	8089
1941-45	6680	194	6874
1946-50	6498	197	6695
1951	6337	143	6480
1952	4032	55	4087
1953	6304	105	6409
1954	4523	34	4557

The Newfoundland catch has declined from a peak of about 400,000 pounds in the late 1930's to 100,000 pounds or less to-day. Mainland catches are much larger, but also show considerable decline. Smelt are not strong swimmers and are held out of suitable spawning areas by small obstructions. It is susceptible to interference with its habitat by the encroachment of civilization. Most of the commercial catch is taken from the earlier stages of the spawning run in small trapnets set near the mouths of rivers, sometimes through the ice.

Future Prospects

The future of the smelt fishery depends upon the practicability of management to increase supplies, for example by increasing spawning areas, or perhaps simply by permitting larger escapements in some places. Improved handling methods would increase consumer demand, which would be advantageous where supplies are good.

The present situation is not a very optimistic one. Availability of smelts in New Brunswick has fallen off 25 to 50 per cent during the last 25 years and demand has also fallen off recently. In Newfoundland catches are about a third of former levels. We cannot yet be sure of reversing the trend, but some assistance may come from the cooler weather anticipated after 5 or 10 years: this will improve the firmness of the ice and hence fishing conditions in the Miramichi estuary.

Reference

(1) McKenzie, R. A. 1946. The smelt fishery of northeastern New Brunswick. Bull. Fish. Res. Bd. Canada, No. 70, 20 pp.

SWORDFISH - Xiphias gladius

Present stock:	50,000,000 lb.	Utilization by Canada:	3,500,000 lb.
		" " others:	800,000 lb.
Stock in 1980:	no change	Utilization by Canada:	5,000,000 lb.
		" " others:	2,000,000 lb.(?)

History and Present Status

The swordfish is a large pelagic fish. It is a summer visitor in northern waters, where in recent years it has reached the southwest slope of the Grand Bank in numbers. The catch is taken chiefly by harpoon boats. The Canadian catch has increased since 1935, accompanying the increase in water temperatures Our average yearly landings have been as follows in thousands of pounds round weight:

1936-40	1692
1941-45	2201
1946-50	2265
1951	2544
1952	3157
1953	3324
1954	4209

We now take 80 per cent or more of the combined removals by Canada and the United States from the common stock.

Future Prospects

Canadian fishing grounds are at the northern end of the range of the swordfish, and the stocks will probably become less accessible with the water temperatures anticipated 25 years hence. This southern shift of the centre of summer abundance of swordfish will place United States fishermen in a better competitive position. However improvement in Canadian vessels and harpooning methods are likely to more than maintain the total catch. The stock is apparently quite large, but the 50 million pounds above is only a guess.

BLUEFIN TUNA - Thunnus thynnus

Present stock:	large, but only partly accessible	Utilization:	400,000 lb.
Stock in 1980:	similar	Utilization:	800,000 lb.

History and Present Status

The tuna is a large roving fish of the warmer seas, and a summer visitor to northern waters. Its life-history in the western Atlantic, and the range of individual fish, are unknown.

In Canada schools come close to the Nova Scotia coast at Lockeport and elsewhere, and at times they are moderately abundant in the Newfoundland bays, where small numbers are caught in occasional years. Average yearly catches, in pounds round weight, have been as follows:

Mainland		Newfoundland	
1936-40	663,000	1937	473
1941-45	454,000	1940	1,553
1946-50	1,011,000	1943	608
		1944	439
1951	475,000	1948	6,257
1952	667,000	1952	8,950
1953	375,000		
1954	284,000		

Catches about four times the above are taken off the Atlantic coast of the United States.

Future Prospects

In order to obtain full utilization of this resource, improved fishing practices must be developed. Eventually international regulation of catch may become desirable, but at present stocks appear to be large in relation to utilization. At present Canada is taking about 20 per cent of the total catch, the United States the remainder.

The fishery of the future will also depend on the arrangement of water masses. Cooling of North Atlantic waters would make the fish less accessible to Canadians, and year-to-year temperature changes will probably always make yields fluctuate erratically.

The estimate of a 800,000 pound catch in 1980 depends on the use of improved fishing techniques which will more than compensate for a predicted lesser accessibility of the stock.

SHARKS OTHER THAN DOGFISH

Blue shark	- *Prionace glauca*
Hammerhead shark	- *Sphyrna zygaena*
Thresher shark	- *Alopias vulpinus*
Mackerel shark	- *Lamna nasus*
Maneater shark	- *Carcharodon caracharias*
Basking shark	- *Cetorhinus maximus*
Greenland shark	- *Somniosus microcephalus*

Stock: unknown, moderately large

Present utilization: nil

Utilization in 1980: up to 10,000,000 lb.

Sharks are large fish, mostly summer visitors to Canadian east-coast waters. They are often abundant on the various banks. Lower water temperatures may reduce availability (except of the northern Greenland shark) but major changes are not anticipated within 25 years. At present they are not used but they represent a substantial source of available oil and protein. Their utilization depends upon the development of efficient methods of capturing, handling and processing.

Some species, at least, can provide very palatable human food: fresh mackerel shark tastes much like pork steak, for example. The skin of some sharks provides a usable leather, or shagreen. Occasionally they might be taken in sufficient quantity to be used in a reduction industry, but at the moment that by itself seems unlikely to justify a fishery within 25 years.

Our best forecast is for some utilization by 1980, say up to 10 million pounds a year, but that the stocks will not yet be fully utilized.

MINOR OR UNDEVELOPED FISH RESOURCES

Tomcod	- Microgadus tomcod
Striped bass	- Roccus saxatilis
Sturgeon	- Acipenser sturio
Silverside	- Menidia menidia
Launce	- Ammodytes americanus
Billfish	- Scomberesox saurus
Ocean pout	- Macrozoarces americanus
Sculpin	- Myoxocephalus scorpius
	Myoxocephalus octodecemspinosus
Angler	- Lophius americanus

There are a number of fishes which play parts of some local significance, and which may in some cases allow for somewhat expanded exploitation. Other species, now used little or not at all, are of large potential importance. The following may be considered:

Tomcod

The tomcod is a semi-anadromous species. It is no place abundant enough to support a well-organized fishery and much of the catch is incidental to the smelt fishery. Price is lower than the quality justifies and a change in national economy may lead to the considerably expanded use which the stock could support. However, the current trend in utilization is down. It is expected that utilization will not greatly change in 25 years and will remain at about 1,500,000 pounds.

Striped Bass

The striped bass occurs and has supported a small and fluctuating commercial fishery at various points along the coast: the head of the Bay of Fundy, the outer shore of Prince Edward Island, and the Miramichi and Richibucto regions of New Brunswick. The commercial catch has averaged about 20,000 pounds a year recently. The species is anadromous, usually spawning close to the head of tide, but sometimes ascending to lakes--especially in the Shubenacadie system of Nova Scotia.

Along the Atlantic coast of the United States it is one of the most important game fishes. The sport catch in Canada was estimated as 14,200 fish weighing 101,500 pounds, in 1954, but a division between salt water and freshwater catch is not available.

In the United States the striped bass has fluctuated considerably in the past, and the present abundance is probably associated with prevailing warm ocean temperatures, at least in part. No thorough test has been made of its possible availability to anglers in Canada, by surf casting, and potentialities may be much greater than is at present realized.

Sturgeon

An anadromous, late maturing fish which does not react favourably to fishing. No real increase can be expected in the current yield of some 3,000 pounds annually.

Silverside

A small fish of warm bays, locally abundant but not dependable in large quantities as the basis for an industry. Small quantities are used as fox food.

Sand Launce

Launce are abundant on the Grand Bank, but apart from occasional captures for bait, no production is expected.

Billfish

Stocks of these pelagic fish are sporadically available in summer months, north to the Newfoundland area in warm years. They occur in quantities large enough to maintain a substantial fishery if economic methods of capture could be developed. The flesh is of good quality, and if the supply could be assured, it is probable that markets could be built up readily.

Trashfish: Ocean Pout, Sculpins, Angler

These species are not currently used but have had use in the "trash fishery" for reduction during the war. Under favourable economic conditions, this fishery will revive and may be expected to produce about a million pounds annually in Canada from each species. The angler is marketed for food in Europe and will no doubt eventually be used in North America.

LOBSTER - *Homarus americanus*

Present stock:	73,000,000 lb.	Utilization:	48,000,000 lb.
Stock in 1980:	67,000,000 lb.	Utilization:	48,000,000 lb., after having declined from a higher level

Lobsters occur in Canadian waters from southern New Brunswick and Nova Scotia to Newfoundland. The fishery is pursued energetically in inshore waters with gear which is kept stabilized in design by tradition and regulation. Growth is relatively slow, the lobsters requiring 5 to 6 years to reach legal size (about 7" total length) in the canning areas and 7 to 8 years to reach legal size (about 9" total length) in the market lobster areas (1). Age at maturity varies from 5 to possibly 15 years and is related to water temperatures. Egg laying occurs principally during the summer. The eggs are carried externally by the mature females for a full year and hatch the following summer. The young are pelagic and subject to surface drift and high variable mortality leading to fluctuations in year-class strength. Movements of lobsters after they take up life on the bottom are very limited (2).

Maritime Provinces and Quebec

Present stock:	65,000,000 lb.	Utilization:	43,000,000 lb.
Stock in 1980:	62,000,000 lb.	Utilization:	45,000,000 lb.

History and Present Status

Statistics of lobster production in the Maritime Provinces and Quebec were not recorded systematically before 1870. After this date, as the fleet grew and as accumulations of large old lobsters were discovered, landings rose rapidly to a peak of over 80 million pounds about 1890. This was followed by a rather steady decline to 1918 when landings totalled 26 million pounds. During the past 35 years landings have been fairly steady, though higher levels have prevailed since the early 1940's. The 35-year average is 36 million pounds, with a low of 27 million pounds in 1940 and a high of 48 million pounds in 1932. The 5-year average for 1950-54 was 43 million pounds. Average yearly landings since 1870, in millions of pounds live weight, are as follows:

Period	Quantity	Period	Quantity	Period	Quantity
1870-74	19.0	1905-09	64.7	1940-44	29.2
1875-79	41.3	1910-14	53.4	1945-49	36.2
1880-84	82.4	1915-19	40.3	1950	44.7
1885-89	79.8	1920-24	36.3	1951	45.6
1890-94	82.9	1925-29	33.9	1952	44.1
1895-99	73.2	1930-34	41.2	1953	41.9
1900-04	67.7	1935-39	30.8	1954	41.2

The lobster fishery is intensive. On the basis of extensive taggings conducted since 1942, it is estimated that approximately 2/3 of the legal-sized

stock is taken annually. This indicates a present average stock of legal-sized lobsters of about 65 million pounds.

Future Prospects

Recent increased landings are related to higher water temperatures. If temperatures decline to the level of the early 1940's, catches may decline to 35 million pounds. However more intensive management based on better knowledge of local stocks might increase this by as much as 30 per cent. This would raise the 1980 estimate to about 45 million pounds. Production during a warm-water period might reach 54 million pounds, and this can be expected if the cooler temperatures fail to appear.

Newfoundland

Present stock:	8,000,000 lb.	Utilization:	5,000,000 lb.
Stock in 1980:	5,000,000 lb.	Utilization:	3,000,000 lb.

History and Present Status

The lobster population appears to be well utilized all round the Newfoundland coast and no major unutilized populations are likely to exist. Statistics since 1910 are as follows, in thousands of pounds live weight:

1911-15	4059
1916-20	2057
1921-24	1490
1925-27	Close Season
1928-30	3263
1931-35	2041
1936-40	3395
1941-45	2116
1946-50	4387
1951	4330
1952	3709
1953	4537
1954	5243

One tagging study in St. Georges Bay in 1938-39 gave approximately a 60 per cent yearly fishing mortality in lobsters of commercial size, and it has remained at least as great. Hence the present stock is estimated as 5/0.6 = 8 million pounds, approximately.

The abundance of lobsters is likely to depend chiefly on temperature. Recent landings have been increasing during the present warmer part of the climatic cycle, since 1943.

Future Prospects

Since a good deal of the Newfoundland area is low or intermediate in temperature in relation to survival of lobster young, increasing temperatures would be expected to increase the population and catch and decreasing temperatures to decrease it. Accordingly, the predicted cooler ocean temperatures by 1980 should, if they occur, decrease lobster supplies and production.

References

(1) Wilder, D. G. 1953. The growth rate of the American lobster (Homarus americanus). J. Fish. Res. Bd. Canada, 10(7), pp. 371-412.

(2) Wilder, D. G. 1954. The lobster fishery of the southern Gulf of St. Lawrence. Fish. Res. Bd. of Canada, Biol. Sta., St. Andrews, Circular (General Series), No. 24, 16 pp.

(3) Templeman, W. 1941. The Newfoundland lobster fishery: an account of statistics, methods and important laws. Newfoundland Biol. Sta., Res. Bull. No. 11, 42 pp.

(4) Templeman, W., and S. N. Tibbo. 1945. Lobster investigations in Newfoundland, 1938 to 1941. Newfoundland Biol. Sta., Res. Bull. No. 16, 98 pp.

OTHER CRUSTACEANS

Rock crabs - Cancer irroratus; C. borealis
Shrimps and prawns - Pandalus spp., etc.

Rock Crabs

These support a fishery in the New England States that during recent years has produced from 1,200,000 to 3,700,000 pounds. These crabs are virtually unused at present in Canada. Very little is known about this Canadian resource but the crabs are known to be widespread north to Newfoundland, and abundant in certain areas. If the demand for chilled crab meat continues to grow, our more extensive coastline might support a crab fishery of up to 10,000,000 pounds.

Shrimps and Prawns (Several genera and species)

About 30 species of shrimps and prawns are known to occur on the Atlantic coast. None of these are as yet exploited commercially although some of the species are fished commercially in other countries. Pandalus borealis occurs at sizes that are commercially acceptable, and is widespread in both Subarea 3 and Subarea 4. Landings of this species reached a peak of 1/2 million pounds in Maine in 1945. Landings of related species in British Columbia totalled 1 1/4 million pounds in 1952. Much greater landings of related species are made in northern Europe.

Limited exploration has not yet revealed populations of shrimp sufficiently concentrated to provide profitable fishing at present prices. If the demand for shrimp were to increase it seems probable that a million pounds could be caught annually on the Atlantic coast.

OYSTER - *Crassostrea virginica*

Present stock:	10,000,000 lb.	Utilization:	5,000,000 lb.
Stock in 1980:	50,000,000 lb.	Utilization:	25,000,000 lb.

(The above weights include the shell.)

History and Present Status

This oyster thrives in warm bays of reduced salinity, from low water to 30 ft. depth from Mexico to northern New Brunswick. In Canada it thrives only in the southern part of the Gulf of St. Lawrence and in the Bras d'Or Lakes. The young are free swimming for some three weeks during which they are subject to many sources of mortality. Others are lost when they settle to the bottom in unfavourable locations. If they settle on good bottom they are relatively safe, but they can be silted over and smothered, crushed by ice, killed by starfish, attacked by disease or riddled by a boring sponge. Survivors reach a marketable size of 3 inches in 4 to 6 years.

Oyster production comes from unleased public fisheries, and from cultivated leased grounds. On the leases, suitable material for settling is put in likely places and the young oysters are protected from many of the hazards afflicting them after settling.

Production has fluctuated, reflecting climatic factors and perhaps the incidence of disease, but a mean annual yield of 17 million oysters can be expected of which New Brunswick produces about 10 million, Prince Edward Island 5 million, and Nova Scotia 2 million. The above 17 million oysters weigh about 5 million pounds, in the shell. Average yearly production has been as follows:

1936-40	4048
1941-45	5976
1946-50	9880
1951	6885
1952	7342
1953	7177
1954	4882

In the Maritime provinces as a whole, production to-day is divided about equally between the public fisheries and the leaseholds. The former exploit the wild populations which flourish without the intervention of culture practices and which are in the public domain. No exact measure of the exploitation rate has been attempted, but it is believed to be about 50 per cent of the commercial-sized stock available each year.

For some years most Maritime oysters have been shipped to Montreal in the fall, where they are held in cold air storage in the shell for consumption on the half-shell during the winter months. In the United Kingdom, Holland and France oysters are also largely consumed in the half-shell trade. This is in sharp contrast to the practice in the United States, where most oysters are shucked (taken out of the shells) at the coast and shipped from there in refrigerated cans. The reason for the difference is economic. The United States produces so many oysters (more than one hundred times as many as Canada) that she can more than saturate the market in her coastal cities. She has therefore reached out to

the markets in her great inland cities, but in order to reach them economically, she cannot afford transport charges on the heavy shells. Eastern Canada, on the other hand, is just now saturating Montreal with oysters in the shell, by shipping almost her entire production there.

Future Prospects

Canadian Atlantic oysters are of high quality and more of them can be produced by present techniques. Many times more could be produced if certain key problems in their production could be solved. Because oyster fishing and oyster farming are part-time occupations and because the present market will not accept substantially larger quantities, the techniques of oyster farming now available are not very diligently practised in most cases. Besides this, the oyster fishery on both public and leased grounds suffers from a shortage of seed stock. Sets of oyster larvae of commercial significance do not occur every year partly because of adverse water temperatures. This automatically limits the public fisheries to a low and fluctuating value. It also seriously hampers the oyster farmer, who must catch and culture the wild seed. He gets it either at the time it sets by using artificial collectors, or a few seasons later by gathering small oysters from inshore water where they have settled on natural objects. Both methods are simple in principle, but failures of sets of commercial importance, especially on artificial collectors, are costly and discouraging. Mainly for this reason, the leaseholds are producing at roughly one-tenth of their capacity given sufficient seed.

Prospects that seed supply will become adequate within the next ten years are reasonably good. The expected trend of water temperatures would favour this development and at the same time favour increased production from the public beds. A reasonable prediction of landings 25 years hence would therefore be 75 million oysters (25 million pounds in the shell).

Marketing the larger production will probably involve a partial shift to local shucking before shipment, as in the United States.

Introduction of the European flat oyster, Ostrea edulis, may permit expansion of the industry northward. However no allowance for this is included in our estimate of 1980 production.

Reference

(1) Needler, A.W.H. 1941. Oyster farming in Eastern Canada. Bull. Fish. Res. Bd. Canada, No. 60, 83 pp.

SCALLOP - Placopecten magellanicus

Present stock: 25,000,000 lb. Utilization: 1,500,000 lb.

Stock in 1980: 20,000,000 lb. Utilization: 3,000,000 lb.

(The above weights are of shucked meats; the whole animal, including shell, weighs about 9 times as much.)

History and Present Status

Scallops have an early, free-swimming stage before settling to the bottom. The best fishing areas are variable from place to place and from time to time. Rotation of fishing areas is frequently desirable to assure continued profitable operation. This is especially true on offshore grounds.

Scallops occur from Cape Hatteras to Labrador but are of commercial significance only between Cape Cod and Newfoundland. Average yearly landings, in thousands of pounds shucked weight, have been as follows:

	Mainland landings	Nfld. landings	Total
1936-40	1131	12	1143
1941-45	722	9	731
1946-50	771	58	829
1951	569	135	704
1952	1270	148	1418
1953	1607	179	1786
1954	1480	239	1719

Canada landed only about 0.75 million pounds annually between 1940 and 1950, about half of which was exported to the United States. But landings have increased markedly in the past four years. The total for 1955 is likely to be close to 2.0 million pounds. At the same time exports have diminished. Further increase in landings seems possible and likely, and with modern handling methods the trend towards home consumption will probably continue.

The important inshore fishery in the Digby area of the Bay of Fundy takes about 500,000 pounds, 10 to 15 per cent of the stock annually (1, 3). The fishery here cannot be increased by more than half without incurring marked fluctuations because of year-class variation in sets. These are best in warm-water years.

Another important inshore fishery is in Port au Port Bay, Newfoundland, from which in 1954, 240,000 pounds were landed in Newfoundland and a large amount also on the mainland.

The offshore fishery is of recent development in Canada. It is mainly based on newly established grounds (St. Pierre bank especially) although recently about a third of its landings were from established grounds in Subarea 5 (Georges Bank). Its continued prosperity at the present level will depend upon further exploration, since the bulk of the catch of the last year or two represents the rich initial harvest from the new areas rather than their possible sustained yield.

These offshore grounds are accessible to other nations also, and may eventually need international management.

Future Prospects

Some increase in production may arise from fuller exploitation of the Newfoundland inshore grounds, and from discovery of new offshore grounds. We believe that the sustained product of offshore banks is likely to exceed the Digby production.

A development which could increase the weight of scallops marketed would be the utilization of the gonad for food in America: elsewhere it is regarded as a delicacy.

Best prediction of 1980 Canadian production is twice the 1951-54 level, or 3 million pounds shucked weight--not including gonads.

References

(1) Dickie, L. M. 1952. Changes in Digby scallop landings--How and Why. Fish. Res. Bd. Canada, Atlantic Prog. Rept., No. 54, pp. 12-18.

(2) Dickie, L. M. and L.P. Chiasson. 1955. Offshore and Newfoundland scallop explorations. Fish. Res. Bd. Canada, St. Andrews Biol. Sta., Circular (General Series), No. 25, 4 pp.

(3) Dickie, L. M. 1955. Fluctuations in abundance of the giant scallop, Placopecten magellanicus (Gmelin), in the Digby area of the Bay of Fundy. J. Fish. Res. Bd. Canada, 12(6): 797-857.

SOFT-SHELLED CLAM - *Mya arenaria*

Present stock:	17,000,000 lb.	Utilization:	7,000,000 lb.
Stock in 1980:	15,000,000 lb.	Utilization:	5,000,000 lb.

(The above weights include the shell.)

History and Present Status

The soft-shelled clam is found throughout the Maritime Provinces, and to a limited extent in Quebec and western Newfoundland. The distribution of colonies that are large enough and compact enough to reward commercial exploitation is discontinuous. They depend on suitable soil conditions and other incompletely understood environmental factors. Most of the important colonies are readily accessible in the intertidal zone or close to it (not more than 1 fathom at low tide). The individuals grow slowly, reaching marketable size only after 4 to 6 years. Mortality rates are high, about 50 per cent per annum, from predators and from being buried in digging operations.

Average annual catch is shown below, in thousands of pounds (in the shell):

	Catch
1936-40	7926
1941-45	10650
1946-50	17294
1951	15949
1952	11977
1953	9493
1954	7340

The soft-shelled clam to-day comes second among our commercially valuable mollusks, the 1954 yield being valued at $400,000. From 1949 to 1951 inclusive it had been in first place, total landings reaching 23,000,000 pounds valued at $543,000 in 1950. This change was brought about by the sudden popularity of fried clams on menus in northeastern United States and decreases in supplies from beds in that region. Production had previously depended on demand but since 1940 it has depended on supply. The sudden increase in production reflects the expansion of the industry to make use of all available stocks. The expanded fishery harvested the heavy accumulated stocks, and yields are now approaching what appears to be steady production level of about 5,000,000 pounds a year.

Clam digging is a valuable supplement to many incomes in the Maritime Provinces. Few people have clam digging as their main source of income.

Future Prospects

It seems unlikely that future production of our clam beds will differ greatly from the stable level now being approached. The expected cooling of the coastal waters in the next 25 years seems likely to have little direct effect on the level of production. It may, however, tend to reduce the abundance of the green crab, which very recently invaded the Fundy area and is now considered to be the chief clam predator.

Pollution of coastal waters by domestic sewage seems to be increasing slowly, and this tends to restrict the fishery. Methods of combating this have been devised, but they are costly and seem unlikely to offset the effects of increased pollution except in a few areas. Pollution by industrial wastes is of limited extent.

QUAHAUG or CHERRYSTONE CLAM - Mercenaria (Venus) mercenaria

Present stock:	13,000,000 lb.	Utilization:	3,300,000 lb.
Stock in 1980:	13,000,000 lb.	Utilization:	5,000,000 lb.

(The above weights include the shell.)

History and Present Status

The quahaug or hard-shelled clam is at the northern end of its range in Canada. There is some evidence that the critical spawning temperature for this species is 24° C. (75° F.). This temperature is reached only rarely by our waters and then only in the shallower parts of highly sheltered inlets in the southern Gulf of St. Lawrence with wide sun-warmed intertidal flats. Consequently this bivalve is found in large populations in only a few areas, the principal ones being the Neguac region of Miramichi Bay, N.B., and the Panmure Island area of Prince Edward Island. It seems to flourish very well in both these areas, and in other bays there are small populations contributing to local demands rather than to a larger market.

While the entire take of this species is still small, it has increased markedly in recent years. The following table shows the catch in thousands of pounds, in shell:

1948	140
1949	664
1950	690
1951	1035
1952	2616
1953	4669
1954	3457

The landed value of the catch in 1953 was $193,000 and in 1954 it was $134,000, or about 4 cents per pound. The quahaugs shipped are not uniform in size, but the number marketed was of the order of 20 million in 1953 and 17 million in 1954.

Because almost no data on natural mortality are available, only guesses can be made of total stocks. The exploitation rate is equally vague. It is judged to be in the neighbourhood of 25 per cent of the standing crop of marketable-sized animals (2 inches in length) and this latter is probably of the order of 50 to 75 million.

About five years ago a strong demand from the United States arose for small quahaugs for consumption on the half-shell. Concurrently the minimum size limit for this species was lowered from 2 1/4 inches to 2 inches and the seasonal fishing closure was abolished. The take increased several fold, and has been maintained to date.

Future Prospects

Methods of farming quahaugs have been successful in Maine, where conditions are not unlike our own. Seed stocks are moved from crowded areas where survival and growth are poor to good maturing grounds. We might profitably imitate this practice at certain times and places, perhaps using a mechanical digger to collect

the seed. However, operations are likely to be limited because they must depend on natural seed production which occurs only in a few areas, and sporadically even there. The anticipated trends in the temperatures of coastal waters suggest that conditions now and in the next five years will prove to be the best we have experienced for at least 30 years.

It is difficult to predict the course of the fishery in the next 25 years. It has increased 500 per cent in the last 5 years. Presumably this rise will continue at a lower rate for the next 15 years (say), after which a decline may set in as a result of falling temperatures.

Reference

(1) Kerswill, C. J. 1941. The growth of quahaugs in Canada. Fish. Res. Bd. of Canada, Atlantic Prog. Rept., No. 30, pp. 3-5.

OTHER MOLLUSCS

Bar clams = Spisula solidissima
Razor clams = Ensis directus
Mussels = Mytilus edulis
Periwinkles = Littorina littorea

Bar Clam

A widely distributed clam nowhere abundant enough to encourage intense exploitation. The production in 1954 was 572,000 pounds (in the shell). Demand, rather than supply, seems to limit fishing actively, but with increasing demand supply will restrict production to some 2,000,000 pounds. Growth is slow in Canada and the species does not lend itself to culture.

Reference

(1) Medcof, J.C. and J.S. MacPhail. 1955. Survey of bar clam resources of the Maritime provinces. Bull. Fish. Res. Bd. Canada, No. 102, 6 pp.

Razor Clam

The only known colony large enough to encourage commercial exploitation is at the head of St. Mary Bay, N.S. There is no reason to anticipate a change in current production of 25,000 pounds annually.

Mussels

Mussels are common throughout our region and probably represent the greatest source of mollusk flesh that is readily available on our coast. Little is known about the species in our region and it is little used. In 1954 only 180,000 pounds (in shell) valued at $2,500 were packed in the Maritime Provinces, and small quantities have been packed in Newfoundland at times. Production is limited entirely by demand.

If public taste for the species could be cultivated there seems to be nothing to prevent it becoming our most valuable commercial mollusk, worth several million dollars annually. In several European countries the same species is regularly used and supports a major industry.

The chances for modifying the food habits of our people or of developing an export market to countries where it is relished in the next 25 years are not bright. Our people are conservative in their tastes and mussel-eaters in other countries already get all they want from their own supplies, which are to a large extent cultured.

Increasing demands for protein foods may stimulate an increase in mussel production but probably to no more than three or four times the present level by 1980.

Periwinkles

Periwinkles are widely distributed on our coast but they have been little studied. In most places only a small percentage of the animals are large enough to be used as food and there has been no systematic search for concentrations of large animals. A few are known and are irregularly exploited but the volume of production has always been clearly limited by demand of our domestic market, not by supply. In 1950 the Maritime Provinces marketed 2,000 pounds (in the shell) valued at $100. Without doubt this could be increased several thousand per cent if local demand or an export market were to develop. Neither of these seems likely within the next 25 years.

SQUID - Illex illeceebrosus

Present stock: large, but fluctuating Utilization: 8,000,000 lb.

Stock in 1980: no change Utilization: 15,000,000 lb.

History and Present Status

The squid is a fluctuating resource, often very abundant and in some years very scarce. Now used almost entirely for bait for local use and for the Portuguese fleet, it was formerly sold in moderate amounts in the dried condition to the Chinese market.

Production is mainly in Subarea 3; much smaller quantities are taken in Subarea 4. The figures below include bait depot collections, but do not include several million pounds used fresh by Newfoundland fishermen, in years when they are available. Average yearly catch, on the above basis, was as follows, in thousands of pounds:

	Newfoundland (Subarea 3 plus 4R)	Mainland (Subarea 4 except 4R)	Total
1911-15	76	?	76+
1916-20	239	?	239+
1921-25	671	?	671+
1926-30	2524	?	2524+
1931-35	1241	?	1241+
1936-40	4373	451	4824
1941-45	386	165	551
1946-50	2597	404	3001
1951	2775	154	2929
1952	4915	214	5129
1953	7157	337	7494
1954	11331	165	11496

The fluctuations in the resource are better shown in a year-by-year tabulation. The years 1930-31, 1933-34, 1941-45 and 1949 produced very few indeed. Recent years have been rather consistently productive.

Sales to foreign fishermen have increased greatly in recent years, being largely responsible for the peak production of 1954.

Even when squid appear in greatest abundance, they are taken in the most primitive way, by jigger. Public sentiment and the fishermen oppose capture by purse seine or trap. Using these gears, considerably larger catches could be made.

There is at present no way of influencing the production of good year-classes of squid, though some possibility exists of predicting them early in the season from catches of small squids on the Banks.

The principal importance of squid in Canadian economy is in relation to the line fishery for cod. Squid bait is twice as productive as any other kind, in terms of cod taken per hook or per pound of bait. In spite of this, other baits are still widely used. Even if frozen capelin and frozen herring

bait cost nothing, it would still pay fishermen in the Newfoundland area to invest 20 cents or more per pound for squid bait. The present domestic price is about 3 cents per pound. Portuguese fishermen appreciate the value of squid bait and will pay several times this price. While the merit or ethics of selling the superior bait to our competitors can be argued, the supply should first be made as available as possible to Canadian fishermen by adequate storage for use in poor years, and for use in the early part of every year before the current year's supply arrives inshore.

A much less important aspect of squid fluctuations is in respect to pilot whales. The latter feed almost exclusively on squid, in summer at least. In year's of squid abundance the whales come close to shore and can be taken in "drives" in large numbers. Without squid, they are much scarcer inshore.

Future Prospects

Whatever the causes of fluctuation in squid from year to year, they do not seem to follow any known temperature trends so there is no basis for predicting a general increase or decrease in supply in years ahead. Presumably fluctuations will continue, though there is some chance that greater utilization would lessen the degree and/or frequency of failures.

We estimate that the average quantities taken can at least be doubled. This implies the relaxation of present prejudice against use of efficient gear for capturing them. With proper facilities, nearly all the take could be used by Canadian fishermen, to the very great benefit of our long-lining industry.

Considerable use of squids for human food may also develop, considering their popularity in many countries.

Our best prediction is for about twice the present total landings in 1980.

BAITWORMS

Bloodworm - *Glycera dibranchiata*
Sandworm - *Neanthes* (or *Nereis*) *virens*

Present stock:	more than 30,000,000 pieces	Utilization:	4,000,000 pieces
Stock in 1980:	no change	Utilization:	18,000,000 pieces

History and Present Status

This is a small fishery which began in Canada in 1952. In 1954 a total of about 4 million worms was landed, worth about $40,000 to the diggers. The bloodworm is taken from muddy flats of Yarmouth County, N.S., while the sandworm is harvested from sandy flats of Charlotte County, N.B. Over 90 per cent of the total landing consists regularly of bloodworms.

The worms are dug with forks resembling clam hacks and sold by count to dealers who pack them in a particular species of seaweed (*Ascophyllum Mackaii*) and ship them alive by air to the eastern United States. There they are sold as bait to salt-water sports fishermen. Digging in Canada is at present confined to the above two areas partly because of their convenient air transport. However, these flats also support the best baitworm populations found on our coast to date. Demand rather than supply limits the operations.

Future Prospects

In Yarmouth County, N.S., the most intensively dug of our flats, the rate of exploitation is relatively light--about 15 per cent. This could be much increased without danger to the stocks for several reasons. The bulk of the intertidal population appears to spawn as three-year-olds and all bloodworms die after spawning. The industry takes only sexually immature worms 3 to 4 years old that for some reason fail to spawn as early as the bulk of the population. Furthermore, there appear to be extensive deep-water populations which provide a sort of reserve spawning stock for the exploited beach.

Slow expansion of the fishery towards the economic maximum exploitation rate, possibly 60 to 70 per cent utilization per year, seems likely as human populations and their demand for bait for leisure-time fishing increase. With higher demand and rising prices some new areas may be brought into production. We forecast that in 25 years the industry will be producing at four or five times its present volume and that financial returns will be proportionately higher.

Reference

(1) MacPhail, J. S. 1954. Marine baitworms--a new Maritime industry. Fish. Res. Bd. Canada, Atlantic Prog. Rept., No. 58, pp. 11-16.

HARP SEAL - Phoca groenlandica

(1) Newfoundland-Labrador Area (the "Front")

Present stock: 2,070,000 (including pups)	Utilization by Canada:	77,000	pups
		10,000	older
	" " others:	95,000	pups
		35,000	older
	Total Utilization:	172,000	pups
		45,000	older
Stock in 1980: 3,000,000	Utilization by Canada:	150,000	pups
	" " others:	150,000	pups

(2) Gulf of St. Lawrence Area

Present stock: 1,200,000 (including pups)	Utilization by Canada:	70,000	pups
Stock in 1980: 1,200,000	Utilization by Canada:	100,000	pups

History and Present Status

The harp seal is a rather large animal of the north Atlantic and adjacent Arctic oceans. It lives to be more than 20 years old; males mature first at about 8 years of age, females at 5-8 years. It is strongly migratory and occupies the southern area of pack ice to breed, moving northward to occupy high Arctic areas of open water during the summer and autumn--mostly in Davis Strait and Baffin Bay. The east coast of Labrador and Newfoundland, and the Gulf of St. Lawrence form the early spring breeding areas of the harp seal in the west Atlantic region.

The white-coated pups born on the ice form the basis of an international commercial industry. For over 200 years there has been commercial hunting of harp seals in the northwest Atlantic. Before world war II almost 90 per cent of the catch was of pups. Now, many older seals are taken as well, constituting in some years up to 40 per cent of the catch by number. The increase in kill of older seals has coincided with the appearance after world war II of a Norwegian fleet of sealing vessels, which have not been able to regain from Russia their former sealing concessions in the White Sea. There is also some utilization, probably small, of harp seals in the Arctic by the Eskimos of Canada and Greenland.

The total kill by ships east of Labrador and Newfoundland has dwindled from half a million annually in the middle 1800's to about 220,000 in recent years (Table A). There has almost certainly been some reduction of the population. The average annual catch since 1949 is 165,000 pups, 59,000 older seals. In the 30 years previous to world war II, the average annual catch was 134,000 pups and 25,000 older seals, and at that lower level of catch the population showed no indication of increasing. Not only is the pup kill now greater, but also the kill of older seals has more than doubled, owing to inability of ships to load up on pups.

Table A. Average take of harp seals on the "Front", by Newfoundland, Canada and Norway.

Year	Country	Pups	Immatures	Adults	Totals
1901-05	Newfoundland	236,407	10,594	6,220	253,221
1906-10	"	247,923	13,395	7,950	269,268
1911-15	"	177,122	7,994	7,499	192,615
1916-20	"	125,348	3,214	1,739	130,301
1921-25	"	73,328	15,525	3,895	92,748
1926-30	"	180,573	16,030	10,162	206,765
1931-35	"	104,950	20,392	7,452	132,794
1936-40	"	136,233	14,273	4,982	155,488
1941-45[a]	"	6,847	4,666	1,290	12,803
1946-50[b]	Nfld. & Canada	60,625	21,663	11,892	94,180
1951	Canada	169,000	25,992	25,546	220,538
1952	"	67,621	6,731	10,510	85,483
1953	"	85,358	4,282	5,413	95,053
1954	"	?	?	?	?
1955	"	68,895	6,000[c]	5,200[c]	80,100[c]

			Adults and immatures	
1938	Norway	16,130	134	16,264
1939	"	24,898	6,495	31,393
1946-50	"	28,432	10,040	38,472
1951	"	72,240	61,764	134,004
1952	"	76,524	53,513	130,037
1953	"	65,825	48,645	114,470
1954	"	?	?	?
1955	"	124,600[c]	20,500[c]	145,100[c]

[a]No sealing in 1943.
[b]Sealing began from Nova Scotia as well as Newfoundland.
[c]Rounded figures.

In the Gulf of St. Lawrence, where variable ice conditions make sealing more difficult, about 70,000 are taken each year, almost all pups.

Nothing definite is known of the absolute size of the seal stocks previous to 1950. Since then, aerial photographic surveys (4) combined with studies of age compositions of catches and of the stock (2) indicate a total stock of about 3,270,000 in the northwest Atlantic--2,070,000 belonging on the Front and 1,200,000 in the Gulf of St. Lawrence. The annual pup production is about 450,000 on the Front and 215,000 in the Gulf.

The present value of the international industry is about $575,000 for fur, and $2,300,000 for oil, leather and other by-products. Of this, Canada's share is about $363,000 and $1,450,000 respectively. The pup is the most valuable source of all products, and in spite of an increased kill of older seals since 1945, the industry still stands or falls on its take of pups.

Future Prospects

Among Canadian fisheries, the sealing industry is unlikely to occupy more than a modest place, but a great deal can be done to stabilize the industry and increase its value by concentrating upon the quality of the products rather than the quantity, and by protecting the maturing and breeding stock. A sustained kill of young seals as large as the present kill probably is not possible otherwise.

The most immediate need is for protection of the breeding stock. Most of the shooting of older seals takes place during April and May after the whelping and mating season, when they haul out on the ice pack to moult. Mature females do not join them to any extent until the end of April, when they already have begun to produce the following year's pups. A closing date of April 30 for hunting by vessels would provide some protection for breeding females, but April 15 would be better. At present there are no formal laws governing the hunting season and kill, although there is informal agreement on opening dates. If practically complete protection (e.g., no hunting of old seals after April 15) were given to maturing and breeding stock, the production of young seals, under the present order of kill, should gradually build up, probably to a yield of over 300,000. Once the breeding stock is seriously down, however, it would take many years to recover.

Our best prediction for 1980 catch implies international agreement concerning the "Front" stock, to reduce or eliminate killing of seals on the ice, other than pups, and if necessary a catch quota to permit recovery of the breeding stock to a somewhat higher level. On that basis the total kill should rise to 300,000 pups by 1980, and might go higher later. In the immediate future, however, it will decrease somewhat.

The Gulf of St. Lawrence stock can probably support a somewhat larger kill of pups, and 100,000 a year is predicted for 1980.

References

(1) Fisher, H. D. 1952. Harp seals of the northwest Atlantic. Fish. Res. Bd. Canada, St. Andrews Biol. Sta., Circular (General Series), No. 20, 4 pp.

(2) Fisher, H. D. 1955. Utilization of Atlantic harp seal populations. Trans. 20th North American Wildlife Conference, 1955, pp. 507-517.

(3) Fisher, H. D., and D. E. Sergeant. 1954. A review of the harp seal problem. Fish. Res. Bd. Canada, MS Rept. Biol. Sta., No. 591, 41 pp.

(4) 1951. Seal census. Canadian Department of Fisheries, Trade News, 3(8): 7-8.

HOODED SEAL - *Cystophora cristata*

Present stock:	small	Utilization by Canada:	1500 pups
			600 adults
		" " others:	3200 pups
			1300 adults
Stock in 1980:	larger, if protection is given meanwhile	Utilization by Canada:	5000 pups
		" " others:	5000 pups

Hooded seals breed in small numbers roughly in the same area and at the same time as harp seals, though they rarely enter the Gulf of St. Lawrence. Larger breeding concentrations must occur in places farther to the north, but their exact location is as yet unknown. While only a few thousand are taken each year now in the west Atlantic (Table A), the pup is worth probably twice as much as that of the harp seal, because of a finer quality of pelt. The catch has fallen roughly from about 10,000-20,000 per year in the early 1900's to 4,000-5,000 now. The principal reason is that the parents, because they defend the young vigorously are frequently killed along with the pups (although their skins are of little value), thus drastically reducing the breeding stocks.

Hooded seals are also taken in the Arctic in small numbers.

Future Prospects

If hooded seals were completely protected from hunting by vessels, their population would gradually build up, probably to furnish a sustained yield of 10,000-20,000 pups per year--provided a way were found to take the pups without killing the parents. It would take at least 10 years to build up the breeding population under complete protection.

For our best prediction we use the lower figure of 10,000 pups, but to achieve even this will require a change in methods of taking this species, or preferably a closed season, in the very near future.

Table A. Take of hooded seals on the "Front", by Newfoundland, Canada and Norway.

Year	Country	Pups	Adults	Totals
1901-05	Newfoundland	19,418	6,952	26,370
1906-10	"	7,898	3,514	11,412
1911-15	"	9,885	4,181	14,066
1916-20	"	6,260	4,287	10,547
1921-25	"	1,986	716	2,702
1926-30	"	4,418	6,187	10,605
1931-35	"	615	380	995
1936-40	"	501	172	673
1941-45	"	274	44	318
1946-50	Nfld. & Canada	2,729	2,153	4,882
1951	Canada	2,702	963	3,665
1952	"	310	73	383
1953	"	1,786	929	2,715
1954	"	849	76	925
1955	"	1,167	336	1,500
1938	Norway	23	21	44
1939	"	1,770	22	1,792
1946-50	"	166	29	195
1951	"	6,574	1,653	8,227
1952	"	712	56	768
1953	"	2,412	1,189	3,601
1954	"	?	?	?
1955	"	3,907	1,500[a]	5,407[a]

[a]Approximate

LARGE WHALES

Finback whale - Balaenoptera physalus
Blue whale - Sibbaldus musculus
Humpback whale - Megaptera novaeangliae
Sei whale - Balaenoptera borealis
Sperm whale - Physeter catodon

History and Present Status

Records of whale catches in Newfoundland and Labrador begin just before the turn of the century. About 71 per year were taken in 1895-99, followed by 595 per year in 1900-05, 544 per year in 1905-09, and 280 per year in 1910-14. Later records are fragmentary, but an almost complete set of figures from 1940 is shown in Table A. During this time whaling was conducted from two Newfoundland ports: Williamsport on the island, and Hawke's Harbour on the southern Labrador coast. The largest single year's catch of the recent period was 760 whales in 1948. The products obtained from 574 whales in 1951 included 886,000 gallons of oil, 32,300 gallons of sperm oil, and 4,100,000 pounds of meat meal. Taking of large whales on our Atlantic coast was discontinued in 1952, for economic reasons.

Table A. Number of large whales taken and landed in Newfoundland and Labrador, 1940-55.

Year	Fin	Blue	Hump	Sei	Sperm	Totals
1940	64	1	..	7	6	78
1941	63	2	3	2	..	70
1942	62	4	1	4	..	71
1943	?	1	?	?	?	152
1944	231	5	10	1	17	264
1945	346	11	9	5	22	393
1946	502	11	5	..	11	529
1947	414	14	6	4	17	455
1948	672	57	14	4	14	760
1949	425	30	11	23	53	542
1950	408	16	16	16	29	485
1951	478	23	27	28	18	574
1952	1	..	1	..	..	2
1953	1	..	..	..	..	1
1954	..	..	..	..	..	..
1955	2	..	..	..	..	2

Fin whales: Fin whales have always been the largest contributor to the Newfoundland whale catch, at least in numbers. The take during the 1940's did not reduce their numbers, and a sustained yield of at least 400 seems quite feasible.

Blue whales: Incomplete records show that during the early days of Newfoundland whaling blue whales were much commoner in the catches. An average of 108 per year was taken during part of the period 1905-09, as compared with 365 finbacks, 80 humpback, 1.5 sei and 3 sperm whales; and this was after an initial reduction by several years' whaling. The larger size of blue whales made them relatively more important than these figures suggest. The sustained

yield from present levels of stock is probably no more than 20-25, though relief from whaling for 15 or 20 years might increase this to 40 or 50 per year, when a larger stock is reestablished and is fished moderately.

Humpback whales: This species to-day probably numbers only a hundred or two individuals in the area. The sustained yield from the present stock is no more than 15. The larger numbers taken in early years (80 per year in 1905-09; probably more previously) suggests that a larger sustained yield should be possible with moderate utilization of a stock rebuilt after 20 years or so of closure.

Sei whales: This species is southern and reaches the catching area late in the season, so supplies in our waters are probably influenced by year-to-year temperature variations. The stock is probably fairly large, and a sustained yield of 100 per year seems moderate (as compared with 28 in the last year of whaling). However the oil yield is poor, and extensive use of this species presupposes use of the meat in fresh or frozen form.

Sperm whales: Sperm whales entering our area are adult male wanderers from a tropical and sub-tropical stock. Potential catch is thus difficult to estimate, but the north Atlantic stock is apparently quite large. From 1945 to 1951 the mean annual catch was 23.

Future Prospects

All the above comments on whales refer to those which reached the area formerly covered by the whaling stations of Hawke's Harbour and Williamsport. There are other stocks of the same species off the Bay of Fundy and the east coast of Nova Scotia which might be exploited. To what extent these stocks intermingle with those formerly whaled off Newfoundland is not known. The southern specimens seen to-day are of very large size and seem quite fearless of man, which suggests they may be a different group.

Interest is currently developing in whale meat as animal food. This is an important factor in supporting the British Columbia whaling industry. It is likely that, in the future, cold storage plants will be installed at Atlantic whaling plants and the fresher meat frozen and shipped to the mainland as animal food. About 5,000,000 pounds of meat could be recovered annually in our area, equivalent to the entire yield from 250 whales. The present respite from whaling will have led to some recovery of stocks and in addition will have induced the whales to move closer inshore. Meat yields therefore for the first season or two would be higher than estimated above, but would fall as whales were caught at greater distances offshore.

Whaling has hitherto followed economic cycles, which have probably prevented general overexploitation since 1918. The total catch at present is limited only by the number of stations and catches licenced. Sustained yields would require better knowledge and detailed control. Blues and humpbacks would profit from no catch at all for quite a number of years yet, such as the bowhead has had in the Arctic.

At present factory-ship whaling is prohibited in the north Atlantic by international agreement. If it were legalized, much wider possibilities would open up, especially for sperm whales. However there would also be very keen competition from other nations.

Reference

(1) Sergeant, D. E. 1953. Whaling in Newfoundland and Labrador waters. Norwegian Whaling Gazette, No. 12, pp. 687-695.

SMALL WHALES

Minke whale - *Balaenoptera acutorostrata*
Pilot or pothead whale - *Globicephala melaena*
White whale or marsouin blanc - *Delphinapterus leucas*

Minke Whale

Present Utilization: 32 whales Utilization in 1980: 100 whales

History and Present Status

Present stocks are unknown. From 1947 to 1954 an average of 28 minke per year has been taken by catchers from a small land station in Trinity Bay, Newfoundland:

1947-49 (av.)	32 minke whales
1950	3
1951	55
1952	17
1953	25
1954	32
1955	13

This is the only catch in the western North Atlantic, and the stock may therefore be considered a virgin one.

Future Prospects

The sustained catch in waters from Nova Scotia to northern Labrador could undoubtedly be at least in the hundreds. Expansion could, however, come only from the development of offshore catching methods such as the Norwegians use. Catchers cut up the whales on board or alongside, and ice down the fat and meat in the hold. The catch is then transferred to a freezing plant and extraction plant on shore, directly or via a refrigerated mother ship. The latter would scarcely be necessary on this coast with its short distances.

The meat is suitable for human food and was until 1954 sold in Newfoundland at about 25 cents a pound wholesale. Quality was uneven, however, partly because of differences in palatability between individual whales. Markets could scarcely be greatly expanded unless prices of regular meats rise greatly. As animal food the meat is excellent, but costs of production would probably be greater than for the meat of pilot whales or (possibly) large whales, while there is no very large oil yield. The Newfoundland Government state their intention to experiment with the catching of minke in northern Labrador waters, in order to supply meat to residents of that coast.

Pilot or Pothead Whale

Present Utilization: 6400 (in 1955) Utilization in 1980: 10,000 or more

This is a small whale, not usually exceeding 24 feet long. Stocks are

unknown, but presumably large. The species is known to extend across the North Atlantic from Newfoundland to the Faeroe Islands, and there may well be some hundreds of thousands in existence. Statistics are as follows:

	1947-49 5 (av.)
1950	172
1951	3100
1952	3155
1953	3584
1954	2298
1955	6412

Pothead whales are taken intermittently in drives of varying numbers, in two bays on the east coast of Newfoundland (1). Utilization of the meat is difficult, since either the whales must be kept alive after being driven and killed in small numbers daily, or they must be killed and the meat removed rapidly by a large enough number of men. Improvements have been made along the first line by bar-seining the animals, but controlled killing has not yet been achieved. The meat is used solely for animal food, it affords a good substitute for horsemeat as food for growing mink, though it has not yet been proved suitable for feeding to breeding stock. Its use will undoubtedly increase. It is likely that fuller use of the carcass could be made by grinding meat, bone and entrails together in a hogger. Meat yield in 1955 was 1,200,000 lb. but with full use of meat alone this would have been 3,000,000 lb., and with the whole carcass hogged, 5,000,000 lb. Oil yield was some 650 tons. The oil from the head and jaw has a low melting point and makes an excellent lubricant for fine machinery. At present, however, this oil is wasted since the demand is very low (about 90 gals. per year only, while the yield in 1955 would have totalled 3,000 gals.). It is understood that the United States Armed Forces use a more costly synthetic oil, and this and similar markets might be sounded.

Reference

(1) Sergeant, D. E. 1953. The pothead whale industry of Newfoundland. Canadian Department of Fisheries, Trade News, Vol. 5, No. 9, pp. 3-4.

White Whale

Present Utilization: 500 (in the 1930's) Utilization in 1980: 1000

The white whale is found in the St. Lawrence River estuary, especially along its north shore, the center of abundance being near the Saguenay River. Formerly a bounty or subsidy was paid for their capture by the Quebec Government. The number on which this was paid varied between 177 and 558 in 1932-38 (1). Some use was made of the fat and skin, and an animal was estimated to be worth $30 about 1944.

Vladykov estimates the possible sustained yield as about 1000 animals yearly.

Reference

(1) Vladykov, V. D. 1944. Chasse, biologie et valeur économique du Marsouin blanc ou Béluga (Delphinapterus leucas). Dept. Pêcheries Maritimes, Québec, 194 pp.

Other Small Whales

Occasional specimens of killer whale, bottlenose dolphin and common dolphin are taken in Newfoundland, but the average is not much over one per year of all three together. Fairly large stocks of these species exist along the coast, but they cannot be taken economically by present methods.

IRISH MOSS - *Chondrus crispus*

Present stock:	100,000,000 lb.	Utilization:	19,000,000 lb.
Stock in 1980:	100,000,000 lb.	Utilization:	30,000,000 lb.

Irish Moss is a perennial. Exposed parts can be cut off or break off in storms. They regenerate rather slowly.

Chondrus is at present harvested in Prince Edward Island and Nova Scotia. Small quantities of the related *Gigartina stellata* (false Irish Moss) are also harvested from the Digby Neck area of Nova Scotia. A harvest of approximately 19 million pounds of green Irish Moss yielding a usable raw material (in all forms) worth about $340,000 is recorded in the Fisheries Statistics for 1952.

Exploitation is at present confined to the stocks of Irish Moss on the rocky coasts of Nova Scotia from St. Mary's Bay to Cape Breton and on the rocky portions of the shores of Prince Edward Island. In addition there are stocks on the Gulf of St. Lawrence and Northumberland Strait shores of New Brunswick and Nova Scotia which have been exploited occasionally in the past and should be again. Stocks may be estimated to total in the order of 100 million pounds of which perhaps one-quarter or more might be taken annually on a sustained yield basis.

Harvesting in Nova Scotia and some parts of Prince Edward Island is by hand raking. In many areas of Prince Edward Island "cast weed", Irish Moss which comes ashore by wave action is the only product collected. Neither of these methods is likely to jeopardize stocks. Mechanical harvesting of this seaweed has never been carried on extensively or successfully. Properly designed equipment might make greater utilization possible.

Future Prospects

Uses and demand for the extracts have continued to increase and greater quantities of Irish Moss are likely to be required. Utilization of our stocks might perhaps be expanded to as much as twice the present level by more intensive harvesting methods and by making use of areas not now regularly supplying the product. There are many areas with lesser stocks which are at present marginal and which are likely to remain so unless the price rises. Most of the dried raw product goes to the United States for processing. Development of superior or cheaper substitute chemicals might seriously weaken the demand.

OTHER SEAWEEDS

Dulse - *Rhodymenia palmata*
Rockweeds - *Fucus* spp. and *Ascophyllum* spp.
Kelps - *Laminaria* spp.

Dulse

About 550,000 pounds of dulse are harvested annually from New Brunswick and Nova Scotia and sold dry for consumption as food in Canada and the United States. Most of the best quality dulse is now harvested as an annual crop on Grand Manan Island. If poorer quality dulse is included, the crop available would be several times the total now utilized.

Since this is a specialized food product, used mainly as a confection and with a distinctive taste of limited appeal, it is unlikely that the demand will greatly increase. Since some plants are always left and since the species is an annual reproducing by spores it is unlikely that serious depletion will take place except perhaps locally and incidentally.

Rockweeds

At present scarcely any rockweed is used commercially although vast stocks occur on the intertidal rocky shores of the Bay of Fundy and on the outer coasts of Nova Scotia. Of 325 miles of coastline surveyed in southwestern Nova Scotia, 140 miles held a harvestable crop of 200,000 tons. On the basis of this survey there probably is a standing harvestable crop of 2 to 5 million tons over the whole Atlantic area. Best rate of cropping of these perennial plants would have to be determined.

Small quantities are now used to supplement stock and poultry feeds, for packing baitworms (*Ascophyllum Mackaii*) and for packing lobsters. It is probable that as new processing methods, new extracts and new uses are found a demand may develop for rockweed. Full usage of stocks is not likely to occur within the period of this forecast.

Kelps

Small amounts of kelp are now being harvested from Nova Scotia and are used as a source of alginates required in the food, textile, pharmaceutical and other industries. Estimates of the amount of available kelp in southwestern Nova Scotia suggest about 1,800,000,000 pounds, with the amount fluctuating from year to year. There are considerable areas of kelp in other locations around the rocky Bay of Fundy and Atlantic shores. There is probably several times as much kelp available in the additional areas. Only a few tons are used annually now. As the demand for alginates grows more kelp may be used.

Harvesting might be mechanized; the giant Pacific kelps were harvested mechanically during World War I. A considerable body of knowledge is already available to guide conservation programs but more might be needed for special local conditions.

Economic factors will probably determine future utilization. No special fluctuations in present stocks are anticipated although yearly variations may occur.

NEW SPECIES (Atlantic Area)

All of the important commercial species in our Atlantic marine waters are native there. The only established newcomers seem to be the brown and steelhead trouts. The brown trout has a limited marine distribution off the Avalon Peninsula of Newfoundland, while rainbow trout run to sea from a few Prince Edward Island streams, returning as "steelhead". Neither species is likely to achieve any major status in the sport world, in competition with native trout and salmon, although they add variety to the angling available in eastern waters. Neither is likely to become a commercial fish.

However, the Atlantic ocean in our latitudes is rather poor in species, as compared with the Pacific. For example, instead of several commercial rockfish species, there is only one, the redfish; there are less than half as many flatfishes; there is nothing resembling a lingcod or blackcod; above all, there are no salmon of the genus Oncorhynchus, which are of such great importance in the Pacific economy.

Of course diversity is not an end in itself: quite the contrary. From the industrial point of view, a smaller number of kinds of objects is advantageous, up to a point anyway, because it simplifies handling, grading and marketing. Hence if introductions are contemplated, we should first be as certain as humanly possible that the new arrival will fill a niche and utilize a food supply that is not how being used by a commercial species. Of if some substitution is contemplated, the new fish should be more valuable than the old.

Very few proposals for introductions have as yet been carefully examined from these points of view. Those listed below have reached the stage of practical consideration, or even trial, but these and other possibilities should be carefully reviewed.

European flat oyster (Ostrea edulis). This is the common oyster of northern Europe, where it lives and spawns in water somewhat cooler and saltier than what our native oyster tolerates. Successful introduction might establish an oyster industry along many parts of the coast of the Maritime Provinces, Gaspé, the Magdalen Islands, and possibly even parts of Newfoundland. It is already living near Boothbay Harbour, Maine. Introductions to Canadian waters might mushroom into an important industry, particularly if care is taken to leave European oyster enemies behind.

Bay scallops. There are one or more species of large scallops which may be suited to our warm-water bays, where the native giant scallop does not occur.

Pacific crab (Cancer magister). Just as the eastern lobster could bring a usable product to Pacific rocky bottoms, so the western crab could become a useful inhabitant of Atlantic sandy bottoms, which to-day lack a commercial crustacean.

Pink, chum and sockeye salmon (Oncorhynchus gorbuscha, O. keta, O. nerka). The introduction of Pacific salmon to the Atlantic was a live topic for many years up to about 1930, and transfers of eggs were made sporadically, more often in the United States than in Canada (1). No permanent success was achieved, but very little really systematic work has been done, ~~and none at all in Canada.~~ To avoid all possibility of competition with native salmon, pinks and chums and sockeye should be given first consideration in any future trials. There are no salmonids

with similar life history on the Atlantic coast, and these three are the major commercial species of the Pacific. Since they require no freshwater food, they would not compete with native salmon. Successful transfer could lead to new major fisheries, especially the pinks and chums. The more valuable sockeye salmon, also, might become established in a number of suitable lakes. This species also has an advantage to sport fishing, of providing an important plankton-consuming link in the food chain leading to trout production in lakes.

Reference

(1) Ricker, W.E. 1954. Pacific salmon for Atlantic waters? Canadian Fish Culturist, No. 16, pp. 6-14.

P A C I F I C R E G I O N

SOCKEYE SALMON - Oncorhynchus nerka

Present stocks:	84,000,000 lb.	Utilization by Canada:	41,000,000 lb.
		" " others:	16,000,000 lb.
Stocks in 1980:	304,000,000 lb.	Utilization by Canada:	122,000,000 lb.
		" " others:	87,000,000 lb.

The sockeye is the most valued of Pacific salmons mainly because it retains its colour best when canned. The landed price in recent years has been close to ~~50~~ 25 cents per pound, in the round. The above production figures and future prospects are sums of estimates made in a number of individual river systems. Each of these has its own history and its own problems, as described below.

With one minor exception, all races of sockeye are reared in a lake for one or more years, so a river's sockeye production depends in the first instance upon its having suitable lake nurseries. Adult sockeye move upstream in summer or early autumn, to spawn in tributaries or outlets of a lake, or sometimes in the lake itself. Their eggs hatch the following spring and the young remain in the lake usually for one or two years, in British Columbia--longer farther north. After going to sea, some return after one full growing season and part of the next (as "jacks" - small fish not taken in any quantity by nets now in use), but most remain 2 1/2 or 3 1/2 growing seasons. Apart from jacks, maturing sockeye average about 7 pounds in weight, but vary from about 3 to 15 pounds.

At sea, sockeye have been found widely dispersed in the Gulf of Alaska, many hundreds of miles off shore, though the movements of Canadian-born fish have not specifically been identified. (In the western Pacific there is an important pelagic fishery for this and for two other kinds of salmon.)

Little ocean tagging of sockeye has been done, but our southern stocks, at least, appear to move inshore and alongshore from the northwest. As with other salmon, "homing" of sockeye to native rivers and native tributaries has been demonstrated to occur with sufficiently high incidence to make this a fundamental basis of management policy.

FRASER RIVER SOCKEYE - Oncorhynchus nerka

Present stock:	42,000,000 lb.	Utilization by Canada:	17,000,000 lb.
		" " others:	16,000,000 lb.
Stock in 1980:	250,000,000 lb.	Utilization by Canada:	87,000,000 lb.
		" " others:	87,000,000 lb.

History

Because almost all of the catch has always been canned, reasonably reliable statistics of production of Fraser sockeye are available for a longer period than for any other west-coast fishery. Both Canada and United States have taken the catch.

Catches shown below are given in thousands of 48-lb cases, the customary commercial unit. During 1951-54 the average number of sockeye required for a case was almost exactly 10 (9.99); and the average round weight of one sockeye was 6.97 pounds, practically 7. Consequently each case represented 69.6 pounds of fresh fish, or practically 70 pounds. The number of fish per case varies from year to year, and in earlier years it tended to be greater than at present (up to about 13 per case in the old "big" years). Figures to 1936 include a few thousand cases of sockeye caught in Johnstone Straits, part of which are bound for the Fraser River. Figures after 1936 include sockeye taken only in International Pacific Salmon Fisheries Commission Convention waters. Data are from (1) and (2). (There is also a small catch taken along the river by Indians).

Years	Average catch per annum, in thousands of cases U.S.A.	Canada	Total
1895-98	176	467	643
1899-1902	543	483	1026
1903-06	327	324	652
1907-10	403	218	621
1911-14	580	275	855
1915-18	153	73	226
1919-22	70	45	114
1923-26	68	48	116
1927-30	156	64	220
1931-34	162	75	237
1935-38	77	134	211
1939-42	119	182	301
1943-46	97	132	230
1947-50	74	63	137
1951	118	134	253
1952	115	116	230
1953	178	176	354
1954	501	487	988
1951-54	228	228	456

The Fraser River formerly contained the greatest sockeye salmon stocks of any river in the world, and it is expected soon to do so again. The stock is divided among some 20 or so lakes, about 8 of which are or have been major producers (3). The total area of Fraser sockeye-producing lakes is about 960 square miles, as compared with about 450 square miles for all other sockeye lakes in British Columbia.

Sockeye are the only species of salmon for which lakes are a production bottleneck. With only one exception, all our races of sockeye live one or more years in a lake before going to sea as smolts. A really large smolt output from a lake in any year is accompanied by marked reduction in size of the individual fish, which in turn results in poor survival in migration or in the ocean (4).

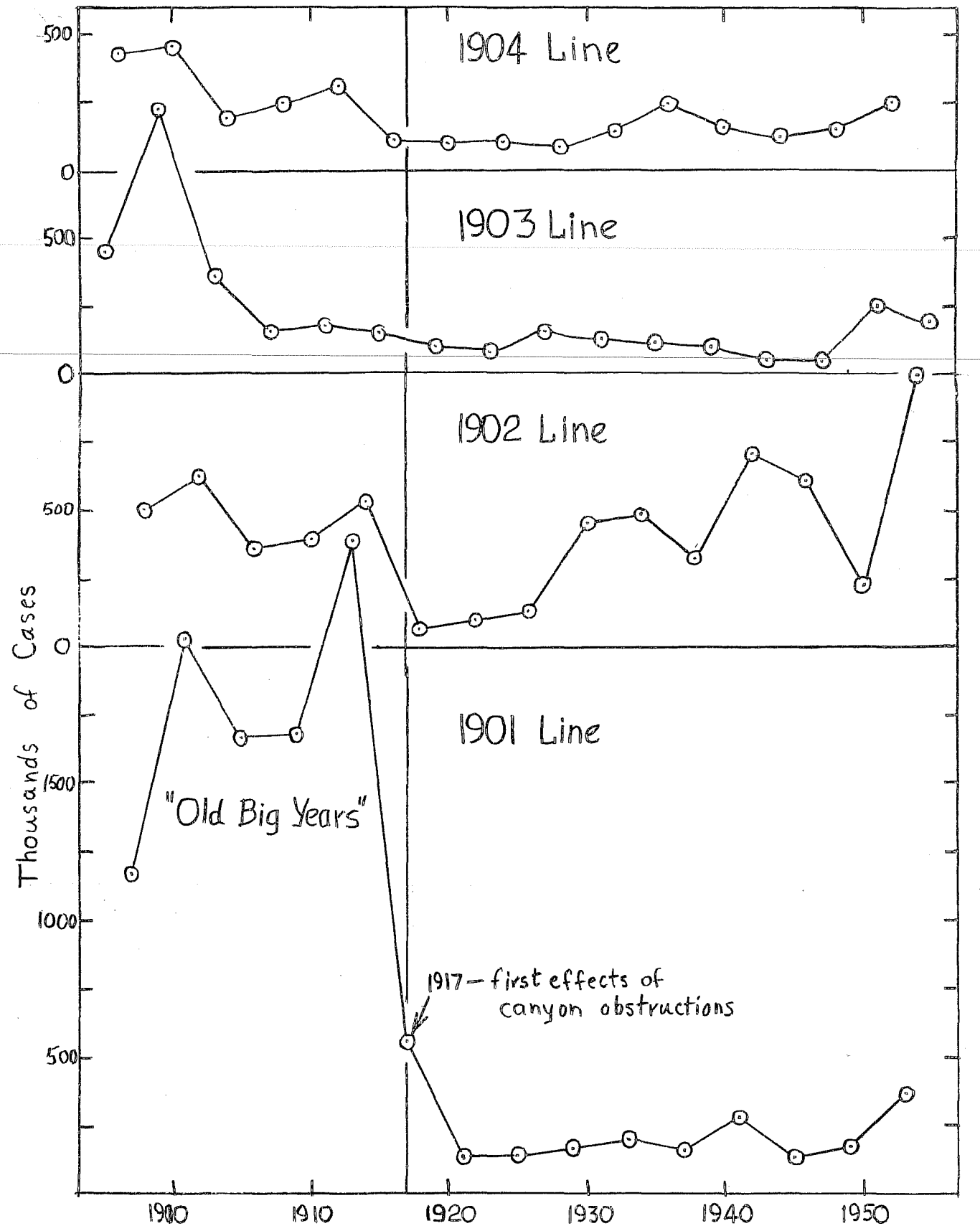
In the Fraser, almost all races of sockeye mature predominantly at age 4. In many lakes one "cycle" or line, out of the four, tends to exceed all the rest. The dominant line may be as much as 100 or 1000 times as abundant as one or more of the other lines. Best available evidence indicates that a "big" year actively suppresses the "off" years. There are two or three ways in which this might occur (5). Although formerly there were hopes that all four lines might be built up to the level of the old "big" years, this now seems unrealistic, or at least it can be left in abeyance until its feasibility can be demonstrated. Consequently all estimates and predictions here will be based on the four-year average catch, the poor lines being averaged with the good, in each nursery area.

Formerly the dominant stocks occurred in the 1901 line for nearly all lakes, with the result that the stock and catch in this line greatly exceeded the other three. However, since 1930 the new dominant and incipiently dominant stocks in different lakes are better distributed through the four lines.

Two factors provide the key to the past history and future prospects of the Fraser sockeye stocks. The first is the very great potential rate of exploitation by the fishery, which could rapidly exterminate the stock but for fishing closures. The second is the Hell's Gate slide and other obstructions of 1913-14.

1. The exceptional potential efficiency of the sockeye salmon fishery reflects the value of the fish, and also the long and vulnerable migration route which it follows, both in salt and in fresh water. Comparisons of catches and estimated escapements during the period 1938-45 showed that for the river as a whole, about 80 per cent of the stock was taken in the fishery, and 20 per cent spawned. This was again true in 1951-54. Individual runs, of course, have varied in this respect. As early as the first decade of the century a high rate of exploitation led to reduced catches and (very probably) overfishing of the "off" years, particularly those of the 1903 line (8). On the other hand, limited canning facilities kept exploitation of the big years (1901 line) below the permissible potential at that time.

2. In 1913 the Fraser was obstructed by rock dumped in at various places during railway construction, followed by a major slide at Hell's Gate early in 1914 (6). A large majority of the fish ascending in 1913 and in 1914 were blocked, those which did get through were mostly males (6 out of 7 was the estimate in two Shuswap streams), and of the females, many died unspawned because of injury or delay in migration (7). Remedial work was carried out



Fraser River sockeye packs, in thousands of cases, arranged by lines or "cycles".

during the winter of 1914-15, and in succeeding years many fish were again able to get upriver. However no agreement was reached between United States and Canada for cessation of fishing in order to rehabilitate depleted spawning stocks. On the contrary, the 1917 run of the 1901 cycle, which appeared in important (though greatly reduced) numbers, was pursued à l'outrance by fishermen who still anticipated the customary big year, and the survivors that season had the misfortune to encounter severe and widespread flooding and scouring of the spawning beds. These reverses reduced the 1901 cycle to a status no greater than its fellows in the overall picture, though it retained superiority, at a low level, in a number of nursery areas. Continued heavy exploitation during the early 1920's prevented the rapid recovery of most stocks, and a few disappeared entirely in all 4 cycles.

First to recover was the late-running Shuswap stock, which received the benefit of special autumn closures and also had favorable water levels at Hell's Gate. Its increase attracted attention on the spawning grounds as early as 1926, and it contributed importantly to the catch first in 1930. The Chilko Lake stock became abundant enough to yield some hundreds of thousands of sockeye to the fishery first in 1929, again in 1932 and 1933, and it has continued strong in those lines. During the 1930's, too, there was a greater awareness of the need for increased escapements, on both sides of the international border, and somewhat longer weekend closures were instituted. Though it was promoted mainly for other reasons, the abolition of trap fishing in Puget Sound in 1935 substantially reduced the United States fishing effort on sockeye for quite a number of years, and this was followed by more rapid increases in a number of runs. In 1940 the catch from the Chilco run exceeded a million fish, and in 1941 it was about 2 million. In 1942 another upriver area came into major production: the Fraser Lake spawners numbered 48,000, survivors presumably of a stock of 200,000 or so in the fishery.

Meantime the International Pacific Salmon Fisheries Commission had been organized in 1937 and began investigations in 1938. One of its first projects was a new survey of points of difficult passage in the river, and construction of aids to migration where desirable (1, 9). In 1945 and 1946 fishways were opened at Hell's Gate, which substantially eased the passage there, followed by those at Bridge River rapids in 1947 and in the Chilcotin River in 1948.

Concurrently, the long-awaited closed seasons were imposed in order to increase escapement of the early and mid-season upriver runs, all of which were still below maximum productive potential--several of them far below it. This closure was made possible by the international regulatory authority exercised by the Commission. With up to 5 sockeye permitted to spawn where only one had escaped before, and with no delays along the migration route, rehabilitation of upriver runs received a tremendous impetus. Nearly all important areas now have spawning stocks numbered in the middle hundreds of thousands, in at least one cycle, and it might seem a short step to obtain the optimum which each needs. However the distribution of spawners is still uneven, some runs are not well timed in relation to temperatures on the spawning grounds, and a majority of the formerly outstanding spawning streams are still very poorly seeded. These include the Driftwood River (Takla Lake), Nadina River (Francois Lake), the lower part of the Horsefly River (Quesnel Lake), Upper Adams River (Adams Lake), the Anstey, Eagle and Salmon Rivers (Shuswap Lake), Gates Creek and Portage Creek (Seton-Anderson system). Most or perhaps all of these must

be restored as major spawning areas before we can take advantage of the full productive potential of the associated lakes. At Adams Lake a new run has just been started by transplantation where the pre-1913 one had been exterminated in all 4 lines (12).

Since 1950 there has been no general closure of fishing, but various special restrictions are designed to give particular aid to runs which are of unusual potential importance.

Present Status of the Stock

The enumeration and estimation of spawning stocks of Fraser sockeye is carried out by the Salmon Commission each year, and the results published in their Annual Report (1). The catch is obtained from British Columbia and Washington sources, and the sum of escapement and catch is the total stock for the river. The catch statistics include some fish bound for a few minor rivers like Nitinat and Skagit; on the other hand, some of the sockeye caught in Johnstone Strait are Fraser fish and are not included in the total. However the number involved in either of these categories is small.

The overall catches and rate of utilization of sockeye for the river were as follows, in thousands of pieces:

	Total stock	Escape-ment	Canadian Indian catch	Canadian commercial catch		United States commercial catch		Overall percentage utilization
			no.	no.	%	no.	%	%
1951	3101	598	78	1288	42	1137	37	81
1952	3204	852	85	1154	36	1113	35	73
1953	5406	1274	108	1992	37	2032	38	77
1954	12108	2485	95	4722	39	4806	39	80
4-year av.	5955	1302	92	2302	39	2272	38	78
1955	..	..	..	1104	..	..	..	..

Future Prospects

(a) Without new types of management and without major setbacks.

Information on the productive potential of the Fraser system comes from 1. the present yield of areas whose runs have been partially rehabilitated, or which were not affected by the obstructions; and 2. the yield and stock of pre-Slide years.

1. Sustained yield estimates from present stocks and catches. Since it requires a lake to raise young sockeye, the most universal criterion of productive potential is lake area. Table A shows, on an area basis, the stock and average estimated catch for 1951-54, for a number of Fraser lakes which may be producing near their natural potential; also the catch from three other British Columbia lakes for comparison. (The catches from Fraser lakes are all based on a catch escapement ratio of 4:1, which is about right for the Fraser as a whole, but may not apply strictly in individual areas). The largest catch from upriver is 19,400 fish per square mile from the Shuswap lakes, but several other areas already exceed 10,000 per square mile. The largest catch for the system, in relation to area, is 28,000 per square mile from Cultus Lake, a small downriver lake. The larger downriver lakes, however, are not very productive, though Lillooet

Table A. Areas, spawning runs and catches of sockeye from various lakes.

Lake	Area (sq. miles)	Spawners (thousands) 1951	1952	1953	1954	Catches (thousands) 1951	1952	1953	1954	4-year average	No. per sq. mile per year
Upper Fraser region											
Shuswap[d]	129	169	18	229	2092	..	..	..	..	2508[a]	19.4
Chilco	75	118	489	198	37	..	..	..	..	842[a]	11.2
Fraser	20.7	96	41	47	143	..	..	..	..	327[a]	15.8
Bowron	5	22	19	14	11	..	..	..	..	66[a]	13.2
Lower Fraser region											
Cultus	2.42	13	19	13	24	..	..	..	..	69[a]	28.4
Lillooet	12.8	40	79	53	41	..	..	..	..	209[a]	16.3[c]
Harrison	87	13	40	10	29	..	..	..	..	92[a]	1.1[c]
Pitt	24	39	50	19	18	..	..	..	..	126[a]	5.3
Other areas											
Babine	172	152[b]	378[b]	715	503	484[e]	906[e]	461[e]	399[e]	562[e]	3.3
Owikeno	30	..	..	..	..	1016	939	1522	576	1013	33.8
Long	7.5	..	..	..	..	439	342	367	191	335	44.7

[a]Based on a rate of exploitation of 80 per cent: i.e., 4 times the average spawning stock, 1951-54.

[b]Low because of losses at the Babine River slide.

[c]If Harrison and Lillooet are considered as one unit, their contribution to catch averages 3.0 thousand per square mile.

[d]Includes Little Shuswap.

[e]Based on 70 per cent of the total Skeena catch.

does rather well with about 16,000 per square mile (assuming all the Birkenhead River sockeye develop in Lillooet Lake). No lake anywhere in the Fraser as yet equals the productivity of Owikeno Lake (Rivers Inlet) or Long Lake (Smith's Inlet), which produce catches of 34,000 and 45,000 per square mile, respectively. Even these are not the largest productions known: for many years the average catch from Karluk Lake, Alaska, exceeded 150,000 per square mile.

The Shuswap lakes, which have the highest productivity upriver, are the home of the well-known "Adams River" run. However, the lower Adams River and Little River spawning areas produce fry at the outlet of Shuswap Lake. The analogy with conditions in Babine Lake of the Skeena system shows that it is unlikely that fry from this source can properly populate this long four-armed lake with sockeye--particularly during the critical early-summer feeding period. Formerly there were large sockeye spawning stocks in Seymour River and in three streams tributary to the upper half of Shuswap Lake, hence probably a more even distribution of fingerlings and greater overall productivity. In the upper lake, steps to restock the Salmon River have been taken recently, and the already-increasing Seymour River stock will soon contribute very substantially to the Seymour arm of the lake (12).

Lakes may differ in productivity because of differences in dissolved nutrients. Carlander (10) and others have shown that the standing crop of fish both in trout lakes and in warm-water lakes, is in general related to the carbonate content (methyl orange alkalinity) of the water. A few determinations of alkalinity, and of the closely-related total dissolved solid content, are available for British Columbia salmon lakes (Table B). These show that Shuswap is in no way exceptional--in fact, rather below average for upriver. Another possible limiting factor is spawning grounds. These tend to be scarce or of poor quality for the larger downriver lakes, but upriver lakes are mostly well supplied. Chilko is the only lake which lacks major spawning facilities away from strong outlet currents--hence it might have trouble getting its fry well distributed. However the Chilco stock has already done quite well. Thus, in relation to lake area, the extent of the spawning facilities currently fully utilized by Shuswap sockeye is below the average of what is available in other upriver systems, and is much less than the potential in Shuswap itself.

From the above it is clear that the present productivity of the Shuswap Lakes can be used to estimate only a lower limit for upriver productive potential, even though it is currently the largest producer in the upper river region. The area of accessible upriver lakes is about 850 square miles. At Shuswap's 19,400 per square mile, their estimated sustained yield becomes 16,500,000 sockeye per year, as a minimum. If the upriver lakes prove as productive as Owikeno Lake is to-day, the average catch which they provide would be 30,000,000 sockeye per year.

2. Sustained yield estimates from catches prior to 1917. By 1895 the sockeye fishery of the Fraser was already well developed, and from then until 1916 it fished stocks which had not been affected by any major disaster. During this time the number of nets and traps used was sufficient to take a large fraction of the stock of the cycles or lines of 1902, 1903 and 1904--probably 85 per cent or more, since at first there were no weekend closed periods in Puget Sound in those days, and only 36 hours a week on the Fraser (42 hours starting in 1908). The decrease in off-year catch and catch per trap in the Puget Sound

Table B. Total dissolved solids (in parts per million) and methyl orange alkalinity (as ppm. of $CaCO_3$) for British Columbia salmon lakes or their outlet streams. (TDS determinations courtesy of B. C. Game Department).

	TDS	Alkalinity
Upper Fraser and Thompson region		
East Barriere L.	70	..
Kamloops L.	78	..
Little Shuswap L.	68	..
Shuswap L.	75	32
Fraser L.	100	50
Nechako R. at Prince George	122	68
Quesnel R. at Quesnel	127	62
Lower Fraser region		
Chilliwack L.	4	..
Cultus L.	104	78
Other watersheds		
Sproat L.	32	..
Babine L.	77	38
Lakelse L.	40	14
Bear L.	44	47
Owikeno L.	19-35	16-28

fishery has been documented (8). Mitchell (7) comments on the decline of the off years in the Shuswap area, and states: "One season we did not get a single fish on the Shuswap spawning beds that did not have one or more (net) marks"-- a revealing statement, even if it be somewhat exaggerated. The average catch from these three lines decreased from 650,000 cases in 1898-1900 to 400,000 in 1902-04 and to 250,000 in 1906-08, then rose slightly to 290,000 in 1910-12. So large a decrease suggests too heavy fishing in the off years to maintain maximum yield, even though we do not necessarily expect sustainable yield to be as large as the catch which can initially be taken from an unexploited stock. However the yield levelled off in the last two periods above, so an equilibrium may have been reached at that rather low level. Hence if we take the catch of the last period as the potential off-year sustained yield of the Fraser, we are being conservative: 290,000 cases, or about 3,500,000 fish per year. If rate of utilization was 85 per cent, the stock present was 4,100,000 fish.

For the old big years (the 1901 line) the situation is different. The canning facilities available up to 1913 were never sufficient to exploit this cycle fully; as the run developed in a big year there was a glut of fish, boats were assigned delivery quotas, and hence actual fishing effort was sharply restricted. Even so, many extra fish were caught and wasted when they could not be sold.(2). Likewise the pack statistics give no indication of full development of this fishery; in fact the pack from this line was greatest in the last year of its appearance: 2,400,000 cases in 1913. Hence while it seems clear that production of this line could have been maintained at least at the 1913 level, it is not so easy to estimate how much higher it might have gone.

The number of cases packed in 1913 was 8 times as great as the average of adjacent off years. Allowance for the larger number of fish used for a case in a big year, and for a considerable quantity of fish caught and wasted, would make the big-year catch at least 11 times as great as an off year, more likely 13 times or more. But to compare populations, rather than catches, we would have to allow for a sharp reduction in actual fishing effort in a big year, and no numerical estimate of this is available. Another line of evidence comes from the age composition of samples of the catches of 1913 and adjacent years. These suggest that the 1913 population was 68 times as great as the then off years (11), with sampling error limits of 31 times and 200 times (for 99% confidence). Since there is now no record of the representativeness of the sampling, it is perhaps best to use the 31-times figure to obtain a conservative estimate of the 1913 stock, which is 31 x 4,100,000 or 127,000,000 fish. Of these 31,000,000 or 24 per cent were canned.

Our imaginations to-day have difficulty in picturing where 90 million or so sockeye could have gone in the Fraser system, which now has less than 3 million spawners in the best years. But a closer consideration makes it reasonable enough. For one thing, to-day the various dominant populations occur in different cycles, whereas formerly they were all in one. Dividing the old upriver contingent among about 8 major spawning areas would give an average of 11 million spawners each. An estimate based on a partial count of sockeye ascending a fishway at Quesnel Lake in 1909 was a minimum of 4 million spawners in that area, and the conditions were such that the total could easily have been 2 or 3 times that figure. Early accounts of the various Shuswap runs make 20,000,000 spawners on that lake along seem a modest estimate. Even to-day, with less than half of the Shuswap spawning areas restored to something close to their early production, a 24 per cent fishery in 1954 would have let 8 million spawners reach the Adams River and associated breeding grounds.

Such large escapements in restricted areas are of course very undesirable. But they were characteristic of nearly all areas in the earlier stages of the fishery, when the big populations were limited only by the bad effects of their own large numbers. Spawning streams and redds were filled to overflowing, eggs died from oxygen lack or fungus attacks, and the net survival rate was so low that the large spawning stock did little more than reproduce its own numbers. Something of the sort occurred again on a small scale in 1949, when over 500,000 sockeye crowded into four very small creeks tributary to the outlet of Takla Lake (1). In spite of the serious overpopulation, these spawners produced about 280,000 adults in 1953 (57,000 spawners plus about four times that number estimated taken by the fishery). With a light fishery or none, therefore, a stock of 250,000-500,000 sockeye spawning in these small streams should have been a normal occurrence. We do not know, of course, whether it was congestion of the spawning grounds or malnutrition of the large broods in the lakes which was the more important controlling factor in early days: it may have been different in different places. But either process implied a very large and very wasteful supply of adult spawners.

To return to the question of potential sustained yield from the old big years, we must consider that increasing the rate of utilization might decrease the total stock size. However the sustainable yield could scarcely be less than 60 per cent of the estimated 1913 level of stock, which implies a catch of 76,000,000 sockeye every fourth year. Add to this the average of 3,500,000 from each of three off years, and the potential 4-year catch becomes 86,000,000 sockeye, or an average catch of 21,500,000 per year. If the 68-times figure above were chosen, or if increased exploitation did not decrease stock size so much, then an average catch of up to 40,000,000 fish per year would be quite conceivable.

Though this evidence from early catches cannot give a precise estimate

of the river's potential productivity, it gives an answer in the same range as the one calculated from modern conditions.

There remains the question of how quickly the river's maximum yield can be attained. Assuming adequate overall escapements, and extra protection for runs or parts of runs that need more rapid rebuilding or improved timing of their arrival on the redds, most or all currently-used lakes except Adams should have one or more major spawning streams in full production after 3 more generations at most--that is, 12 years. The new stock in upper Adams River, new stocks that may be established in the upper part of Shuswap Lake, and possibly the Driftwood River and Seton-Anderson stocks may take a little longer than 3 generations to build up to optimum numbers. However all of these should be in full production before 1980.

(b) Future catches with new management measures.

There are some possibilities for opening up new sockeye lakes on the Fraser, as shown by areas marked in green on the Salmon Commission's 1953 map (3). Mabel Lake above Shuswap Lake, and Horsefly Lake above Quesnel Lake are the largest. A first attempt to establish a run in Mabel Lake was made by egg transplantation in 1954 to the Middle Shuswap River (12). The total area of these lakes is substantial, though of course much less than that of existing accessible lakes.

Producing sockeye lakes which have been lost by power or other developments on the Fraser include Coquitlam and Alouette. Potential producers, to which access might have been provided at reasonable cost, include Stave Lake and the great upper Nechako system cut off by the Kenny dam. A cooperative development might yet open up Stave Lake for sockeye production, but the Nechako group is lost.

In general, the potentialities for opening new areas on the Fraser are not very great relative to the potentialities of existing areas. Their contribution to the estimated future catch might become one or more million fish per annum, but would still be only a small fraction of the total.

For other types of management, see the discussion under the Skeena. Detailed consideration of such possibilities on the Fraser is not possible at this time, but they may eventually become important. Already the merits of artificial assistance to spawning are being re-examined in the light of modern salmon values (12).

(c) Future catches if stocks suffer serious setbacks.

Increasing industrial and agricultural use of Fraser River water is likely, but with alert supervision and cooperation from users no serious effects from pollution are predicted--at least not within 25 years. There is still a potential danger to upper Fraser stocks from high temperatures, since the damming of the Nechako, but again we anticipate that cool water will be provided as needed.

New dams for power are the most serious threat to Fraser sockeye. At worst, they could reduce the production of the river to what comes from the few lakes near sea-level: Pitt, Harrison and Cultus, which to-day yield only about 300,000 fish per year. Intensive management could increase this but, in effect, a great primary industry would be dead.

Techniques available to date would not permit salmon to survive alongside either one high dam or a series of low dams on the Fraser and its major tributaries. Though the means are not available as yet (14), it is not impossible that in say 10 years' time the problem of guiding smolts to a bypass and taking them below a dam can be solved--at a price, of course. Prospects of success are better on clear rivers, where visual as well as electrical guiding would be possible(15).

Contrary to popular belief, the adult fish may prove the greater problem--perhaps one which is insoluble. This arises from the large size of the fishways which would have to be provided: fishways having a capacity considerably greater than that of the Hell's Gate structures. In 1954 the big Adams River run of about two million spawners for the first time encountered water levels which required it to use the Hell's Gate fishways: the result was a delay of up to 4 days for fish at the peak of the run, simply because of crowding in the limited space available (13). This much delay at <u>one</u> spot is not serious; but, repeated even 2 or 3 times, it could be fatal for some runs, if it held up the fish beyond the normal time of their sexual maturity, or of favourable spawning temperatures. We anticipate, of course, that when the river is in full production there will be several large bodies of sockeye, some of them much larger than the present Adams River run, going upstream at intervals throughout the summer. The estimate below is for an <u>average</u> escapement of 11,000,000 fish per year, and since some years are sure to exceed others, provision for at least 20,000,000 sockeye spawners in a season must be made. In addition, there are likely to be UP+D 25,000,000 or more pink salmon in odd-numbered years, and a million or so of other species. A need to enlarge even the Hell's Gate fishways may well arise in the near future.

The best review of the problems and costs involved is obtainable from a preliminary survey of one scheme of power developments for the Thompson River and the Fraser below Lytton (13). The sum of $321,000,000 is estimated as the initial cost of facilities for the adult fish only, on the main-stream dams only. Even with this expenditure, the report indicates that sockeye would be too much delayed to maintain the necessary high reproductive potential. No provision was included for by-passing smolts, since the means for this are not yet available.

Thus there are formidable and expensive problems to be faced before sockeye and power dams can both make use of the Fraser. We will not predict that these problems can, or that they cannot, be solved. We do anticipate that no major power dams will be built in the system unless it becomes possible to make completely adequate provision for sockeye salmon, and so have made our catch forecasts on the basis of the natural productivity of the river.

Though it may be unduly conservative, our forecast is that after 25 years the Fraser will on the average yield 25,000,000 fish per year to the fishery, or about 175,000,000 pounds. Canada's share will presumably be half, as at present. About 24 of the 25 million will be fish reared in lakes above Yale. On a lake area basis, this upriver catch is about 45 percent more than what is taken from the Shuswap Lakes to-day, but it is considerably less than the yield from Owikeno Lake or Long Lake.

With the lakes and/or spawning beds near maximum utilization, reproduction will probably become somewhat less efficient than it is to-day, so the future rate of utilization is estimated as 70 per cent instead of the present 78; this makes the average total stock equal to 36 million fish or 250,000,000 pounds each year.

Any major program of artificial assistance to spawning, or other intensive management, should substantially increase this total.

References

(1) Annual Reports of the International Pacific Salmon Fisheries Commission. New Westminster, B. C.

(2) Annual Reports of the British Columbia Department of Fisheries. Victoria B. C.

(3) The International Pacific Salmon Fisheries Commission's Annual Report for 1953 includes a map showing accessible lakes and spawning streams of the watershed.

(4) Foerster, R. E. 1954. On the relation of adult sockeye salmon (Oncorhynchus nerka) returns to known smolt migrations. J. Fish. Res. Bd. Canada, 11(4): 339-350.

(5) Ricker, W. E. 1950. Cycle dominance among the Fraser sockeye. Ecology, 31(1): 6-26.

(6) Details are given in Annual Reports of the Department of Marine and Fisheries (Canada) and of the British Columbia Commissioner of Fisheries. Effects of the catastrophe upon the native population and the settlers in the Shuswap area are described in (7). A comprehensive description and documentation of events in the commercial fishery is given by Rounsefell and Kelez (8).

(7) Mitchell, D. S. MS, 1925. A story of the Fraser River's great sockeye runs, and their loss. (A copy is in the library of the Biological Station, Nanaimo, B. C. Mr. Mitchell was superintendent of the salmon hatchery at Granite Creek, Shuswap Lake).

(8) Rounsefell, G. A., and G. B. Kelez. 1935. Abundance and seasonal occurrence of the salmon in the Puget Sound region and the development of the fishery. Bull. U.S. Bureau of Fish., 49(27): 693-823.

(9) Thompson, W. F. 1945. Effects of the obstruction at Hell's Gate on the sockeye salmon of the Fraser River. Int. Pac. Salmon Fish. Comm., Bull.No.1, 175 pp. (Later Bulletins, by Jackson, Talbot, etc., provide additional information.)

(10) Carlander, K. D. 1955. The standing crop of fish in lakes. J. Fish. Res. Bd. Canada, 12(4): 543-570.

(11) This estimate, on pp. 8-9 of (5), comes from the ratio of 5_2 to 4_2 sockeye in 1913 and adjacent years. The 5_2 fish were nearly all of downriver origin, and in the off years averaged 24 per cent in the scale samples. In the big year 1913 there was only 0.35 per cent of 5_2 fish in the sample, though the abundance of downriver fish hence presumably of 5_2 fish, was about average; hence the total 1913 run can be estimated as 24/0.35 or 68 times the average run of the off years.

(12) Annual Report of the International Pacific Salmon Fisheries Commission, for 1954. (This report discusses the present state and future prospects of a number of runs.)

(13) A report on the fish facilities and fisheries problems related to the Fraser and Thompson River dam site investigations. Canada Department of Fisheries and International Pacific Salmon Fisheries Commission. 102 plus xxv pp., plus figures. 1955.

(14) Andrew, F. J., L. R. Kersey and P.C. Johnson. 1955. An investigation of the problem of guiding downstream-migrant salmon at dams. Int. Pacific Salmon Fish. Comm., Bull. No. 8, 65 pp.

(15) Brett, J. R., D. MacKinnon and D. F. Alderdice. 1954. Trough experiments on guiding sockeye salmon fingerlings. Fish. Res. Bd. Canada, Pacific Prog. Rep., No. 99, pp. 24-27. (A report on later work will appear in the same series.)

(16) Clay, C. H. 1955. Downstream fish migration over dams. British Columbia Professional Engineer, Oct., 1955, 4 pp.

SMITH INLET SOCKEYE

Present stock:	2,700,000 lb.	Utilization:	2,025,000 lb.
Stock in 1980:	2,700,000 lb.	Utilization:	2,025,000 lb.

History

At Smith Inlet more than 95 per cent of the adult sockeye taken in the fishery are 4- and 5-year old fish. The proportion of two age classes varies from year to year.

The annual packs, by 5-year averages, in 48-lb. cases, have been as follows:

Years	Av. catch (thousands of cases)	Years	Catch (thousands of cases)
1926-1930	23	1951	49
1931-1935	24	1952	35
1936-1940	23	1953	30
1941-1945	14	1954	19
1946-1950	23		

There has been no prolonged decline or increase in the Smith Inlet sockeye catches since the fishery was first developed. A slump did occur during 1940-1945, which may have resulted partly from lowered fishing effort during the war. The recent catches have averaged as high, even slightly higher than in the past.

The only significant sockeye nursery lake at Smith Inlet is Long Lake, with an area of about 7.5 sq. miles. There are two important spawning streams.

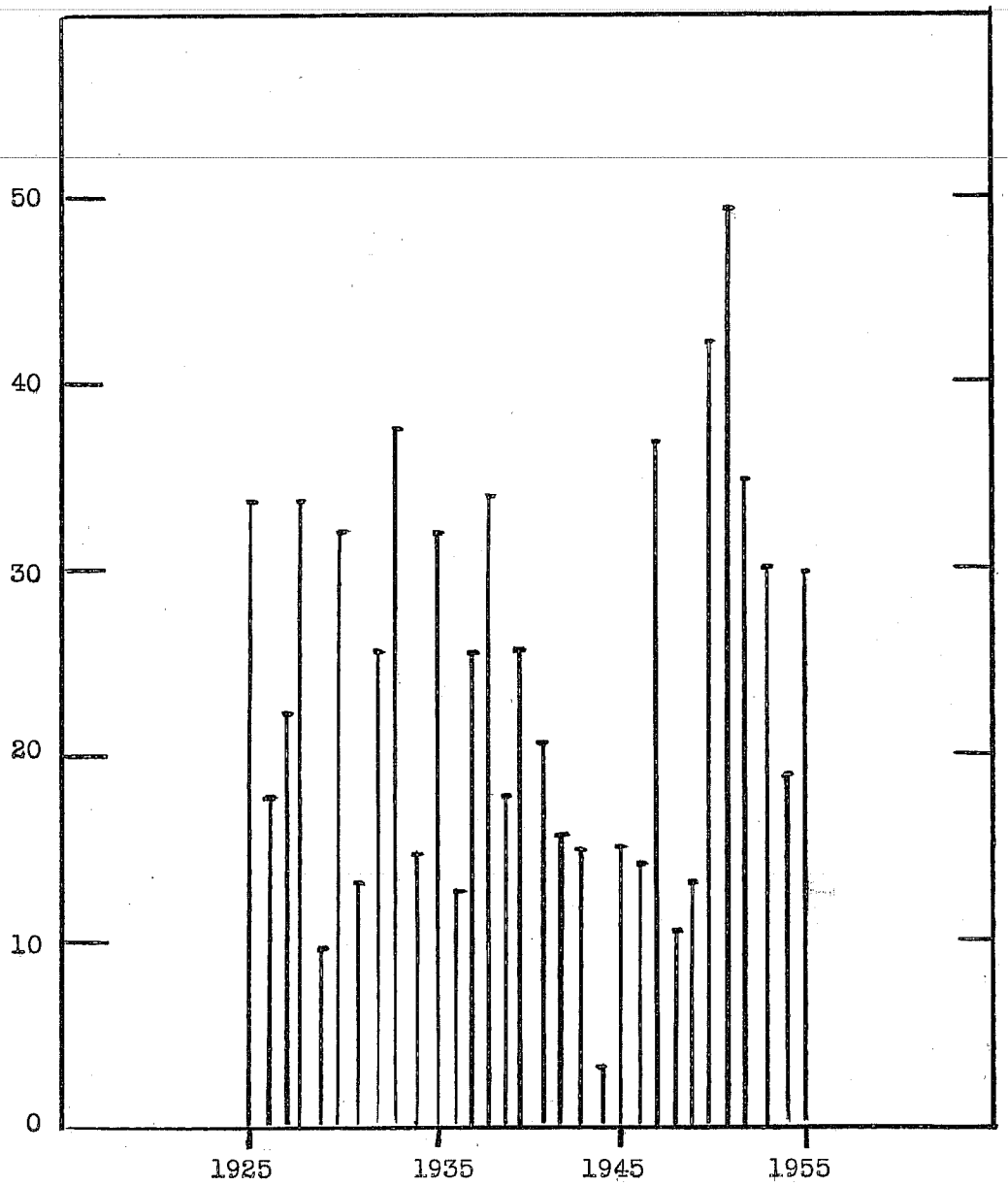
Present Stock and Utilization

Recent catches, in pieces, are as below:

1951	439,100
1952	342,200
1953	367,100
1954	190,800
1955	323,700

Long Lake at Smith Inlet is the most efficient known producer of sockeye in British Columbia--even more efficient than Owikeno. The 1951-54 average catch was 335,000 sockeye, or 44,000 per square mile of lake. In 1955, a disastrous year in most areas, it maintained close to an average yield.

As at Owikeno Lake the fry enter the upper part of the lake and hence have a good chance for uniform distribution throughout the lake, at an early age. Because the Smith Inlet sockeye yield is so great - 44,000 fish per square mile of lake - we estimate that the rate of utilization is high - about 75%.



Smith Inlet sockeye packs, in thousands of cases.

Future Prospects

(a) Without major improvements or disasters. Expectations for the Smith Inlet sockeye under existing conditions of management and environment are that present stocks and catches will be maintained.

(b) Catch with intensive management. Long Lake is producing sockeye salmon so efficiently that it is doubtful whether any attempt to aid production would be desirable, for fear of disturbing some existing delicate balance. When management measures are well tested elsewhere, perhaps they could be tried. However we do not look for increases from this source within 25 years.

(c) Adverse factors. No major adverse changes to the natural environment seem likely during the next 25 years.

RIVERS INLET SOCKEYE

Present stock:	12,300,000 lb.	Utilization:	8,000,000 lb.
Stock in 1980:	12,300,000 lb.	Utilization:	8,500,000 lb.

History

As at Skeena River, there are two major age classes of adult sockeye (4- and 5-year old fish) at Rivers Inlet. Rivers Inlet also, has experienced a series of large broods of 5-year old fish occurring at 5-year intervals early in the 1910-1954 period of recorded age class composition; and a series of large 4-year old broods occurring at 4-year intervals, in the latter part of that period. The catch fluctuations at Rivers Inlet have been very similar to those at the Skeena but peaks or low catches in the two systems have not usually occurred in the same year.

The annual packs by 5-year averages, in 48 lb. cases, are shown below:

Years	Av. catch (thousands of cases)	Years	Catch (thousands of cases)
*1907-1910	74	1951	103
1911-1915	97	1952	84
1916-1920	67	1953	133
1951-1925	94	1954	51
1926-1930	76		
1931-1935	88		
1936-1940	67		
1941-1945	69		
1946-1950	87		

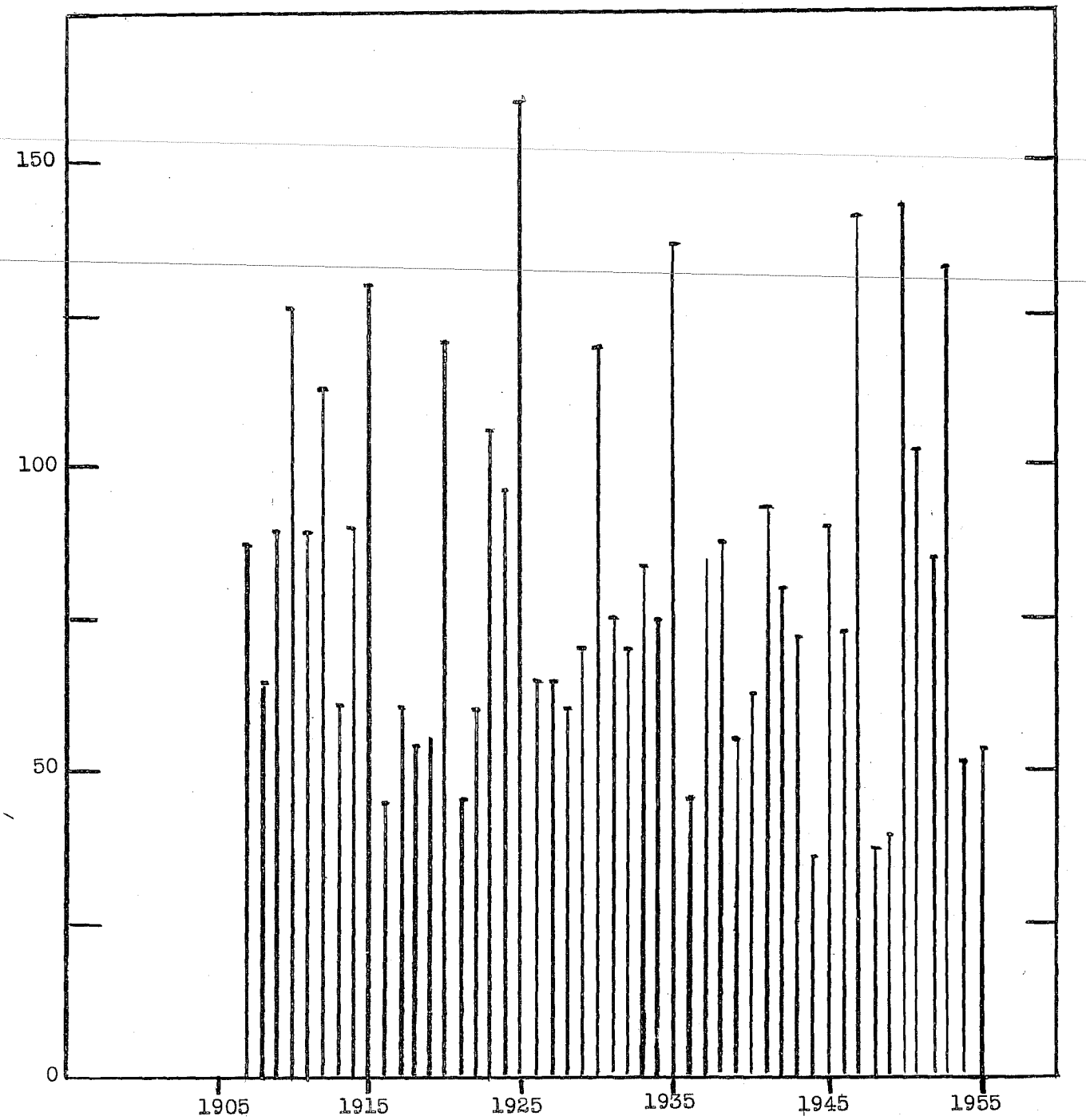
* Four-year average

The history of the development of the fishery and of changes in the fishing effort at Rivers Inlet has been similar to that of the Skeena. The prolonged decline in catch which was experienced in the Skeena River during 1915-1935 did not occur at Rivers Inlet, and in this system, apart from annual variation, sockeye catches have remained relatively constant during the past 40-odd years.

There is only a single nursery lake (Owikeno) for young sockeye at Rivers Inlet. In the past this lake has supported a sockeye stock which, although probably smaller than the total Skeena stock, has provided catches of equal magnitude. The average yield in 1951-54 was 34,000 fish per square mile. The spawning beds at Rivers Inlet appear to be more than adequate for the number of sockeye produced there, so that the capacity of the lake to feed young sockeye is considered to be the principal factor limiting further production.

Present Stock and Utilization

Recent River's Inlet catches, in pieces, are as follows:



Rivers Inlet sockeye packs, in thousands of cases.

1951	1,016,600
1952	938,700
1953	1,522,300
1954	575,700
1955	582,100

Utilization of the returning adults at Rivers Inlet is estimated as of the order of 65 per cent. This estimate is partly based upon the evidence that the Rivers Inlet system is a more efficient producer of sockeye salmon (per unit area) than the Skeena River system, where the average proportion taken by the fishery is about one-half. Among the features of Owikeno Lake that contribute to its relatively high rate of production is that it has extensive spawning streams, which mostly flow into the upper part of the lake. When the fry enter Owikeno Lake they are probably quickly distributed over the lake and use its food supplies to best advantage.

The present average level of the Rivers Inlet sockeye catch is 8,000,000 lb. - as high as it ever has been. At an estimated rate of exploitation of 65 per-cent, the stock is about 12,300,000 lb.

Future Prospects

(a) Without major improvements or disasters.

Under present conditions the Rivers Inlet catches are expected to be maintained at about the same level as has existed for the past 40-odd years. There is a possibility that slightly greater fishing effort would produce a larger sustained yield, so the 1980 estimate is raised to 8,500,000 lb., at 70 per cent exploitation.

(b) Catch with intensive management.

Such direct aids to sockeye production as were outlined under Skeena River (lake fertilization and predator control, for example) might be effective in raising production at Owikeno Lake. However the production of the lake is already so large that it may be better to forego dubious gains for fear of disturbing the present excellent biological balance. In any event, River's Inlet smolts are small, so improvement of spawning sites or increased fry from artificial propagation might do more harm than good. Until the various management procedures are tested at other sites, we do not recommend their adoption at Rivers Inlet.

(c) Adverse factors.

Present proposals for the possible utilization of Rivers Inlet waters are such that they would be unlikely to affect production seriously since they are not, apparently, concerned with the lake or important spawning streams. However, information is very indefinite and useful prediction of possible effects is not feasible.

SKEENA RIVER SOCKEYE

Present stock:	14,000,000 lb.	Utilization:	7,000,000 lb.
Stock in 1980:	25,000,000 lb.	Utilization:	15,000,000 lb.

History

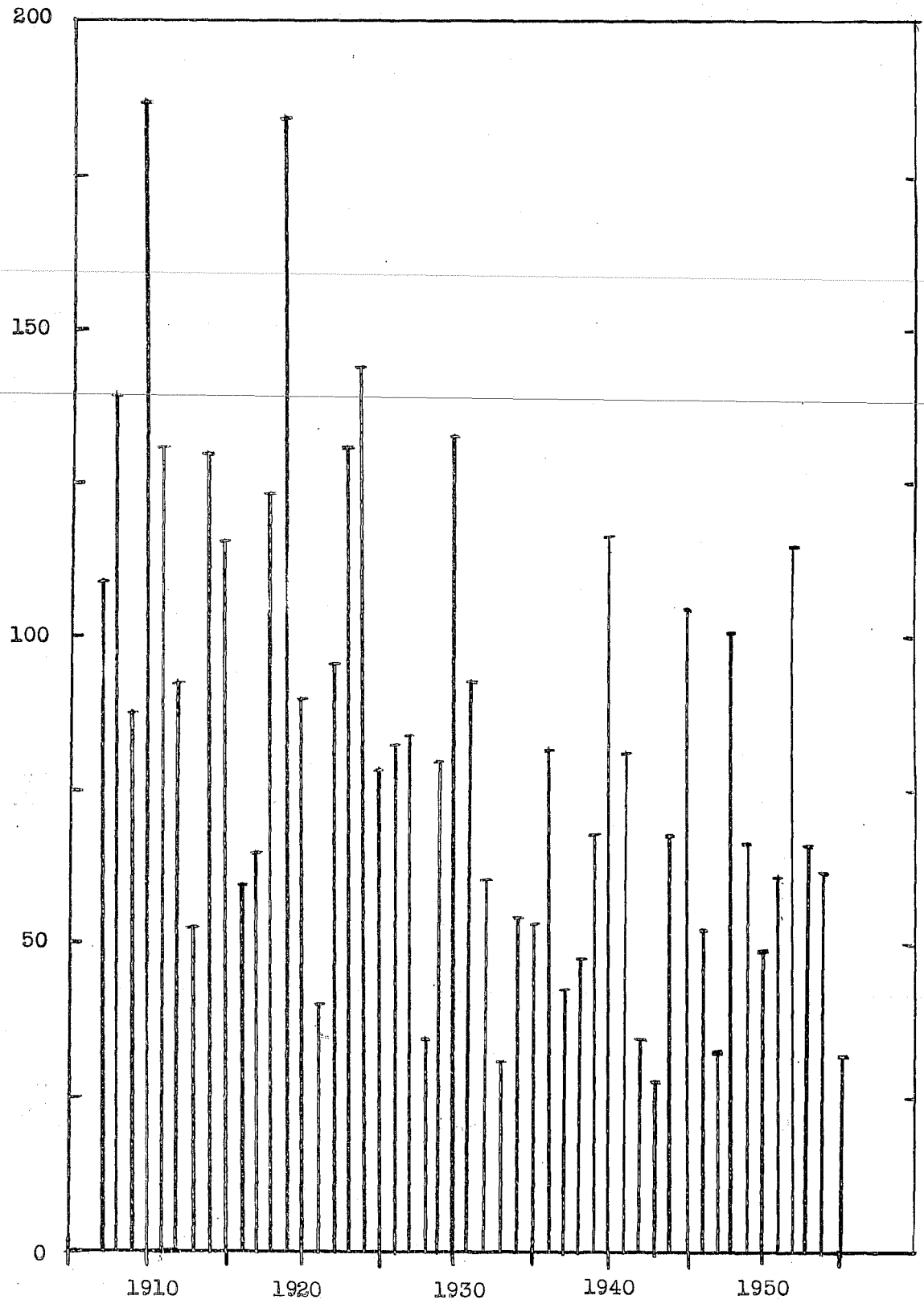
The Skeena sockeye mature mostly at 4 or 5 years of age, the proportion varying from year to year. Freshwater life is typically one year. Because of the mixture of ages in the spawning stocks, really strong overall "dominance" of one cycle was never maintained for long on the Skeena, as it was on the Fraser. However the 5-year-old fish had a series of big broods in 1914-19-24, while a series of large 4-year-old broods occurred in 1936-52. Though lacking the regularity or the extreme contrasts that exist on the Fraser, the Skeena catch fluctuations are quite marked, and it is logical to suspect that the same causes operate on both rivers.

The 5-year average packs are shown below, in cases (one 48 lb. case = about 75 lb. whole fish = about 12 sockeye).

Years	Av. catch (thousands of cases)	Adjusted no. of boats	Years	Catch (thousands of cases)
1906-10	122	980	1951	62
1911-15	105	1050	1952	115
1916-20	105	1130	1953	65
1921-25	99	1190	1954	56
1926-30	82	1250		
1931-35	56	1240		
1936-40	71	1080		
1941-45	62	830		
1946-50	60	(820)		

Milne (2) has assembled the statistics on the number of boats fishing the Skeena, and something on their relative efficiency. The effective effort, shown above as an adjusted number of boats, increased up to the late 1920's, remained fairly high until 1935, gradually decreased to 1941, took a sudden drop in 1942 when fishing by Japanese was suspended, and remained at this reduced level through 1948. Since the war the fleet has been more mobile, and comparable information is less meaningful. The period of high effort in 1915-35 was one of declining catches; while taking into account the necessary lag, the recent decrease in boats has been followed by improved catches. (Catches in 1952 and 1953 would have been considerably higher except for a strike and a closure near the peak of the run.) The prima facie case for existence of overfishing during the 1920's seems fairly good. The only doubt arises because of the large fraction of the stock (about half) which is devoted to escapement in the recent period: a possible reason for this is indicated below. There are indications, too, of some deterioration of the watershed from logging and fires, which have reduced the minimum flow and increased flooding in some spawning streams.

The principal natural obstacle to salmon migration was at Moricetown Falls on the Bulkley River, which affected the sockeye run to Nanika Lake (3½, 9).



Skeena River sockeye packs, in thousands of cases.

However this lake contained only about 10 per cent of the total sockeye stock. The difficult spot was remedied by fishways constructed in 1950-51. Early in 1951 a slide occurred in the Babine River, affecting the Skeena's major sockeye area. For two years, 1951 and 1952, only about a third of the arriving fish passed this obstacle, and those which did were not in good condition, especially in 1952. The slide was removed during the winter of 1952-53 (4, 5).

Present Stock and Utilization

Recent catches of Skeena sockeye are available from Canadian statistics. Estimates of escapement are made yearly by fence count for the major stock, at Babine Lake. Comprehensive surveys in 1944-48 showed that the Babine run was about 70 per cent of the total escapement to the watershed (6). Best estimates are shown in Table A.

In recent years average utilization has been about 50 per cent -- 43 per cent commercial and 7 per cent Indian. The stock in 1951-54 was about 12 per cent greater than in the previous 4 years, and the catch was 14 per cent greater. However, spawning stocks suffered a severe setback in 1951 and 1952, when the Slide stopped about 2/3 of the Babine run and damaged many of the survivors. The very poor catch of 1955 was partly a result of this, but partly also associated with the below-average sockeye (and chum) catches taken in almost all parts of the coast from the Fraser River north. Unfavourable ocean conditions are indicated.

Future Prospects

(a) Without major improvements or disasters.

The area of accessible lakes in the Skeena watershed is about 266 square miles, of which 174 square miles is in Babine Lake (including the 2 square miles of Nilkitkwa). Two determinations of dissolved materials are available (Table B, Fraser section): Lakelse is rather low in minerals, and this may be typical of other Coast Range lakes also; however Babine Lake is comparable to Shuswap region lakes in dissolved solids, though rather lower in alkalinity.

The only lake for which production can be estimated on an area basis is Babine, which produced a catch of about 3,300 sockeye per square mile in 1951-54 (see table A, Fraser section). Poor distribution of spawning facilities may be an important factor limiting production at Babine. Over half of its sockeye today spawn in the outlet, many of them even below Nilkitkwa Lake, 8 miles below Babine proper. There is one fair-sized stream tributary to the upper lake, also a number of smaller creeks. However some of these are subject to summer drought and winter freezing, particularly since a series of fires during the early 1920's reduced forest cover in the region. Preliminary surveys in 1955 have shown that the young sockeye are mainly concentrated in the north arm of Babine Lake and in Nilkitkwa Lake--which is only about 1/8 of the whole water area. This uneven distribution makes the lake's commercial yield per unit area low, in two ways: there is the loss from unused growth potential in most of the lake, while in addition the slow fingerling growth near the outlet makes for a high rate of freshwater mortality, to compensate for which as much as 50 per cent of the adult stock must be allowed to spawn.

Table A. Catch, estimated escapement, and estimated total stock of Skeena sockeye in recent years, in thousands of pieces.

Year	Total stock	Escapement	Indian catch	Commercial catch		Total utilization
				no.	%	%
1944	1524	620	90	814	53	59
1945	2798	1400	150	1248	45	50
1946	1390	680	75	635	46	51
1947	1150	690	70	390	34	40
1948	2562	1200	150	1212	47	53
1949	1509	700	110	699	46	54
1950	1391	750	110	531	38	46
1951	1406	635[a]	80	691	49	55
1952	2894	1460[a]	140	1294	45	50
1953	1764	995	100	659	37	43
1954	1361	700	90	572	42	49
1955	..	..	..	157	..	..

[a] Includes losses at the Babine Slide: 319,000 in 1951, 700,000 in 1952.

The unfortunate history of a greater rate of utilization in the past makes it unlikely that more intensive fishing, by itself, would have a long-term beneficial effect on the Skeena. (Increased fishing will always increase yield temporarily, of course.) "Normal" management may take the course of favouring escapement of the earlier runs, which spawn in the upper part of Babine Lake. However it is difficult to predict how successful this can be, or how much benefit it will confer.

In the immediate future, there will be some decline in Skeena production because of effects of the Slide in 1955, 1956 and 1957 (5). However these effects should be overcome in the next two cycles, and by 1980 the lake should have reached its natural maximum production.

Apart from Babine Lake, it may prove possible to distribute spawners more advantageously throughout the Skeena watershed by manipulation of times of fishing or, possibly, sizes of nets used. However results of earlier tagging suggest that most stocks are fairly well represented throughout the fishery, so this approach may not prove practical.

(b) Catch with intensive management.

Three general types of direct aid to sockeye production have been considered for the Skeena: fertilization of lakes, predator control, and artificial propagation.

1. The dense concentration of young sockeye in the upper arm of Babine Lake and in Nilkitkwa Lake suggests possibilities of fertilization to increase their growth and survival. Fertilization for increasing sockeye production has been tried, so far, only in Bare Lake, a small lake on Kodiak Island, where results seem promising (7). Any application to Babine or any other

Skeena Lake would be on an experimental basis at first, and success cannot be predicted. Potentially, it might possibly double smolt production, which would triple the permissible catch (since increased escapement would not be necessary). Any practical major program would doubtless involve large continuing expenditures, but the expense is to be measured and charged against the benefits: for example, doubling the average 1947-50 catch would mean extra fish having a landed value of about $1,000,000 per year (1955 prices).

2. Predator control was found to be successful in rapidly increasing sockeye stocks at Cultus Lake in the 1930's (8). This was accomplished at little expense, by decimating a population of large squawfish in the lake and without any reduction in trout stocks. No doubt the same could be accomplished on other small lakes that have large coarse fish populations. However, not many such lakes exist, and in any event small lakes will not contribute any great fraction of our sockeye production as long as the large ones remain accessible. Prospects for predator control as a major management practice on lakes such as Babine are not bright, partly because they lack easily-caught carnivorous fish other than trout. However, studies on the Skeena and elsewhere suggest that local control to protect fry in streams as they descend to a lake, or to protect smolts when they are leaving, may prove possible and profitable.

3. Completely speculative as yet is the possibility that fry could be caught as they hatch from spawning beds in the outlet of Babine Lake, and released in the upper lake. Possibly a hatchery which used outlet fish would be justified, for the same purpose. Hatchery costs and benefits everywhere need to be reassessed, in the light of modern salmon values and more economical hatching techniques.

For our prediction of catches in 1980 we have considered that some type of regulation or management will add substantially to the Skeena stock and catch in 25 years' time. A catch about double that of 1951-54 is the best estimate, the increase to be partly from increase in stock, partly from an increased rate of exploitation made possible by improvements in growth or distribution of fingerlings at Babine.

(c) Adverse factors

As in other watersheds, power development plans exist for the Skeena. The Aluminum Company of Canada proposes eventually to divert the Nanika River from Morice Lake, which may damage this area. A proposal exists for using Babine Lake as a storage reservoir in connection with large power developments on the Fraser, by diverting its water into Stuart Lake. If maximum storage were taken, this would completely destroy the major producing area of the Skeena River, and reduce it to the status of a third-rate sockeye salmon stream.

References

(1) Pritchard, A. L., and Associates. MS, 1948. Interim Report - Skeena River salmon investigation. Dept. of Fisheries, Ottawa. (This document is a comprehensive account of the Skeena stocks and fishery and provides the basis for much of what is in the references below.)

(2) Milne, D. J. 1955. The Skeena River salmon fishery, with special reference to sockeye salmon. J. Fish. Res. Bd. Canada, 12(3): 451-485.

(3) Milne, D. J. 1950. Moricetown Falls as a hazard to salmon migration. Bull. Fish. Res. Bd. Canada, No. 86, 16 pp.

(4) Godfrey, H., W. R. Hourston, J. W. Stokes and F. C. Withler. 1954. Effects of a rock slide on Babine River salmon. Bull. Fish. Res. Bd. Canada, No. 101, 100 pp.

(5) Godfrey, H., W. R. Hourston and F. C. Withler. MS, 1956. Babine River salmon after removal of the rock slide.

(6) Brett, J. R. 1952. Skeena River sockeye escapement and distribution. J. Fish. Res. Bd. Canada, 8(7): 453-468.

(7) Anon. 1955. Size of salmon migrants from Bare Lake, Kodiak Island. Progressive Fish-Culturist, 17(3): 122.

(8) Foerster, R. E., and W. E. Ricker. 1941. The effect of reduction of predaceous fish on survival of young sockeye salmon at Cultus Lake. J. Fish. Res. Bd. Canada, 5(4): 315-336.

(9) Houston, W.R., and J.W. Stokes, 1952. Moricetown Falls biological survey - 1951. Canadian Fish Culturist No 13, pp. 22-32

NASS RIVER SOCKEYE

Present stock:	2,600,000 lb.	Utilization:	1,600,000 lb.
Stock in 1980:	3,500,000 lb.	Utilization:	2,100,000 lb.

History

Four major age classes occur in the Nass River sockeye stocks--4- and 5-year old fish with a 1-year freshwater phase, and 5- and 6-year old fish that spend two years as young in the lakes before they migrate seawards. The proportions of these age classes vary considerably from year to year, although almost invariably the 5-year fish with two years in the lake predominate.

Annual packs by 5-year averages, in 48 lb. cases, are shown below (1 case = about 10 fish in recent years = 72 lb. fresh round):

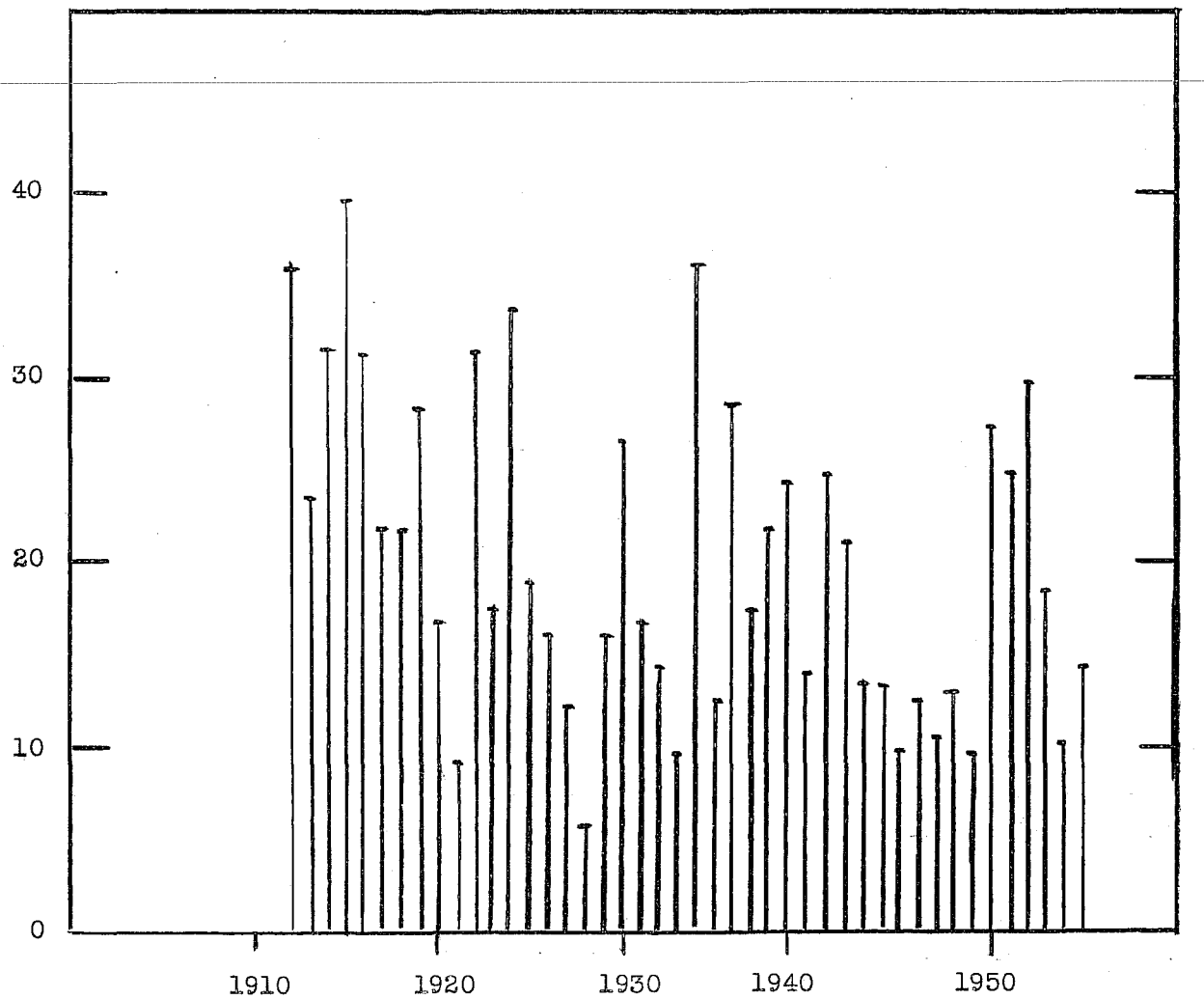
Years	Av. catch (thousands of cases)	Years	Catch (thousands of cases)
1911-1915	26	1951	24
1916-1920	24	1952	29
1921-1925	22	1953	18
1926-1930	15	1954	10
1931-1935	18		
1936-1940	21		
1941-1945	17		
1946-1950	15		

At least until recent years, the history of the sockeye fishing effort on the Nass has probably paralleled that of the Skeena, the period of most fishing being 1915-1935. Formerly Nass catches were packed in canneries located on the river, but more recently they have been carried to the Prince Rupert area on the Skeena River and canned there. With the Nass fishery, the decrease from the early peak production to the low packs of 1926-30 probably indicates overfishing, and as with the Skeena this occurred during the period 1915-1925. After 1941 fishing effort was reduced because of circumstances related to the war, following which respite there were increased catches in 1951 and 1952.

The distribution of the spawning escapement in the Nass watershed is not very well known, but the only important nursery lakes are the Medziadin and the Bowser. Falls in the Medziadin River which flows out of Medziadin Lake used to constitute an obstacle to adult migrants at times of low water, but the construction of a simple fishway in 1913 alleviated that situation. No other serious obstacles have been reported on the Nass, nor have any catastrophic phenomena occurred within the known history of the area.

Present Stock and Utilization

The recent Nass catches, in pieces, are as below:



Nass River sockeye packs, in thousands of cases.

1951	225,500
1952	304,500
1953	198,400
1954	101,600
1955	156,900

The rate of utilization of the Nass stocks cannot be estimated accurately because of the remoteness of the spawning areas and the difficulty of knowing escapements. The similarity of the history of the fishery with that of the Skeena River might suggest a similar rate of utilization (50%); on the other hand, the lake spawning and production situation is very different in the two watersheds. Our best guess is that the fishery currently takes 60 per cent of the stock, so that the latter averaged 208,000/0.6 = about 350,000 fish in 1951-54.

Future Prospects

(a) Without major improvements or disasters.

Under present management by regulation, the production of sockeye salmon on the Nass should provide a maximum sustained yield averaging about 20,000 to 25,000 cases per annum (1.5 to 1.9 million lb. per annum). This is somewhat below the high yield of 1915-1925 when removals were apparently too great and led to some depletion. Utilization of the stock should either remain as at present or might possibly be raised slightly.

The Nass nursery lakes have a combined area of about 45 square miles. At the present time they provide an average annual catch of about 4600 sockeye per square mile. This is considerably lower than that of the best Fraser River lakes, but somewhat greater than that of Babine Lake on the Skeena.

(b) Catch with intensive management.

Some of the types of direct aid to sockeye production described under the Skeena might be effective in the Nass system also, though maldistribution of spawning does not occur as far as known. It is likely that improvement measures will be tested thoroughly in accessible areas before being used on the remote Nass lakes. However this may well occur within 25 years, and raise Nass production correspondingly.

(c) Adverse factors.

Proposals exist for the utilization of the Nass waters for industrial purposes, but since it is not known how they will affect migration routes or nursery areas, no useful predictions of resulting changes to stocks can be given.

OTHER SOCKEYE AREAS

Present stock:	10,000,000 lb.	Utilization:	5,600,000 lb.
Stock in 1980:	11,000,000 lb.	Utilization:	7,000,000 lb.

History and Present Status

A fairly large number of additional lakes contain sockeye populations, situated along the mainland coast and on Vancouver Island. Catches in recent years were, in thousands of pieces:

1951	650
1952	843
1953	1185
1954	546
1955	491

The 1951-54 average was about 800,000 pieces weighing 5,600,000 pounds. The rate of exploitation is estimated rather arbitrarily as 55 per cent.

None of these areas have suffered important changes, and their catch has probably been about as at present for some time.

Future Prospects

Since many of the areas under discussion are so scattered, reliable estimates of spawning runs has often not been possible. With increased accessibility of and attention to the runs, a more efficient ratio of catch to escapement--either greater or less--may become possible in some places.

Fishways recently constructed on the Sproat, Stamp and Nimpkish Rivers are expected to increase sockeye production from Sproat, Great Central and Nimpkish Lakes. A few other runs may benefit from future constructions.

Among the largest lakes in the group under consideration are several that drain to the west coast of Vancouver Island: Kennedy, Henderson, Sproat, Great Central and Nitinat, which have a combined area of about ~~400~~ 175 square miles and to-day give a catch of about 135,000 sockeye on the average, or only ~~340~~ 770 per square mile. The waters of this region are very poor in dissolved nutrients, and the very heavy rainfall subjects spawning streams to violent freshets. However it may prove that a reasonable annual expenditure could ameliorate one or other of these handicaps and greatly increase production.

On the other hand, a hydroelectric development has already been projected that involves the Alberni lakes (Sproat-Great Central), which in its present form could scarcely fail to limit salmon production in at least one of these lakes.

On balance, we anticipate a gradual increase in average yield in future, up to about 1,000,000 fish or 7,000,000 pounds by 1980. Any important success in environmental management could at least double this figure.

PINK SALMON - Oncorhynchus gorbuscha

Present stock size:	116,000,000 lb.	Utilization by Canada:	45,000,000 lb.
		" " others:	13,000,000 lb.
Stock in 25 years:	130,000,000 lb.	Utilization by Canada:	54,000,000 lb.
		" " others:	16,000,000 lb.

History

Pink salmon are to-day the most abundant salmon in British Columbia. They spawn in more than 1,000 streams, situated both on the mainland and on many of the coastal islands. The only major area which does not contribute significantly to the natural propagation of the stock comprises portions of southern and western Vancouver Island.

Some pink salmon spawning grounds in the Fraser and Skeena watersheds are situated several hundred miles upstream from the river mouths. Much spawning, however, takes place relatively close to salt water, at times even within the range of tidal influence. The fry travel to the ocean as soon as they emerge from the gravel beds and hence are not, or are very little, dependent on fresh-water food supplies. Maturity is reached at an age of two years, the length of the life cycle being invariable to the best of our present knowledge. Pinks can be taken well out to sea, away from the continental shelf, but present results suggest that they do not travel as far as chum and sockeye salmon.

Although pink salmon showed some commercial importance prior to the war of 1914-18, intensive exploitation of the species by British Columbia fishermen dates from that period. However, as early as 1907 considerable catches were being made by Washington fishermen from stocks which undoubtedly spawned to a large extent in British Columbia waters. Since 1918 pink salmon fishing has been prosecuted in all the main geographic regions of the British Columbia coast and, with a few exceptions due to economic conditions or the peculiarities of a particular area, exploitation has been complete within the limits imposed by regulations adopted for conservational reasons. A review of trends up to 1947 is given by Hoar (1). The catches since 1920 are shown below. The average weight of a pink salmon is about 4.5 pounds.

Period	Average catch millions of fish
1920-23	8.2
1924-27	9.3
1928-31	12.3
1932-35	7.5
1936-39	9.6
1940-43	5.8
1944-47	9.2
1948-51	10.0
1952-55	9.7
1950	8.0
1951	13.0
1952	11.2
1953	11.1
1954	5.4
1955	11.0

For recent years, a breakdown by regions of the coast is shown in Table A. The United States catch in Puget Sound is also included, because these fish are taken from the same stock as that which Canadian fishermen fish.

Table A. Pink salmon catches by regions, in thousands of pieces.

	Statistical area	1951	1952	1953	1954	1955
Queen Charlotte Is.	1, 2	45	2761	12	1515	43
Nass River	3	1206	291	246	564	438
Skeena River	4	452	1451	426	739	1328
Central Coast	5-11	4925	3801	1120	2053	1988
Upper W. Coast Vancouver Is.	24-27	40	209	67	171	45
Johnstone St. and G. of Georgia	12-18	2290	2720	5104	401	3085
Fraser River, etc.	(19-23 28,29)	2726	3	4127	1	3961
Total for Canada		11684	11235	11110	5444	10887
Puget Sound and Juan de Fuca (USA catch)		5343	2	6000	15	..

In common with other salmon fisheries, the history of pink salmon exploitation has been marked by the introduction from time to time of larger vessels with longer range, new or improved aids to navigation and communication, and more efficient fishing gear. Due to competition for the limited (although large) quantities of fish available, there has been a trend towards catching the fish at an earlier stage in their migration, at points more remote from the spawning streams.

At the present time about 70 per cent of the catch of pink salmon is made by purse-seines and 30 per cent by gill-nets. Throughout the history of the fishery by far the greater part of the catch has been canned. It is indicated that from 1917 to 1924 as much as 10 per cent to 20 per cent was utilized fresh or frozen. Since that time probably not more than 5 per cent has been so used.

Management policy throughout the history of the fishery has been mainly directed to permitting the arrival of a sizeable part of each year's run on the spawning grounds. This policy is implemented in two ways: 1. Fishing is prohibited during certain periods in coastal waters and also at all times in streams and near stream mouths. Limitations on the kind and use of gear are also imposed. In general, an escapement from the fishery of 50 per cent of the runs has been aimed at, irrespective of the size of the runs. 2. Access of adults to spawning grounds has been maintained or improved. This has involved the removal of obstructions, construction of fishways and the prohibition of introducing harmful substances in streams frequented by salmon.

Hatchery propagation was never practised extensively for this species. Recently, however, there have been instances in which improvement of spawning conditions has been attempted in compensation for diversion of water for other purposes. These improvements have included the provision of artificial gravel beds and control of water flow (2).

Present Status

Since 1917 the annual British Columbia catch has fluctuated noticeably but the long-term trend has been remarkably stable. Total stocks were probably slightly greater in the 1920's than in subsequent periods but there seems to have been no continued decline.

From a consideration of the percentages of tagged fish recovered by the fishery and by comparing catches and spawning escapements in certain areas, it is concluded that in the case of fish travelling through Johnstone Strait and those frequenting the north-central part of the British Columbia coast, exploitation of the runs amounts to about 50 per cent (4, 5, 6). This figure has been used in estimating the present size of the total British Columbia stocks. The rate may be somewhat higher or lower in certain areas and was probably somewhat lower generally (perhaps 40%) prior to about 1945. The recent increase in rate of utilization did not result in any increase in sustained yield. Hence the fishery is now as intensive, or perhaps slightly more intensive than what is required for maximum yield.

A special situation exists in two important areas: (1) A southern mainland region comprising Howe Sound, the Fraser River and Puget Sound (Washington), towards which very large numbers of fish migrate in odd-numbered years, is almost devoid of pink salmon runs in the intervening even-numbered years, as shown in Table A. (2) A similar alternation of "good" and "off" years is characteristic of much of the Queen Charlotte Islands, the good seasons in this instance, however, being the even years. This regular alternation, which has persisted throughout the period for which records are available, can exist because of the unvarying two-year life cycle. Two separate stocks are necessary for runs to occur every year. In the areas cited, one stock is scarce or absent.

The status of the stocks in two areas require special comments.

(a) Skeena River area. A marked slump in pink salmon catches occurred throughout northern and central British Columbia in 1932, apparently a result of exceptional droughts in 1930. In most places the former level of catch was soon restored, but in the Skeena area this slump, and a somewhat similar depression which occurred in the "odd-year" succession a few years earlier, have not been followed by subsequent restorations of catch-level (14). Annual catches which in the 1920's averaged near 2,500,000 fish have averaged hardly half this quantity since 1930. Undoubtedly there has been a drop in the abundance of fish. At the same time it appears that in the Skeena area exploitation of the pink salmon runs has not been as consistently heavy from year to year as in other coastal areas and therefore does not as accurately reflect the size of the stocks.

In recent years two special events enter the picture. The Babine River slide obstructed substantial numbers of pink salmon in 1951 and 1952, though probably not more than a quarter of the total Skeena escapement (9). Its effects should be short-lived. In 1951 fishways were opened at Moricetown Falls on the Bulkley River (10). Designed to assist all species of salmon at this point, these structures will probably be particularly valuable to pinks, which are less capable of surmounting obstacles than are most other species. The upper Bulkley River contains extensive spawning areas which can add importantly to the productive potential of the Skeena.

(b) Fraser River - Juan de Fuca Strait. The special features of this area are (1) the biennial nature of the fishery (2) the exploitation of the stocks by both Canadian and United States fishermen.

The trend of the combined fishery is shown to some extent by the Washington pack figures, which declined from an average of about 14,000,000 fish per odd-numbered year in the decade 1911-1919 to about 6,000,000 fish in 1941-1949. It is not easy to segregate accurately the (much smaller) Canadian catches which should be regarded as being drawn from the same stocks of fish. However, Canadian catches do not reflect the overall decline, since our fishing intensity was light during the period of the highest United States catches and has tended to take an increasing proportion of the combined yield (from about 10% in 1911-1920 to 30%-40% in recent years). Canadian catches in the last 10 years have actually been greater than in any previous decade, largely because of an increased use of seiners along the southern Vancouver Island shore.

Although the largest combined catch (more than 22,000,000 fish) was made in 1917, the runs prior to that date were not exploited in proportion to their abundance, and they had already suffered a major disaster at Hell's Gate in 1913. The international pink salmon fishery was not so critically dependent as was the sockeye fishery on the runs to the upper Fraser, since many pinks spawn in the lower Fraser watershed and in other streams from Howe Sound to Puget Sound. Nevertheless the upriver escapements prior to 1913 were reported to run into the millions, and were wiped out in that year. Rounsefell and Kelez (7) have calculated an index of pink salmon abundance from catches of traps north of Deception Pass in Puget Sound, which shows an abrupt decrease between 1913 and later years, suggesting a decrease in stock by about 75 per cent. The traps in question were situated so that they probably measure Fraser fish almost exclusively (not those of Puget Sound, Howe Sound, etc.), but the stock of the whole region probably decreased by at least 60 per cent at that time. No recovery of the pink runs to the upper Fraser was observed until after fishways were constructed at Hell's Gate in 1945.

At the present time international competition for pink salmon is increasing in this area. Beginning in 1947, a major part of the Canadian fishing effort has been shifted from gill-netting operations in and near the Fraser River to purse-seining in Juan de Fuca Strait, thus intercepting the incoming fish at an earlier stage in their migration.

Currently, two opposite influences are at work. (1) Some re-establishment of the up-river Fraser runs is taking place, with considerable escapements now reported from the Seton Lake system and the Thompson River. (2) In the absence of some form of joint management policy, intensified international competition for fish may result in serious depletion.

Future Trends

(a) With the present kinds and intensity of management, and no major disasters.

Continuation of present management policy would seek to prevent depletion of stocks by overfishing. Increases in fishing intensity would be countered by increased restriction. If, however, pressure were to become much greater

than at present the difficulty of dividing the stock into desirable proportions of catch and escapement would undoubtedly increase.

In the absence of specific major disasters to spawning stocks, some adverse influence can yet be expected from reduced forest cover, local interference and encroachment by increasing human population, use of water for other purposes, etc. Effects of logging were apparent in the lower Fraser region in 1955, when fast runoff following heavy rains almost destroyed the seeding of many streams.

Present production of pink salmon in the Skeena and Fraser watersheds is probably considerably less than the potential. In the former some spontaneous increase in the size of the runs, such as that which has occurred from time to time in other areas, might take place under existing conditions and give improved catches for an indefinite period. The restoration of the upriver Fraser stocks will probably proceed for another few pink salmon generations, without radical departure from existing management practices, or it may be hastened by increased protection for the early part of the run. However, as matters stand, this restoration will affect only the odd years, and more than half of the increase in catch will accrue to United States fishermen.

In the absence of either special management or special disasters, the total average catch for British Columbia might be about the same in 1980 as at present--unavoidable local deterioration of the watersheds being compensated mainly by increase of the upper Fraser and the Skeena stocks.

(b) With new or intensified management.

Since Canadian production of pink salmon has suffered no marked decline since the early years of the fishery, management cannot aim at a rapid or spectacular "restoration" of a pre-existing high level. To raise the present average catch level implies the catching of more fish than at any previous period.

It is true that by summing the maximum known catches from each separate part of the British Columbia coast, a total can be reached which is much greater than any single year's production has ever been. However the natural fluctuations of climate, etc., which have mainly caused these past variations, will certainly occur in the future too.

Nevertheless there are types of management which are not, or are little, practised at the present time and which show promise of increasing yield if new effort is put into them. Those on which some information is available include: (1) opening of new spawning areas by fishways surmounting natural obstructions; (2) control of water supply to incubation and migration areas; (3) construction or improvement of spawning beds; (4) operation of hatcheries; (5) regulation of escapements to individual streams or tributaries in the direction of producing the optimum density of spawning populations; (6) reduction of predation on emerging fry; (7) stocking of streams from which pink salmon are absent or which support runs only in certain years. The first of these is an established policy already in operation (10, 13), whose tempo might be stepped up given additional funds. Most of the others have been or are being tried experimentally.

By the use of some combination of these tools of management it is probable that the production of some streams could be doubled. Water control and removal of predators have been shown in small-scale experiments to increase fry output to a marked degree (11). Excellent survival of eggs has been obtained in artificial redds with an assured water supply (2). Extensive application of these procedures awaits a study of costs and benefits in a larger operation; and if that proves satisfactory, perhaps a means of assigning costs directly to beneficiaries will have to be devised. With modern salmon values, even conventional hatcheries, using an improved drip technique, might prove economic. An attractive feature of measures of types (2) to (6) above is that they increase the stock without requiring increased escapement, so that the percentage taken by the fishery can be increased.

The possibility of establishing "off-year" runs on the lower mainland and Queen Charlotte Islands is a matter for speculation. A new transplantation experiment is being carried out (3), but it is not yet possible to evaluate its usefulness: past failures make prediction of success hazardous. As already indicated, Skeena River pink salmon production could probably be increased by measures which, in the first instance, might well include the regulation of escapements to individual streams and perhaps the stocking of others which are not being effectively utilized.

To be fully successful, most plans for increasing production would necessitate separate control of the fishing on runs belonging to each important stream or watershed. However, the present tendency to fish farther from the spawning streams (that is, before segregation of the various local runs has been established) militates against this kind of management. A reversal of this tendency is the most immediate need, at least in areas where it would not cripple Canada's competitive position. If the latter were stablized by international agreement, better control of escapement would be possible.

The maximum catch increases which would seem likely from these various measures in 25 years are about as follows:

	Catch on two-year basis
(1) Establishment of off-year runs	
(a) Fraser area	6,000,000 fish (Canada only)
(b) Queen Charlotte area	2,000,000 fish
(2) Removal of obstructions to migration	2,000,000 fish
(3) Intensive spawning management (control of water supply, improvement of redds, predator control on redds, hatcheries, etc.)	6,000,000 fish
Total	16,000,000 fish
	8,000,000 fish per year

Since the success of off-year transplantation, especially, is quite speculative, it would be unwise to count on more than 4,000,000 extra fish per year,

or about 18,000,000 pounds, even with expanded and vigorous management activity during the next 25 years. The ultimate limit may be considerably greater, however.

(c) Adverse factors.

Since pink salmon spawn to a large extent in the lower portions of the larger watersheds and also in many small coastal streams which do not offer attractive prospects for hydro-electric development at the present time, the construction of dams would be unlikely to have such drastic or widespread detrimental effects for this species as they might for sockeye. A notable exception would be any dam which interfered with the passage of the spawning populations now rapidly developing in the upper Fraser. Dams on the Fraser are discussed under "sockeye", and it is of some importance to predict the number of pink salmon that would have to use any new fishways constructed there. In recent years before the upper Fraser runs increased appreciably the international odd-year catch of pinks bound for the Fraser and the region of Howe Sound to Puget Sound averaged about 10,000,000 fish. At the estimated 50 per cent rate of capture, the best figure for the size of stock of the region under recent conditions of intensive utilization is twice this, or 20,000,000 pinks--before the upper Fraser came back into the picture. We estimated earlier, from Rounsefell and Kelez' data, that when the upper river was cut off by the 1913 obstructions the pink stock of the region decreased to about 40 per cent of its previous level. On this basis the average total stock of the region, when the upper river is completely rehabilitated, would become 20,000,000/0.4 = 50,000,000 pinks. That is, the upper river will add 30 million pinks to the present average stock of 20 million. Unless upriver reproduction were to prove exceptionally efficient, half of these will be needed for spawning. Hence in an average odd-numbered year about 15 million pinks will ascend the Fraser canyon. Environmental variability could bring this up to 25 million or more in some individual years.

There is another point to be considered in connection with proposed dams. Because they go downstream as fry, pinks may be more vulnerable to hazards of seaward migration than are sockeye; and observations to date indicate that fry will prove less amenable to guiding than smolts (12).

The intensification of international competition in the Juan de Fuca - Puget Sound region, if not checked or balanced by appropriate joint action to ensure adequate escapements, might bring these important runs to a very low level in the course of a few two-year generations.

As already noted, development of offshore fishing or fishing in other areas remote from the freshwater destinations of the fish carries the danger that certain runs will be depleted while other runs may be under-utilized.

Other adverse developments are likely to be local, gradual and insidious rather than dramatic. The spread of human population, the difficulty of offsetting fishing intensity, the use of water for hydro-electric or other purposes, the effects of deforestation--these effects may be somewhat more serious or develop more rapidly than is at present contemplated.

Without increased countermeasures, a combination of unfavourable events could certainly reduce average catches by 20 per cent in the course of 25 years.

Our best estimate of future events depends on the conditions that (a) no dams will block the Fraser or destroy the Thompson River spawning beds; (b) international competition will not reach harmful levels, or will become

regulated by an agreement; (c) no offshore fishery will develop; (d) moderate success will be achieved in increasing stocks by methods outlined under (2) above. On this basis we estimate that by 1980 stocks will have increased by about 12 per cent, to 130,000,000 pounds; and catch will be up by a little over 20 per cent, to 70,000,000 pounds, of which Canada will take all but about 16,000,000 pounds.

References

(1) Hoar, W. S. 1951. The chum and pink salmon fisheries of British Columbia, 1917-1947. Fish. Res. Bd. Canada, Bull. No. 90, 46 pp.

(2) 1954. Man-made spawning stream. Department of Fisheries, Trade News, 7(4): 3-4.

(3) Neave, F., and W. P. Wickett. 1955. Transplantation of pink salmon into the Fraser valley in a barren year. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 103, pp. 14-15.

(4) Pritchard, A. L., and A. C. DeLacy. 1944. Migration of pink salmon (Oncorhynchus gorbuscha) in southern British Columbia and Washington in 1943. Fish. Res. Bd. Canada, Bull. No. 66, 23 pp.

(5) De Lacy, A. C., and Ferris Neave. 1947. Migration of pink salmon in southern British Columbia and Washington in 1945. Fish. Res. Bd. Canada, Bull. No. 74, 11 pp.

(6) Manzer, J. I MS, 1954. Pink and chum tagging experiments in Johnstone Strait and Discovery Passage, 1953. (Unpublished MS, Fish. Res. Bd. Canada, Nanaimo).

(7) Rounsefell, G. A., and G. B. Kelez. 1938. The salmon and salmon fisheries of Swiftsure Bank, Puget Sound and the Fraser River. U. S. Bureau Fisheries, Bull. 49(27): 693-823.

(8) Neave, Ferris. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Bd. Canada, 9(9): 450-491.

(9) Godfrey, H., W. R. Hourston, J. W. Stokes and F. C. Withler. 1954. Effects of a rock slide on Babine River salmon. Fish. Res. Bd. Canada, Bull. No. 101, 100 pp.

(10) Swann, L. G. 1951. Moricetown Falls--a challenge met. Department of Fisheries, Trade News, 3(10): 3-5, 20.

(11) Wickett, W. P. 1952. Production of chum and pink salmon in a controlled stream. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 93, pp. 7-9.

(12) Based on preliminary observations on sockeye and pink salmon fry, by J. R. Brett and associates, Fisheries Research Board.

(13) Clay, C. H. 1955. A procedure for installation of fishways at natural obstructions. Canadian Fish Culturist, No. 17, pp. 1-12.

(14) Milne, D. J. 1955. The Skeena River salmon fishery, with special reference to sockeye salmon. J. Fish. Res. Bd. Canada, 12(3): 451-485. (Figure 5 on page 468 shows catches since about 1905).

(15) Chatwin, B. M. 1953. Tagging of chum salmon in Johnstone Strait, 1945 and 1950. Bull. Fish. Res. Bd. Canada, No. 96, 33 pp.

CHUM SALMON - Oncorhynchus keta

Present stock:	150,000,000 lb.	Utilization by Canada:	58,000,000 lb.
		" " others:	23,000,000 lb.
Stock in 25 years:	150,000,000 lb.	Utilization by Canada:	60,000,000 lb.
		" " others:	23,000,000 lb.

History

Chum salmon resemble pink salmon in that there is only a very short free freshwater life for the fry, during which they feed little or not at all. This species is larger than the pink (average 12 lb.) and matures at 3, 4 or 5 years of age as a rule. In the ocean it goes far out to sea. In British Columbia most chums spawn in short coastal streams. There are not and apparently never were appreciable spawning stocks above the Fraser canyon. In the Skeena they rarely ascend to Babine Lake or to Moricetown Falls. However in the Yukon River they enter Canada and proceed as far as Teslin Lake.

The chum salmon fishery in British Columbia became intensive at about the same time as the pink salmon fishery, which it resembles in many ways. Chums are exploited in all the coastal areas of the province. In the last few years about 55 per cent of the catch has been made by purse-seines and 45 per cent by gill-nets. As compared with pink salmon, a much larger percentage of the catch has been utilized in ways other than canning--now mostly fresh or frozen, at times smoked or drysalted. The more varied disposal of the product makes estimates of annual catches for earlier years somewhat less reliable than those for pink salmon. Approximate figures are as follows:

Period	No. of fish (millions)
1920-23	2.6
1924-27	6.4
1928-31	5.2
1932-35	4.2
1936-39	4.5
1940-43	5.2
1944-47	4.4
1948-51	5.9
1952-55	3.6
1950	8.6
1951	6.3
1952	2.5
1953	4.7
1954	5.9
1955	1.5

The distribution of catches for recent years (Table A) indicates that the species is caught mainly along the central coast and in Johnstone Strait. The United States Puget Sound fishery takes more than Canada does of the stock in the region of the Washington-British Columbia boundary, though part of our Area 12 to 18 catch consists of Fraser River and even Puget Sound fish. The situation here is similar to that for the pink salmon, except that there is much more chum spawning than pink spawning in Puget Sound rivers.

Table A. Chum salmon landings by regions, 1951-55, in thousands of pieces.

Region	Statistical area	1951	1952	1953	1954	1955
Queen Charlotte Is.	1, 2	477	111	142	667	74
Nass River	3	278	99	174	88	66
Skeena River	4	70	38	56	121	30
Central coast	5-11	2260	507	1233	1022	422
Upper west coast of Vancouver Is.	24-27	256	75	394	385	99
Johnstone St., Gulf of Georgia	12-18	2220	948	2015	2575	585
Fraser R., Howe Sound, etc.	19-23 28,29	643	703	655	1082	266
Canadian Total		6204	2481	4670	5941	1542
Puget Sound and Juan de Fuca, USA (canned pack only)		1400	1690	2800	1600	..

Present Status

Considerable fluctuation in annual catches has been witnessed since 1920. Catches to 1947 were graphed and studied by Hoar (1), who observed 3 or 4 periods of low catch, the first in the early 1920's. He was unable to decide whether these reflected mainly poor supplies or poor demand, but believed that large fluctuations in abundance had occurred. Although there has been no long-term trend downward or upward, marked weaknesses in certain recent years (beginning in 1944) indicate that there has been some reduction in the average abundance of fish since the earlier years of the fishery. The low catch of 1952, however, was due in large part to a prolonged strike in that year. The 1955 catch and stock were low everywhere, as for sockeye. These two species apparently wander farthest out to sea and have similar length of life, so an exceptionally unfavourable ocean environment at some time during the period 1953-55 is suggested.

Local areas in which reduced chum salmon catches and/or escapements have appeared within the last dozen years have included Vancouver Island and the Queen Charlotte Islands. In the former area, probable causes include: (1) severe flooding of spawning streams in certain years, (2) intensified fishing of stocks which make long inshore migrations through Johnstone Strait and the Strait of Georgia, (3) changes in stream flow pattern produced by deforestation in the eastern and southern sections of Vancouver Island. On the west coast of Vancouver Island and in the Queen Charlottes past difficulties in the enforcement of closed fishing periods and areas have apparently contributed to a lowering of population levels.

As far as known, the rate of utilization of chum salmon, is similar to that of pink salmon: recent tagging in Johnstone Strait indicated 50 to 52 per cent adjusted rate of return of tags for stocks entering there (6, 15). We have used 55% as the rate of utilization for the whole area. On the basis of an average catch of 5 million fish by Canada and 2 million by the United States, the present average stock available each year is estimated as $7/0.55 = 12.7$ million fish or about 150 million pounds.

Future Trends

Chum salmon are sufficiently similar to pinks in their distribution, habits and in the length of the freshwater period of the life-cycle to respond to the same favourable or adverse influences. The comments made under "pink salmon" in general apply also to the present species. The more variable total length of the life-cycle reduces the danger of eliminating a local population indefinitely through a catastrophe which affects only a single season's escapement. Also, the effect on the fishable stock of improved, or worsened, conditions is deferred for a longer period.

Since chums make little use of the upper parts of our longer rivers, any construction of main-stem dams on these watersheds would have little effect on this species. An exception is the Yukon River, where chums would be affected by proposed diversions, but these chums do not contribute to the Canadian commercial fishery.

The chum's failure to ascend the Fraser canyon, even in early days, means that it will probably not become established in the upper part of that river in the way pinks are.

Opportunities and methods for spawning-ground management will frequently be similar for both pinks and chums. However, the fact that the two species are so similar in their requirements is likely to lead, under intensified management, to a form of "competition" between them. In considering the maximum output of fish which can be obtained from the use of a given freshwater area, a choise may have to be made as to which species, or what proportion of each, is to be promoted. Under these circumstances pinks would generally be favoured as being frequently more desirable and because quicker results could be expected from management procedures. Therefore, while increased efficiency of propagation can be expected in streams where chums are dominant, the species is less likely to benefit proportionally from a program of new or special undertakings in the fish-cultural field.

On the whole, no great change is anticipated in the abundance of chum salmon in the course of the next 25 years. Unavoidable local deterioration of their freshwater environment, from logging and other utilization, is likely to be compensated by more direct management, by opening up of inaccessible parts of some spawning streams, and by increased escapements in areas whose spawning stocks have been too greatly reduced.

References

See under "Pink Salmon".

COHO SALMON - Oncorhynchus kisutch

Present stock:	40,000,000 lb.	Utilization:	23,000,000 lb.
Stock in 1980:	40,000,000 lb.	Utilization:	30,000,000 lb.

(N. B. Catches made by United States fishermen are not included above, nor is their proportionate share of the stock.)

History

Coho salmon mature predominantly in their 3rd year, and have spent one year in fresh water--usually in a river or creek. They ascend both large rivers and small creeks, penetrating to very small tributaries for spawning. About 1500 streams have coho stocks; in contrast to spring salmon, the best 10 probably have less than a third of the total. They are absent from the Fraser River above Lytton, though present in the Thompson drainage. In the sea they seem to occur mostly fairly close to shore, though occasional individuals have been taken in high seas exploration. Fish tagged off our coast are nearly all retaken in our waters or in closely neighbouring parts of Alaska and Puget Sound: migrations of more than 300 miles are exceptional.

Fishing is mostly by trolling offshore, by seines and by gill-nets. Information on the catches of coho salmon is similar to that mentioned for spring salmon, with the following differences: The proportion caught by gill-nets is smaller and more are taken by purse seines. The proportion taken by trollers has always been large, and in recent years amounts to approximately 2/3 of the total catch. Recent catches are among the largest in the history of the fishery. Catches for the last decade are shown below, in thousands of pounds landed weight (mostly gutted, head-on):

Years	District 1 (Fraser R.)	District 2 (Northern)	District 3 (Southern)	B. C. Total
1945	2289	14350	14418	31057
1946	1354	11085	7503	19943
1947	1464	8507	10173	20143
1948	1623	10044	12589	24256
1949	1129	9715	10845	21688
1950	1722	7288	11014	20024
1951	1221	13818	17171	32211
1952	664	7314	11630	19608
1953	662	6806	13677	21105
1954	992	8252	9684	18928

The sport fishery in the Strait of Georgia takes at least 200,000 small fish each year, and the commercial catch is approximately 3,000,000 fish per annum. Since 1945 the catch has remained fairly steady (20 to 30 million pounds). It constitutes about 15 per cent by weight of the total British Columbia salmon catch. Since most of the coho salmon mature in their third year, the success of a large brood year is shown by the large catches in 1945, 1948 and 1951. The failure of the 1951 brood year is shown by the small catch in 1954. The poor return from the large run in 1951 can be attributed at least partly to the dry summer of 1952. Much of the variation in catch from year to year depends

on summer stream flow and the survival of young coho salmon during their first year of life (1, 2). The low catch in Districts I and II in 1952 is due in part to a strike during the season.

Coho salmon are usually between 5 and 10 pounds weight. Although most are used on the fresh and frozen market, a considerable number are canned.

Present Stocks and Utilization

Quite a number of coho tagging experiments have been made, but there is apparently considerable mortality of troll-caught fish, and rate of return is usually not more than ~~25~~ 15 per cent even in the most recent experiments (3, 4, 6). It is also difficult to get escapement estimates from fish which disperse as widely as coho. However, the best estimate suggests that it is somewhat less than half of the stock, or about 2,000,000 fish out of a total of 5,000,000.

Future Prospects

(a) Without major improvements or disasters.

It seems inevitable that some coho stocks will decline because of encroachment of civilization on the streams where they spawn and live during their first year of life. Also, logging of the watersheds will continue and will decrease the capacity of stream nurseries, though eventually an equilibrium should be reached in this respect. A larger proportion of the catch will be taken by the sports fishery in inshore waters.

(b) Catch with intensive management.

Coho will take advantage of opening new streams above present obstructions, probably more than any other species. Control of water flow might rarely be undertaken for cohoes alone, but they may benefit from installations designed primarily for pinks or chums. Removal of log jams on small streams may be necessary, especially in areas where coastal streams have been most seriously affected by logging. Pond rearing of cohoes to the smolt stage is also possible, but expensive. With an extensive program of management it should be possible to offset much of the loss due to man-made or natural changes in the environment.

However, whether this is done on a substantial enough scale will depend on how valuable coho salmon are considered to be (to both commercial and sport fishermen) in comparison with other species of salmon which frequent the same streams (young coho prey on other small fish) and also on the value of the watersheds to other industries.

(c) Major adverse factors.

Considerable reduction in coho supply would come from major dams on the Fraser or elsewhere. More important, probably, since the stream residence stage is vital to survival of coho, are the less spectacular effects of reduction in stream flows from logging and fires, by local diversions of water for irrigation or water supply, by ditching of farm lands, by construction of roads, and by industrial or agricultural pollution. Both the stock and the catch of coho salmon could be considerably reduced in the next 25 years by these circumstances.

Our best prediction is based upon the assumption that during the next 25 years vigorous action will be taken to alleviate deteriorated condition in coho streams, and to open up as many new stretches as possible. It is unlikely that this will do more than maintain present stocks, but somewhat more efficient utilization of the species may be possible, providing somewhat larger average catches.

References

See under Spring Salmon

SPRING or CHINOOK SALMON - Oncorhynchus tshawytscha

Present stock:	22,000,000 lb.	Utilization:	13,000,000 lb.
Stock in 1980:	20,000,000 lb.	Utilization:	15,000,000 lb.

(N. B. Catches made by United States fishermen are not included above, nor is their proportionate share of the Pacific stock.)

History

Spring salmon spawn in over 200 large to medium size streams in British Columbia, of which the best 10 probably account for half of the total fish. The young may spend up to a year in fresh water after hatching, but usually it is only a few months. Equalling or exceeding the sockeye in vigor, springs ascend to the headwaters of the Yukon, Skeena and Fraser, and formerly of the Columbia as well.

Prior to 1945 accurate catch statistics are not available for spring salmon. However, estimates of the catch by types of gear from 1920 to 1945 suggest that in the early years the gill-nets caught two-thirds of the catch and the trollers one-third. The gill-net catch appears to have remained relatively constant over the years, but from 1941 to 1946 the number of trollers increased rapidly, and they now take two-thirds of the total catch. Consequently the catch in the last decade is probably the highest in the history of the fishery. Since 1945 the annual catch (in thousands of pounds landed weight, mostly gutted head-on) for the three administrative districts of British Columbia are shown below:

Year	District 1 (Fraser R.)	District 2 (Northern)	District 3 (Southern)	B. C. Total
1945	5021	2639	5142	12802
1946	3695	4038	7498	15231
1947	3843	3552	4111	11505
1948	2646	3394	7467	13508
1949	3568	3131	7796	14494
1950	2970	2703	7794	13466
1951	2565	2672	6420	11657
1952	2133	3274	7464	12870
1953	3112	3056	7904	14072
1954	3304	2531	6403	12237

During this period the catches in each of the three districts have remained relatively constant. The total commercial catch (10 to 15 million pounds, or about a million fish) constitutes 8 per cent by weight of the total British Columbia salmon catch. About 50,000 fish are taken by sport fishermen.

Spring salmon are large in size (usually 10 to 25 pounds), and many are used fresh or frozen. Most fish are mature or maturing when caught, but in certain areas trollers take many immature ones. As far as known, they hardly go out to sea beyond the continental shelf. ~~Most~~ All are taken within sight of land.

The ocean migration routes and the origins of the stocks which are fished have been investigated by tagging and marking experiments. Spring salmon spawn

mainly in the larger rivers, and the young move along the coast a long distance northwest from the rivers in which they spawn. Consequently, the Columbia River stocks are important in the Canadian and Alaska fisheries, and even Sacramento fish have been taken here (5). It is estimated that in 1930 Columbia fish contributed over 50 per cent of the troll catch outside the Strait of Georgia, but since then they have declined, until in 1950 they probably accounted for only about 30 per cent (6). Formerly the spring and summer runs of Columbia chinooks were most important, but they declined as a result of water diversions and overfishing (apparently); when the Grand Coulee dam cut off all spawners from entering Canada in 1939, chances of restoring populations in the upper river were lost. In the last five years the late run of "fall chinooks" to the Columbia River has also declined sharply. High catches in Canada have been maintained by increased numbers and efficiency of trolling boats, which has meant heavier exploitation of stocks from the larger rivers in British Columbia, such as the Fraser. Also, fishermen are catching smaller fish, and more of the immature fish, than formerly. In addition, more United States boats now fish off Vancouver Island, in Dixon Entrance and off southeast Alaska, than in the early days.

A small sport fishery has long operated in the Strait of Georgia. In recent years it has expanded rapidly and is spreading northward.

Present Stocks and Utilization

Because spring salmon spawn in the upper tributaries and in the riffles of the larger rivers where observations are difficult, no very accurate measure of the spawning escapements is available. Best figures indicate that the spawners are less than half of the total stock, or about 500,000 fish.

Estimation of rate of exploitation from tagging results is difficult because of the unknown, but large, mortality of the fish after tagging. Also, the international fishing and the long ocean migrations of the major stocks are complex, and make it impossible to estimate their size individually.

Since the recent increase in fishing effort has not produced any overall increase in catch, it seems likely that we are at or close to the highest yield which can be sustained by the available stocks as a whole. Some populations are probably too heavily fished; there is fairly good presumptive evidence that the recent decrease of Columbia River fall chinooks is mainly a result of overfishing.

Future Prospects

(a) Without major improvements or disasters.

Without special management, an increase in the industrial utilization of water in the spawning and nursery areas of the larger rivers will gradually reduce additional stocks, and even with a better distribution of effort the commercial catch would probably not be maintained quite at its present high level. With an increase in British Columbia's population, and more time for recreation, the local sport fishery will continue to expand. The number of United States sportsmen fishing off British Columbia will also increase.

(b) Catch with more intensive management.

Since the spawning areas are mostly limited to large rivers and tributaries where water control and even censusing of the stock is very difficult, little increase in stock can be anticipated from the methods which show promise for pink and chum salmon. However some spawning areas can be opened up by fishways over natural obstacles. Restrictions on the catching of immature fish might result in a somewhat higher catch than at present.

(c) Adverse factors.

A few important spawning streams have already been damaged by industrial use, for example, the Nechako and the Puntledge. The full effect of these diversions has not yet been felt. Mainstream dams on rivers such as the Fraser could be very damaging to springs, as to sockeye. If more important tributaries are cut off, hatcheries might be the only method of making up the loss.

An increase in competition from United States commercial trollers and sport fishermen seems inevitable over the next 25 years.

Our best future estimate is based upon the belief that during the next 25 years some reduction of the total spring salmon stocks will occur inevitably, because of greater utilization of spawning waters for industrial purposes, but that the large rivers will not be disastrously dammed, and present overfishing of the Columbia will be remedied. Better knowledge and more detailed regulation will permit somewhat more intensive utilization, sufficient to offset the decline in supply and the increased competition.

References

(1) Neave, F. 1949. Game fish populations in the Cowichan River. Fish. Res. Bd. Canada, Bull., No. 84, 32 pp.

(2) Smoker, W. A. 1953. Stream flow and silver salmon production in western Washington. Washington Dept. Fish., Fish. Res. Papers, 1(1): 5-12.

(3) Kauffmann, D. E. 1951. Research report on the Washington State offshore troll fishery. Bull. Pac. Marine Fish. Comm., No. 2, pp. 77-91.

(4) Neave, F. 1951. Observations on troll-caught salmon of the west coast of Vancouver Island, 1949. Ibid., No. 2, pp. 93-101.

(5) Clemens, W. A., R. E. Foerster and A. L. Pritchard. 1939. The migration of Pacific salmon in British Columbia waters. Am. Assn. Adv. Sci., Spec. Pub., No. 10, pp. 51-59.

(6) Milne, D. J. MS. Recent British Columbia spring and coho salmon tagging experiments, and a comparison with those of 1925-30. Fisheries Research Board of Canada, Nanaimo.

STEELHEAD - Salmo gairdneri

Present stock:	5,000,000 lb.	Commercial catch:	600,000 lb.
		Subsistence catch:	350,000 lb. (?)
		Anglers' catch:	300,000 lb. (?)
Stock in 1980:	5,000,000 lb.	Commercial catch:	500,000 lb.
		Subsistence catch:	350,000 lb.
		Anglers' catch:	600,000 lb.

Present Status

The species S. gairdneri can be anadromous or can live wholly in fresh water; and the relations between the two types are obscure. Steelhead are identifiable as the returning anadromous individuals of the species. They occur in nearly all rivers along the British Columbia coast, sometimes in quite small ones. In appearance, size and habits steelhead greatly resemble the Atlantic salmon. However, steelhead appear to grow faster in fresh water and spend less time there (1-4 years, but usually not more than 2); and among the returning adults there is no sharp distinction between grilse and larger fish (1, 2). Sizes range up to about 25 pounds, with 15 pounds usually considered a big fish.

Steelhead are less common than any of the Pacific salmons, though the light fishery which many stocks experience suggests that the catch statistics do not do them justice. Per mile of coastline, they are apparently about as abundant as are Atlantic salmon in the east.

Steelhead runs in different streams may occur in summer or in winter; some streams have both types. Winter fish are commonest in coastal streams.

The commercial catch of steelhead is taken almost wholly by gill nets, since the species rarely takes a troll in salt water. The landings in recent years have been as below (weights are mostly dressed, head-on):

	Pieces	Pounds
1951	..	408,200
1952	54,600	508,100
1953	43,100	463,200
1954	53,000	561,900

Largest catches are from the Skeena area; the Fraser yields about 10,000 fish.

However the commercial catch gives little indication of the abundance of steelhead, for most of the runs occur at places or times where there is little or no commercial fishery. There is a considerable subsistence fishery by Indians, using gill nets, dip-nets or gaffs. Its landings would be in the tens of thousands of fish, but no exact figures are available.

Sport fishermen take considerable numbers of steelhead in rivers, but again no comprehensive figures are available. Their fishing is heavily concentrated on the more accessible lower mainland and Vancouver Island streams, but it also extends up such of the larger rivers as are clear enough to fish, especially the Thompson, Bulkley and Babine. The only figures available for the take by sportsmen is a tentative estimate of 2,500 caught during the winter of 1948-49

in the Chilliwack-Vedder system (3). The total must amount to some tens of thousands of fish. Sport fishing success varies greatly with the weather and with stream conditions. The take is not related either to commercial catch or to variable success of steelhead reproduction: in fact, successive year-classes seem remarkably uniform in numbers (2).

In the province as a whole, steelhead seem to be relatively lightly fished, and our estimate of stock is based on 25 per cent utilization by all methods. From accessible streams, however, there is presumably a heavier take. If overfishing occurs at all, it is only locally where, in addition to some commercial take, an intense subsistence or sport fishery is fishing a rather small river.

Future Prospects

Steelhead are highly valued by sportsmen, but are a very minor part of the commercial salmon fishery. Hence it seems likely that steelhead will to some extent be spared commercial use in heavily-populated parts of the province, as times goes on, except for what are caught incidentally in fishing for salmon. Accordingly the estimated commercial catch for 1980 is decreased somewhat, whereas anglers' catches are increased. Maintenance of the future stock implies no obstructive dams on major rivers. Local deterioration, as on the Capilano, will presumably be compensated by intensified management and the opening up of new reaches of some streams.

References

(1) Neave, F. 1949. Game fish populations of the Cowichan River. Fish.Res. Bd. Canada, Bull. No. 84, 32 pp.

(2) Mather, F. P., and P. A. Larkin. 1955. Life history of the steelhead trout of the Chilliwack River, British Columbia. Trans. Am. Fish. Soc. for 1954, 84: 27-38.

(3) Larkin, P. A. 1949. Report on the preliminary survey of the steelhead of the lower Fraser River. B. C. Game Comm., Rept. for 1948, pp. 58-69.

PACIFIC HERRING- Clupea pallasi

Present stock:	395,000 tons	Utilization:	190,000 tons
Stock in 1980:	395,000 tons	Utilization:	260,000 tons

History

Herring have been fished in British Columbia waters since 1877, when a catch of about 75 tons was made. The largest catch, about 211,000 tons, was made in the 1953-54 fishing season. In Table I are shown the average catches by 5-year periods from 1910-11 to 1950-51, and by season from 1950-51 to 1954-55, for each sub-district. Records from 1910 to 1916 represent the fiscal year which includes an entire herring season (October to February), records from 1917 to 1932 are for the calendar year, while those for 1933-34 onwards are for the herring season. The error introduced in using the calendar year is not great, as the major part of the fishery had taken place by the end of December.

Table I. Average catch by 5-year periods from 1910-11 to 1950-51 and by season thereafter for each sub-district, from (1).

Year	Queen Charlotte Islands	Northern	Central	Upper East Coast of Vancouver Island	Middle East Coast of Vancouver Island	Lower East Coast of Vancouver Island	West Coast of Vancouver Island	Total
1910/11-1914/15	353	3009	3	..	..	20504	1758	27627
1915/16-1920	2	1415	235	..	197	20152	14053	31608
1921-1925	..	1773	523	17	221	24318	28936	55787
1926-1930	15	5208	303	16	61	42780	22599	70982
1931-1935/36	11	4765	69	75	14	23956	21813	50703
1936/37-1940/41	3400	14560	31580	3760	3320	28060	25720	110400
1941/42-1945/46	500	4420	21600	4700	7090	42940	18180	99420
1946/47-1950/51	630	30350	38100	5840	12150	39570	44520	171160
1951-52	11200	57300	39900	8250	10350	41000	30000	198000
1952-53	185	2184	1090	106	83	8091	23	11824
1953-54	28550	29750	31650	6650	19600	52660	41350	210210
1954-55	21625	20280	27615	9530	25740	51130	14200	170120

The general trend has been towards a steady expansion of the fishery, primarily in response to market conditions. The most important influences have been the development and loss of the oriental market for drysalt herring and the development of the reduction industry for herring oil and meal. The oriental drysalt market opened in 1904 and by 1927, in response to this market, the annual catch had increased to about 85,000 tons. As a result of the loss of this market between 1927 and 1934-35 the annual catch dropped to 30,000 tons. The development of the reduction industry, first established in 1924, brought about an increase from 30,000 tons in 1934-35 to about 100,000 tons in 1936-37. In the period between the latter season and 1945-46, the annual catch fluctuated around 110,000 tons. From 1945-46 to 1948-49 the catch increased to 185,000 - 190,000 tons and has remained at that level until the present (3). About 98 per cent of the present catch is reduced to meal and oil.

Prior to 1911, fishing was confined mainly to waters off the lower east coast of Vancouver Island, with a small fishery for bait in the Prince Rupert area in northern British Columbia. Commercial fishing operations were expanded to include Barkley Sound on the west coast of Vancouver Island in 1911-12, areas northwest of Barkley Sound in 1926-27 and waters off the central mainland in 1936-37. Herring were first taken in numbers off the lower east coast of the Queen Charlotte Islands in 1938-39, and off the upper and middle east coast of Vancouver Island in 1939-40. From 1917 to 1933 the annual catch in the Prince Rupert area averaged about 3,000 tons, fluctuating chiefly according to demand. In the following seasons until 1940-41 fishing effort in Prince Rupert area and Tuck Inlet increased with 20,900 tons being taken in 1939-40 (6). With the exception of 1941-42, when about 19,000 tons were taken from Khutzeymateen Inlet, catches declined until 1947-48, when the productive Ogden Channel region was first exploited. In recent years, only one small stock, that in Skidegate Inlet on the upper east coast of the Queen Charlotte Islands was fished for the first time. The substantial increase in total catch since 1945-46 was largely a result of greater exploitation of regularly fished stocks.

Present Status

From 1947-48 to 1954-55, the annual herring catch has varied from about 169,000 tons to about 211,000 tons, averaging approximately 190,000 tons. The fluctuations in annual catch are attributed mainly to variations in the relative strengths of the year-classes contributing to the fishery. Variations in fishing effort and degree of exploitation have had a relatively minor effect, except in 1952-53.

Little exact information exists on the size of the whole British Columbia herring stock or on the sizes of the various individual populations. The best information is for the lower east coast of Vancouver Island. Tester (5), from age composition and catch data, estimated that from 1942-43 to 1951-52 the average size of this population at the start of the fishing season was about 71,000 tons. During the same period the average catch was about 40,000 tons, giving an exploitation rate of 56 per cent. Tester's estimate agrees well with that made by Stevenson and Outram (2), obtained by adding the number of fish in the catch to the number in the spawning population, estimating the latter from the number of miles of spawn deposited after the close of the fishing season and the number of eggs and equivalent number of spawners per unit area.

An estimate of the average size of the population on the west coast of Vancouver Island from 1946-47 to 1951-52 can be made by converting into tons and averaging Stevenson and Outram's estimate of the numbers of fish present at the start of each season. This estimate is 91,000 tons. During the same period[1/] the average catch was 42,100 tons, giving an average exploitation rate of 47 per cent.

1/ In 1952-53, because of a strike of herring fishermen there was no regular fishery. The small catch in this year is omitted in calculating the average catch.

While no good information exists concerning the exploitation rates in other populations, indications are that they are probably much the same for the lower east coast and west coast of Vancouver Island populations - at any rate not greater than the former (56%). Based on the average rate of exploitation of the above two populations (52.5) and on the average total annual catch of herring from 1947-48 to 1954-55 (omitting 1952-53) the average total of fished populations of herring in British Columbia amounts to 365,000 tons. The 30,000 ton estimate for the west coast of the Queen Charlotte Islands brings the grand total to 395,000 tons.

Future Trends

Further increase in the herring catch can come about through:

1) Exploitation of additional stocks. The great expansion of the British Columbia herring fishery has been achieved through the exploitation of a greater and greater number of the herring stocks. At the present time all known herring stocks with one exception are being utilized. This exception is the population on the west coast of the Queen Charlotte Islands. Herring are known to be present here, but nothing is known of the size of the population. Judging from the topography of the coast and the relatively small amount of spawn revealed by an aerial spawn survey in 1953, this population would appear to be relatively small. Lacking further information as to its size, it is assumed that this population contains 30,000 tons of herring and when fully exploited would yield an annual catch of not more than 20,000 tons. There is, of course, the possibility that some other unexploited stocks will be found.

2) The increased exploitation of stocks now being utilized. One of the results of the comparative study of the lower east coast of Vancouver Island population, where rigid catch quota restrictions were applied, and the west coast population, where no catch quotas were applied, was that on the west coast of Vancouver Island in particular, there was no relationship between the amount of spawn deposited and the strength of the resulting year-class. Strong year-classes resulted as often as weak year-classes from small spawnings and weak year-classes as often as strong year-classes from large spawnings (4). This finding suggests that the spawning population could be reduced somewhat and the catch increased, without endangering future population abundance. While detailed information does not exist for other populations, no indications have been found to suggest that a direct relationship between spawn deposition and year-class strength exists in them. It seems reasonable to assume, therefore, that all populations can withstand a higher rate of exploitation than at present. In Table II are shown for each population the present catch quota where applicable, the average catch from 1947-48 to 1954-55 (omitting 1952-53), and an estimate of the increased sustained catch that it is assumed the population can withstand.

With the full exploitation of all populations the annual British Columbia herring catch may fluctuate around a level of approximately 260,000 tons. Because of the greater rate of exploitation, the average age of the fish in all populations would decrease somewhat, the contributions of older fish would be reduced and there would be greater dependence on the incoming year-class. Fluctuations in annual catch might therefore be greater than at present.

Further increase in the herring catch is expected to come about only through increased and full utilization of all stocks. There appears to be little chance

Table II. The average catch from 1947-48 to 1954-55 and the future estimated sustained catch, by sub-district.

Sub-district or population	Present quota	Average catch 1947-48 to 1954-55	Assumed increased catch
West Coast of Queen Charlotte Is.	No Quota	..	20,000
East Coast of Queen Charlotte Is.	No Quota	25,000 1/	25,000
Northern mainland	30,000	36,400	40,000
Central mainland	40,000	40,100	50,000
Upper East Coast of Vancouver Is.	10,000	6,800	10,000
Middle East Coast of Vancouver Is.	10,000	15,300	20,000
Lower East Coast of Vancouver Is.	40,000	43,800	55,000
West Coast of Vancouver Is.	No Quota	38,500	40,000
Total		205,900	260,000
Average total catch		187,000	

1/ Based on the years 1953-54 and 1954-55 only. Accounts for the difference between the average total catch and the total of the average catches.

of increasing the size of these stocks or the size of a year-class at recruitment through remedial or protective measures during early life-history stages. The strength of a year-class is apparently determined by the success of survival during the larval stage. While it might be possible, though not necessarily practical, to increase spawn survival through protective measures, it would be impossible to influence survival during the larval stage and hence to influence year-class strength.

While it is expected that full exploitation of the herring stocks can be attained within 25 years, future market conditions and new developments in fish-locating and fishing methods will have a bearing on this prediction.

A pronounced decrease in the demand for herring meal and oil (which appears unlikely at the present time) could greatly delay the time of full exploitation of the stocks. On the other hand, greater utilization of herring for food purposes (for instance, establishment of a sardine industry) may quickly bring about full utilization. Almost the entire herring catch is taken by purse-seines. Less than one per cent is taken by otter trawls, gillnets and traps. Purse-seining, when the fish are tightly schooled in relatively shallow water, is such an efficient method of fishing that it is unlikely that another method will be developed that can compete successfully with it in fishing such concentrations. A possible exception would be the wide use of large traps.

Further improvements in seining methods and in methods of locating fish can reasonably be expected. Such improvements may result in increased exploitation with a less than proportional increase in fishing effort, thereby

providing a greater financial return. The power hauling block developed in the last two years for salmon seining may be increased in size and modified for handling herring seines within the next 5 years. This may permit the use of longer and deeper seines without increasing crew size. Providing existing regulations on the maximum length and depth of seines are changed, bigger nets may come into use within the next 5 to 10 years.

Considerable attention is now being given to the adaptation of the echo-sounding and horizontal scanning equipment to the particular needs of fishermen. While the scanning equipment at present on the market has not found ready acceptance, improvements in design and performance will possibly lead to its adoption within 5 to 10 years. The use of such equipment and of improved echo-sounders should increase the ease with which fish are located, and hence fishing efficiency.

The recently developed mid-water trawl should prove satisfactory for taking herring and should be in commercial use within 5 years. While this net may prove more effective than the purse-seine on small, scattered, or deep schools of herring it is unlikely to be able to compete successfully with the seine on large, dense schools. Its use, therefore, may not have a major effect on herring fishing. The mid-water trawl should be capable of supplying steadily, throughout the open season a relatively small amount of high-quality fish. This could lead to the establishment of an increased market for herring for human consumption either as fresh, kippered, smoked, or speciality-pack herring. It is not now expected that the mid-water trawl, when commercially established, will take more than 10,000-20,000 tons of herring annually, or about 5-10 per cent of the total annual catch.

References

(1) Data from Annual Reports of the Fisheries Branch of the Dept. of Marine and Fisheries, Fisheries Statistics of Canada, and British Columbia Catch Statistics issued by the Federal Department of Fisheries.

(2) Stevenson, J. C., and D. N. Outram. 1953. Results of the investigation of the herring populations on the west coast and lower east coast of Vancouver Island in 1952-53, with an analysis of fluctuations in population abundance since 1946-47. Rept. British Columbia Fish. Dept., 1952, pp. 57-84.

(3) Taylor, F. H. C. 1955. The Pacific herring (Clupea pallasi) along the Pacific coast of Canada. Internat. North Pac. Fish. Comm., Bull. No. 1, pp. 107-128.

(4) Taylor, F. H. C., and D. N. Outram. 1954. Results of the investigation of the herring populations on the west coast and lower east coast of Vancouver Island in 1953-54. Rept. British Columbia Fish. Dept., 1953, pp. 52-82.

(5) Tester, A. L. 1955. Estimation of recruitment and natural mortality rate from age composition and catch data in British Columbia herring populations. Jour. Fish. Res. Bd. Can., 12(5), pp.649-691.

(6) Tester, A.L. 1945. Catch statistics of the British Columbia herring fishery to 1943-44. Fish.Res. Bd. Can., Bull. 67, pp. 3-47.

PACIFIC HALIBUT - *Hippoglossus stenolepis*

Present stock:	700,000,000 lb.	Utilization by Canada:	24,000,000 lb.
		" " others:	38,000,000 lb.
Stock in 1980:	600,000,000 lb.	Utilization by Canada:	45,000,000 lb.
		" " others:	60,000,000 lb.

Long the object of an important subsistence fishery, the halibut is first recorded as entering Canadian commercial production in 1888. Reasonably complete statistics date from 1915, which happens to be the high point of the early fishery, when 19 million pounds were reported. However production started to decline immediately afterward. Subsequent Canadian catches are as shown below (2):

Years	Av. catch (millions of lb.)	Year	Catch (millions of lb.)
1916-20	8.9	1951	21.0
1921-25	9.1	1952	24.8
1926-30	8.6	1953	25.8
1931-35	8.5	1954	27.5
1936-40	12.3		
1941-45	13.2		
1946-50	19.9		

After the 1915 peak, catches declined because decreasing fishing success made the fishery less profitable, until dissatisfaction led to formation of the International Fisheries Commission to investigate and eventually regulate the halibut fishery. This body, now the International Pacific Halibut Commission, has carried out these duties down to the present. The Annual Reports and other Bulletins of the Commission are the source of almost all available information concerning halibut of the eastern Pacific.

The Commission has divided the region fished by Canadians into two Areas. Area 2 comprises the coast from Willapa Harbour, Washington, to Cape Spencer, Alaska, and most of the Canadian catch comes from this Area. Area 3, which provided us with nearly 10 million pounds in 1954, extends from Cape Spencer west to the Aleutian Islands. Both areas are also fished by United States vessels, which have traditionally taken the larger part of the catch in both Areas, and still do in Area 3.

The fishery is mainly by long-lining. The Commission's regulations prohibit trawling for halibut, on the grounds that too many small fish would be taken. Trolling is permitted within the season, and many trollers turn their attention from salmon to halibut at that time.

All halibut catch statistics are in terms of gutted head-on weight, and this unit is employed here.

Area 2

Present stock:	200,000,000 lb.	Utilization by Canada:	16,000,000 lb.
		" " U.S.A.:	17,000,000 lb.
Stock in 1980:	200,000,000 lb.	Utilization by Canada:	25,000,000 lb.
		" " U.S.A.:	25,000,000 lb.

History

Catches by Canada and the United States, number of standard units of effort (6-line skates), and catch per unit effort, are shown below (from 3, 6, 7, 8):

Years	Yearly catch (millions of lb.)	Av. no. of skates set (thousands)	Catch per skate
1902, 04, 05	24.1	...	...
1907, 10	50.9	185	275
1911-15	52.8	353	149
1916-20	29.3	326	90
1921-25	28.8	477	60
1926-30	23.8	535	44
1931-35	22.3	431	52
1936-40	26.2	427	61
1941-45	25.3	347	73
1946-50	28.1	314	90
1951	30.6	319	96
1952	30.9	...	increased
1953	33.0	...	increased
1954	36.7	...	increased

The catch increased to a maximum in 1912, decreased to 1931, and soon after was brought under a quota regulation. The quota has been gradually raised. In 1954 Canada took 19.6 million pounds and the United States 17.6 million pounds.

The gear in use (that is, actually set) increased to 1929, declined somewhat with the economic depression, and since 1932 has been decreasing as catch per skate has increased faster than the catch quota. On the other hand, the number of vessels fishing halibut has increased until the fishing season in Area 2 is now reduced to about a month, whereas formerly it lasted all year.

The catch per skate can be used as an index of the abundance of the commercial stock, but only with important reservations. Chief among these are the following: 1. In early years the fishing had a spotty distribution; fishermen were still discovering new banks having rich accumulations of fish and tended to concentrate on them, so that the catch per skate was relatively too high to represent total stock (on fishable grounds). 2. One result of the shortening of the "regular" season in recent years has been a tendency to concentrate fishing effort on banks nearer port. In an effort to obviate this, and to provide fishing at the season of greatest availability special areas were opened to summer fishing, in 1951-53, and in 1954 and subsequently the season has been divided everywhere. 3. In general, profitable halibut fishing grounds have always

been only a small part of the sea bottom of the continental shelf, yet halibut occur sparsely in much of the unfished area. Hence any decline in abundance on the fished grounds in a given year is cushioned by reserves of temporarily unavailable fish spread thinly over a much wider area. These dispersed fish are not a separate population, but move onto the fished banks over longer or shorter periods of time.

Even allowing for these reservations, it appears that the total commercial stock of halibut declined a great deal from 1911-15 to 1926-30, though not to the degree indicated by the catch per skate; large halibut decreased more than small ones. In recent years there has been an increase in overall abundance, but the shortening of the season makes it difficult to be sure of its magnitude: it might be greater or less than what catch per skate indicates, but probably is somewhat less. No data are published since 1951, but reports are of further increases in catch per skate through 1954, followed by some decline in 1955.

Present Stocks

Since the size at which a halibut becomes available to the fishery is vague, any estimate of the commercial stock must have an equal arbitrariness as regards the lower size limit. We have chosen to make an estimate by dividing the total catch in pounds by the rate of utilization of "fully-vulnerable" fish (30 inches or about 12 pounds, and up).

The most comprehensive and best-reported tagging experiments on Area 2 halibut were those conducted in 1925 (9). Using only fully-vulnerable sizes, the adjusted annual rate of recapture for 1926 can be estimated as 40 per cent on fished banks, and the corresponding continuous or "instantaneous" rate of fishing is 0.57 (based on a calculation in (5)). With the long season prevailing at that time, recruitment probably occurred largely during the time fishing was in progress. Hence the stock was equal to catch divided by rate of fishing, or 24.7/0.57 = 43 million pounds. However the type of calculation used is such that this represents the stock only on the fishable banks. A considerable degree of wandering to more sparsely-population regions is suggested by the experiment: there is an unacccounted disappearance of tagged fish, amounting to 21 per cent per annum (0.35 on the instantaneous basis), which apparently represents wandering of tagged fish away from fished grounds. Presumably an equal or greater movement of fish occurred back onto the banks. Quite possibly the total stock in the Area was more than twice the figure given.

Recent tagging experiments are not yet reported in detail. Preliminary tabulations in the Annual Reports indicate wide variations according to place and time of tagging, and it is not yet possible to obtain an overall picture; but there is no question that rate of fishing has decreased. Another way to get at modern conditions is to consider rate of fishing as proportional to gear in use. In 1926, 477,000 skates were fished, while the 1946-50 average was 314,000; so rate of fishing should have been reduced from 0.57 to 0.57 x 314/477 = 0.38. But since the season is now so short, it is better to convert this to rate of exploitation (assuming instantaneous natural mortality rate constant at 0.18) before dividing it into catch. The corresponding rate of exploitation is 0.29; hence average initial stock in 1946-50 was 28.1/0.29 = 97 million pounds. Again this represents only the stock on the fishable banks. Trends to 1954 would raise this figure to at least 105 million pounds, which

can be taken as the best estimate of present stock available on halibut banks in any given year. Catches by trawlers on the very extensive grounds where halibut are not densely enough concentrated for long-lining seem to indicate that the additional "dispersed" fish would bring the total up to about 200 million pounds.

Future Prospects

Prediction of the halibut fishery's future depends on discovering the reasons for past trends. All are agreed that the supply of fish available has fluctuated radically since 1910. As for what caused the changes, there have been three general schools of thought.

1. An analysis and interpretation of the dynamics of the Area 2 stock was made in 1934 by Thompson and Bell (8). They showed that, with constant recruitment, the trend of catch and of catch per unit effort would have been approximately that observed over short periods of time (1918-26 and 1925-33), as a result of observed changes in fishing effort. This analysis still remains a classic account of the short-term reaction of a fish stock to its fishery. Combined with data on rate of growth and natural mortality, it was the basis for the policy of restricting fishing by catch quotas.

However this type of analysis has not provided an adequate background for interpreting events over long periods. It did not apply to the whole period 1918-33 as a continuous sequence, and even in the shorter period 1925-33, an excess of observed over expected catch per skate begins to appear on the graphs in the last two years. After 1935, catch and catch per skate increased much more than would have been possible with constant recruitment. In other words, even though much of the increase in catch per skate is a result of permitting replacement of stock into the older age categories, recruitment must also have increased, starting in the early 1930's. From a different analysis, Thompson (7) reached the same conclusion about events after 1945. As a matter of fact, it had already been suggested that increased recruitment might occur as a possible desirable effect of quotas which would permit a larger accumulation of mature fish (8). In any event, the increase of stock recently has gone far beyond what could be predicted on the basis of 1918-33 events with constant recruitment (and growth). Hence this model of the stock cannot provide a quantitative basis for predicting future trends until it is brought up to date in terms of recent growth rates and recent levels of catch and catch per skate.

2. Without affirming any necessary causal relationship, Ketchen (4) has pointed out that ocean temperatures were in general decreasing during the series of years which produced the declining Area 2 halibut stocks of 1915-30, and in general they were increasing over the period which produced the recent improvement (allowing a 10-year lag between hatching and time of maximum contributions to the fishery by a year-class). We do not yet know whether temperature changes of the magnitude observed affect the survival of halibut eggs and larvae. However, on the hypothesis that they do, and that temperature has been the most important cause of changes in abundance, the prognosis for the immediate future is a sharp decrease in stock--though not necessarily in catch. The pertinent air and sea temperatures started to decline in 1943, continued to do so through 1950 or 1951, and have risen slightly since. The minimum of 1950 was almost as low as the minimum temperature of 1921 which corresponds to the minimum catch per skate

about 1930. On this basis we should anticipate a new decline in Area 2 halibut stocks up to 1962 or so, then the start of an increase.

3. Analyses of Baranov, Graham, Schaefer (6) and others show that a fish stock will not produce its maximum yield until its abundance (or at least that of the mature individuals) is reduced considerably below the original natural state. This increased productivity at reduced density may be accomplished partly by improvement in growth rate, possibly in part by reduced natural mortality among the commercial stock, but principally by increased recruitment resulting from increased survival of eggs, fry and young. Thus a decrease in mature stock from a high unfished level produces first an increase in recruitment. Where, exactly, the point of maximum recruitment occurs must be discovered by observation for each individual stock. For some fisheries it has been found to occur only after the mature population is at much less than half of its original numbers.

Thus it is pertinent to examine the hypothesis that the recent improvement in halibut abundance is the result of increased recruitment from the lowered level of stock which existed during the 1920's and 1930's. Since the excess increase of catch per unit effort began in 1932, the increase in recruitment should have begun with the spawning of about 10 years earlier. In 1922 the Area 2 halibut availability first fell below 70 pounds per skate, and it did not rise to that figure again until 1943, after passing nadir in 1930. Hence the period of increased recruitment would last until 10 years after 1942, or one or two years more if the increased average age of the stock is taken into account. The further consequence of this hypothesis is that, since 1942, abundance has been above the level which gives maximum recruitment, and that a decrease in the Area 2 stock may be expected to begin immediately.

Comparing the three analysis above, Nos. 2 and 3 both predict an impending decrease in Area 2 stock (not catch) on the basis of past trends. Since they do this on very different grounds, the fact that they agree is no recommendation for either, if perhaps not a detraction. Analysis No. 1 cannot be used to predict the future until it is brought up to date.

Recent regulation policy has been to increase quotas cautiously, and no better empirical approach can be suggested. If there are no major changes in season, in quota, or in fishing effort during the next few years, it will be possible to test hypotheses 2 and 3 rather decisively: if a progressive decline in catch per skate fails to appear, then neither of them is applicable. The opposite result, unfortunately, would not provide a basis for choice between 2 and 3, at least not for many years. However the practical measure which each suggests would be the same: a moderate increase in rate of exploitation. On hypothesis 2, this would be simply for the sake of catching the fish produced by favorable oceanic conditions while they are available (near the maximum bulk for each brood), and before they get too far into the slow-growing years of maturity and senescence. On hypothesis 3 this consideration would also apply, but th more important purpose would be to reduce the mature stock and to maintain it closer to the level which permits maximum recruitment.

Although there exists this uncertainty in respect to the dynamics and the best level of stock for Area 2 halibut, the long-term prospects are fairly good. An empirical approach would probably anticipate a catch in the immediate future somewhat greater than the 1951-54 average, possibly about 35 million pounds per year. The No. 3 hypothesis suggests that sustained yield might be substantially greater than that--perhaps by half or more. The ocean-temperature hypothesis predicts declining supplies in the near future, but suggests an increased rate of utilization which would tend to compensate for this.

Our best guess is that in 1980 the catch will be 50 million pounds, somewhat greater than the 1954 high of 37 million, and that it will be taken from about the same size stock as now exists. The division of catch between Canada and the United States is predicted on a 50:50 basis. However there is no legal necessity for this. Canada is more favorably situated to harvest a majority of the Area 2 banks, and her share of the catch has tended to increase in recent years, and in 1954 it exceeded the United States catch by 2 million pounds.

Area 3

Present stock:	500,000,000 lb.	Utilization by Canada:	7,500,000 lb.
		" " others:	21,300,000 lb.
Stock in 1980:	400,000,000 lb.	Utilization by Canada:	20,000,000 lb.
		" " others:	35,000,000 lb.

History

The fishery west of Cape Spencer began about 1910, but developed quickly and reached 22.1 million pounds in 1914. Catches by Canada and the United States, fishing effort, and catch per unit effort are shown below (from 3, 7, 8):

	Av. catch (millions of lb.)	Av. no. of skates set (thousands)	Catch per set
1915	23.7	89	266
1916-20	14.5	75	153
1921-25	20.5	167	126
1926-30	28.8	364	78
1931-35	22.6	271	82
1936-40	24.2	232	112
1941-45	27.4	209	134
1946-50	28.8	255	113
1951	25.4	...	(113)
1952	31.4	...	increased
1953	27.1	...	increased
1954	33.8	...	increased

Canada's share of the catch has risen gradually, and in 1954 it was practically 10 million pounds out of a total of 34 million pounds.

As in Area 2, the fluctuations in fishing success reflect the change in stock on the grounds, but in an exaggerated form: especially in the case of the abrupt decline in catch per skate from 1915 to 1918. A special feature of the Area 3 picture is a second small dip in catch per skate between 1944 and 1948, followed by a renewed rising trend.

As elsewhere, much of the original decline in catch per skate can be attributed to the removal of accumulated older stock, which is an inevitable consequence of starting a fishery.

Present Stock

In 1926-27 tagging experiments in Area 3 were concentrated on winter spawning fish, and gave a rate of utilization of about 10 per cent. It has been suggested that this was probably too low to be representative of the whole stock, or at any rate of stock present on the summer fishing grounds.

Preliminary reports on recent taggings show low returns: from 2 per cent up to about 5 per cent at most, per year. These presumably include some fish too small to be completely vulnerable, and no breakdown by length is available. Nor is it possible to correct these figures for wandering of the fish away from the fishable grounds. However, comparison with corresponding figures for Area 2 indicates that the present rate of utilization of halibut over 12 pounds weight in Area 3 cannot be greater than 10 per cent per year on the fished grounds. Thus the present stock on fished grounds would be about 10 times the average catch of recent years, or 290 million pounds. The total stock is likely to be more than half as much again, or say 500 million pounds.

Future Prospects

The same three analysis and hypotheses as discussed for Area 2 must be considered in Area 3.

1. The original analysis on the basis of constant recruitment by Thompson and Bell (8), described the period 1920-29 fairly well. The balance of growth rate and natural mortality rate then indicated that with constant recruitment a greater catch would come from more fishing; however Area 3 as well as Area 2 has been managed so as to increase catch per unit effort by decreasing fishing. In recent years evidence has been obtained that the rate of growth used for the earlier analysis was too small to be representative (1953 Annual Report). However no general reassessment of the theory of management has yet been published.

2. In 1948 Burkenroad (1) suggested that fluctuations in Area 3 halibut abundance resulted from trends in recruitment which are determined by changes in the oceanic environment. This was proposed partly on general grounds, because stocks of other ocean fishes, especially those having pelagic eggs, often vary for this reason, and the halibut need not be an exception. More specifically, he pointed out that in the early development of the Area 3 fishery, the removals by fishing were many times too small to explain the apparent decline in abundance--as indicated by catch per skate--especially from 1915 to 1918. While the magnitude of this discrepancy can be considerably discounted if we allow for inadequacies of catch per skate as an index of abundance, it seems fundamentally a sound observation. However Burkenroad had no basis for predicting future changes, other than a very tentative suggestion that a 34-year cycle might operate and trends to date do not indicate it.

Ketchen's (4) temperature trends are related to catch per unit effort in Area 3, even better than they are in Area 2. (The lag which he uses in 12 years, corresponding to the greater mean age of halibut in Area 3.) In particular, the recent depression of fishing success from 1944 to 1948, and subsequent rise, parallels a similar dip in February-April air temperatures at Massett 12 years earlier. The immediate future will provide a test of the possible significance of this coincidence, for the temperatures reached a peak in 1942 and declined sharply to 1950. On this basis, a decrease in catch per skate would be expected to start about 1954.

3. No attempt will be made to work out for this Area the details of the behaviour of catch per skate, assuming an inverse relation between stock and recruitment. In general, it would be much as in Area 2; however this approach

could not explain the 1944-48 dip and subsequent rise in catch per skate. In general, of course, both effects of environment and effects of density are likely to influence reproduction: that is, effects 2 and 3 might well operate concurrently, and of course 1 must play a role too.

Balancing the present inadequate information as well as possible, we consider that in future some increase in rate of exploitation and decrease in stock size will be desirable in Area 3, and that this will permit appreciably greater yield. Accordingly the stock estimate for the future is a decrease to 400 million pounds, while rate of utilization from fished banks is increased to about 14 per cent per year, giving a yield of 55 million pounds yearly to the two countries. This rate of utilization is substantially less than predicted for Area 2. However the cooler temperatures in Area 3 imply a smaller rate of production of surplus stock for the fishery. In addition, because of the longer distance from markets, profitable fishing in Area 3 requires denser concentrations of fish, even if this might mean some sacrifice of total yield.

We emphasize that these are only our best guesses: a more conservative evaluation could put the 1980 catch at a figure no greater than the present 30 million pounds, and if an unfavourable ocean climate were to develop it might become even less.

References

(1) Burkenroad, M. D. 1948. Fluctuation in abundance of Pacific halibut. Bull. Bingham Oceanographic Coll., 11(4): 81-123.

(2) Bell, H. F., H. A. Dunlop and N. L. Freeman. 1952. Pacific coast halibut landings 1888 to 1950 and catch according to area of origin. Bull. Int. Fish. Comm., No. 17, 47 pp. (Catches since 1950 are given in successive Annual Reports of the Commission.)

(3) Dunlop, H. A. 1951. The effect of fishing upon the stocks of Pacific halibut. Proc. United Nations Sci. Conf. on Conservation and Utilization of Resources, 7: 16-20.

(4) Ketchen, K. S. (in press) Climatic trends and fluctuations in the yield of northeast Pacific fisheries. J. Fish. Res. Bd. Canada, 13(3).

(5) Ricker, W. E. 1948. Methods of estimating vital statistics of fish populations. Indiana Univ. Studies, Sci. Ser. No. 15, 101 pp.

(6) Schaefer, M. B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Inter-American Tropical Tuna Comm., Bull. 1(2): 27-56. (This includes the most recent table of Area 2 catch per skate, agreeing with the graphs in (3), but differing slightly from (7) and (8).)

(7) Thompson, W. F. 1950. The effect of fishing on stocks of halibut in the Pacific. Pub. Fish. Res. Inst., Univ. of Washington. 60 pp.

(8) Thompson, W. F., and F. H. Bell. 1934. Biological statistics of the Pacific halibut fishery. (2) Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. Comm., No. 8, 49 pp.

(9) Thompson, W. F., and W. C. Herrington. 1931. Life history of the Pacific halibut. (1) Marking experiments. Ibid., No. 2, 137 pp.

GROUNDFISH

Introduction

Along the British Columbia coast the fishery for groundfish involves at least 30 species of demersal fish, which as a group exclusive of the halibut contribute an average of 52,000,000 pounds to the annual production (1950-54). Canada's share is obtained largely in competition with United States vessels in international waters and averages 23,000,000 pounds or roughly 50 per cent of this total.

The bulk of the catch is derived by otter-trawling, a method of fishing which came into prominence in the Pacific area during World War II. The remainder is obtained by older fishing methods such as long-lining and hand-lining.

Forecasting of productive potential and yield in the next 25 years is made difficult by the fact that following initial expansion of the fishery, production of individual species has failed to stabilize. In the brief history of the fishery, emphasis has shifted from species to species and from bank to bank as the accumulated stocks have been removed. Much of the instability can be attributed to unstable markets. Demand varies not only from year to year but from species to species, and with differing effects on the fishing activities of the Canadian and American fleets.

Superimposed on the economic factors, and perhaps dominanting them in the case of some species, are fluctuations in abundance. The causes have not as yet been accurately assessed. Detailed knowledge of the population parameters of many of the species is still lacking, and this adds to the difficulty of establishing a sound basis for prediction.

There is *prima facie* a good case for believing that a greatly increased yield of foodfish, say three to four times the present production, could not be sustained. The fishing banks along the British Columbia coast are relatively small in size and all are now within the general working range of the Canadian and United States fleets. Recent expansion of the fishery to deeper water and increased interest in species of lower quality, concomitant with declining yield of the more highly prized species, gives added weight to the suggestion that the present yield is approaching the productive potential, at least in so far as foodfish for human consumption are concerned.

The situation is by no means the same for all species, and thus, in giving an account of the current state of the stocks and prospects for future increases in production, each species deserves separate consideration.

Summary of Estimates

The estimates presented in Table A are in general based on the following assumptions: (1) that there will be an increase in demand for all species of groundfish, (2) that there will be no radical changes in fishing technique or processing methods which would alter greatly the existing market limitations on the sizes of fish which can be utilized, (3) that international management will lead to some rehabilitation of stocks which are now being, or may soon be, overfished and (4) that reversal of the current climatic trend may lead to improved environmental conditions for the survival of certain species.

Discussions of factors which could make these assumptions untenable are given under individual species, some of these can have serious effect on the various predictions, not only of total yield, but of Canada's share in the yield.

The present yield of groundfish utilized for human consumption is estimated at about 47,000,000 pounds. The estimated 1980 yield is somewhat less than double this amount, namely 84,000,000 pounds. Canada's share, while at present only 44 per cent of the total production, could be increased to 55 per cent through increased fishing effort, with particular emphasis on those species which under present conditions cannot be exploited profitably by the United States.

The present rate of exploitation for all foodfish stocks combined is estimated as 47/372 = 0.126 (instantaneous rate) or 12 per cent per annum. This is believed to vary from as low as 8 per cent in some species to as high as 27 per cent in others. The rate of exploitation in 1980 might reach 84/336 = 0.25 (instantaneous rate) or 22 per cent on the average, but ranging from 10 per cent to 39 per cent depending on the species.

Inclusion of estimates of the production of animal food and meal would raise the total yield of groundfish to 156,000,000 pounds by 1980. If this should happen, Canada's share would probably amount to 70 per cent, the reason for this being that Canada is in a better position to launch a large-scale reduction industry.

The average landed value of the Canadian catch of groundfish in the 1950-54 period was about $1,250,000. On the basis of existing prices, the value of the predicted Canadian catch by 1980 would be about $4,000,000. However, as increased exploitation presupposes increased prices paid to the fishermen, the value of predicted landing would probably be considerably higher, perhaps $5,000,000 to $6,000,000.

Table A. General summary of the stock of groundfish along the British Columbia coast; present and future utilization.

	Millions of pounds							
	Present Stock		Utilization by Canada		Utilization by U.S.A.		Total Utilization	
Species	stock	in 1980	Present (1950-54)	in 1980	Present (1950-54)	in 1980	Present (1950-54)	in 1980
Lemon Sole	15	12	2.8	4	1.3	1	4.1	5
Brill	15	32	1.5	3	3.5	7	5.0	10
Rock Sole	40	30	3.2	7	0.5	2	3.7	9
Butter Sole	25	22	1.0	5	0.0	0	1.0	5
Dover Sole	40	35	0.7	4	0.6	4	1.3	8
Gray Cod	53	45	4.6	10	6.2	15	10.8	25
Lingcod	120	100	3.9	7	2.3	3	6.2	10
Rockfish-10spp.	30	20	0.9	1	8.1	2	9.0	3
Blackcod	14	20	1.3	2	2.7	3	4.0	5
Other fish 10spp.	20	20	0.7	2	0.9	2	1.6	4
Total Foodfish	372	336	20.6	45	26.1	38	46.7	84
Animal Food Meal and Liver (Dogfish)	40	30	2.4	7	1.0	5	3.4	12
	600	800	1.0	50	0.7	10	1.5	60
Total all Species	1012	1160	24.0	102	27.8	53	51.8	156

References For All Groundfish (excluding Halibut)

(1) Barraclough, W. E. 1948. Measures of abundance in dogfish (Squalus suckleyi). Trans. Roy. Soc. Canada, Ser. 3, Vol. 42, Sect. 5, pp. 37-43.

(2) Barraclough, W. E. 1954a. Decline in availability of brill on the west coast of Vancouver Island as associated with a decline in recruitment. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 98, pp. 17-21.

(3) Barraclough, W. E. 1954b. Winter recaptures of tagged brill from deep water off the west coast of Vancouver Island. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 100, pp. 16-18.

(4) Bell, F. H., and A. T. Pruter. 1954. The Washington and Oregon sablefish fishery. Pacific Mar. Fish. Comm., Bull. No. 3, pp. 39-56.

(5) Bonham, K., F. B. Sanford, W. Clegg and G. C. Bucher. 1949. Biological and vitamin A studies of dogfish landed in the State of Washington. Washington Dept. Fish., Biol. Rept., No. 49A, pp. 83-114.

(6) Chatwin, B. M. MS(1956). Further results from tagging experiments on lingcod. Fish. Res. Bd. Canada, Nanaimo.

(7) Chatwin, B. M. MS(1956). Mortality rates in Strait of Georgia lingcod. Fish. Res. Bd. Canada, Nanaimo.

(8) Cleaver, F. C. 1949. The Washington otter-trawl fishery with reference to the petrale sole Eopsetta jordani. Washington Dept. Fish., Biol. Rept., No. 49A.

(9) Edson, Q. A. 1954. Preliminary report on the Alaska sablefish fishery. Pacific Mar. Fish. Comm., Bull. No. 3, pp. 73-85.

(10) Forrester, C. R., and K. S. Ketchen. 1955. Preliminary results of gray cod tagging in Georgia Strait in the winter of 1954-55. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 103, pp. 8-10.

(11) Hart, J. L. 1943. Migration of lingcod. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 57, pp. 3-7.

(12) Ketchen, K. S. MS(1948). Natural mortality rate of the lemon sole (Parophrys vetulus) and estimates of minimum size limits for maximum yield. Fish. Res. Bd. Canada, Nanaimo.

(13) Ketchen, K. S. 1953. The use of catch-effort and tagging data in estimating a flatfish population. J. Fish. Res. Bd. Canada, 10(8): 459-485.

(14) Ketchen, K. S., and C. R. Forrester. 1954. The sablefish fishery of British Columbia. Pacific Mar. Fish. Comm., Bull. No. 3, pp. 57-72.

(15) Ketchen, K. S. 1955. Trends in the gray cod fishery of Georgia Strait. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 102, pp. 10-13.

(16) Ketchen, K. S. 1956. Climatic trends and fluctuations in yield of marine fisheries in the Northeast Pacific. J. Fish. Res. Bd. Canada, 13(3). (In press.)

(17) Ketchen, K. S. MS(1956). Factors influencing the survival of lemon sole (Parophrys vetulus) in Hecate Strait, British Columbia. Fish. Res. Bd. Canada, Nanaimo.

(18) Manzer, J. I. MS(1950). The Skidegate Inlet butter sole Isopsetta isolepis and the fishery in 1946. Fish. Res. Bd. Canada, Nanaimo.

LEMON SOLE - *Parophrys vetulus*

Present stock:	15,000,000 lb.	Utilization by Canada:	2,800,000 lb.
		" " others:	1,300,000 lb.
Stock in 1980:	12,000,000 lb.	Utilization by Canada:	4,000,000 lb.
		" " others:	1,000,000 lb.

History

The fishery for lemon sole is entirely by means of the otter-trawl. It began in the Strait of Georgia prior to World War I as a small operation on banks close to Vancouver. A fishery by three steam trawlers began in Hecate Strait during that war but it was short-lived. During the 1920's and 1930's the fishery was confined almost entirely to banks within the Strait of Georgia, and remained at a low level supplying the local fresh fish demand. About 1940 the trawlers began to extend beyond the Strait to banks along the west coast of Vancouver Island. Substantial increase in the landing of lemon sole, however, came about only with the re-awakening of interest in the fishing grounds of northern Hecate Strait. This occurred towards the end of World War II with the great development of the market for fresh and frozen fillets.

As shown in the following table, lemon sole landings by the Canadian fleet during the 1930's averaged only half a million pounds annually. By the 1946-50 period, however, the average was close to two and a half million pounds, with a peak production of 5.4 million pounds in 1950.

Years	Average catch in thousands of pounds
1931-35	400
1936-40	530
1941-45	1180
1946-50	2478
1951	2158
1952	2537
1953	2340
1954	1472

Since 1950 the catch has varied between 1.5 and 2.5 million pounds.

Estimates of the total catch by area and total catch for the British Columbia coast are shown for the period 1948-54 in Table A. These include records of catches by United States trawlers from grounds off the west coast of Vancouver Island and in Hecate Strait as obtained from unpublished records kept by the Washington State Fisheries Department.

The average annual yield from Canadian territorial waters in the 1948-54 period was about 0.5 million pounds. The international fishery of Hecate Strait has yielded 2.8 million pounds on the average, with Canada's share averaging 1.9 million pounds or 68 per cent. Off the west coast of Vancouver Island the average catch has been about 0.6 million pounds, of which Canada has taken on the average about 17 per cent or 0.1 million pounds.

Table A. Yield of lemon sole by Canadian and United States otter-trawlers from various regions along the British Columbia coast.

Year	Catch in thousands of pounds					
	Inshore grounds	Offshore grounds				Total yield
	Canadian	Hecate Strait		Other Areas*		
		Canadian	U. S. A.	Canadian	U. S. A.	
1948	336	1656	537	52	575	3156
1949	326	1274	1084	85	603	3372
1950	429	4780	1000	151	487	6847
1951	660	1428	829	70	732	3719
1952	815	1546	1399	176	491	4427
1953	514	1736	478	90	333	3151
1954	571	778	840	123	54	2366
Average	521	1885	881	109	468	3863

*Includes Cape Scott and the west coast of Vancouver Island.

Present Status

For the present purposes the lemon soles occurring off the British Columbia coast can be divided into three main stocks--one in the Strait of Georgia, one in Hecate Strait and one along the west coast of Vancouver Island.

Strait of Georgia. Tagging of various populations in this area, and information on mortality rates, suggests that the adult stock is subjected to an annual rate of exploitation of at least 25 per cent (instantaneous rate of 0.29). Since the average annual yield is 0.52 million pounds, the stock of adult fish is estimated as 0.52/0.29 = 1.8 million pounds.

Hecate Strait. A population study conducted in 1950 suggests that the size of the commercial stock is of the order of 9 to 12 million pounds (13).

West coast of Vancouver Island. Little is known of the stock in this area, except that it is of small size and that it mingles to a certain extent with the large stock which inhabits grounds off the United States (Destruction Island and Umatilla grounds). The body of fish inhabiting the Vancouver Island grounds (including Cape Scott) probably does not exceed one million pounds.

Thus, the total commercial stock of lemon sole along the British Columbia coast is about 15 million pounds.

Future Trends

In preliminary investigation it appears that the lemon sole stock of the Strait of Georgia cannot sustain a much greater yield than that which it is now providing (ca. 0.5 million pounds per year). By maintaining some measure of control over fishing effort it should be possible to keep the catch at this level in the next 25 years. However, this may be undesirable since the restriction might lead to inefficient utilization of other species. In theory,

a greater yield of lemon sole could be achieved by utilizing fish of smaller size, providing an adequate spawning stock is maintained (12), but under existing methods of processing this is not feasible economically.

On the Hecate Strait grounds the rate of exploitation is about 20 per cent and the minimum size tolerated by the market is considerably greater than that in the Strait of Georgia. Preliminary study suggests that the stock could stand an annual removal of approximately 4 million pounds with the existing minimum size, and possibly 6 million pounds if the minimum size were lowered to that which prevails in the inshore fishery.

Canada's share of this catch would depend on the extent of United States interest in the Hecate Strait area. If, in the next 25 years, international agreement should be reached on the extension of territorial limits, then the United States would be denied access to the more productive lemon sole areas of Hecate Strait. Otherwise, Canada's share is not likely to rise much above 70 per cent or 3 to 4 million pounds per annum.

Water temperatures are known to have an effect on the survival of young lemon soles in Hecate Strait (17), and hence govern the size of the adult stock in that area. There is no way of saying at the present whether the present low temperatures (which favour survival) will be maintained during the next 25 years. If temperatures remain in the same range as they have in the past six years continued good survival can be expected. If they become much colder, or if they return to the high level reached in the early 1940's survival can be expected to decline. This would be expected to reduce the size of the adult stock, possibly to less than half its present level.

On other international fishing grounds the stocks are relatively small and any change in their present sizes is not likely to influence greatly the future total production. However, a greater yield could be achieved if Canadian trawlers were to compete with the United States fleet on grounds just off Cape Flattery. But it is unlikely that the yield from these other offshore grounds could be increased beyond one million pounds.

While there is a remote possibility that Canadian production of lemon sole could exceed 7 million pounds per year in the next 25 years, a more realistic estimate would be about 4 million pounds. This is based on the assumption that Canadian production from Hecate Strait will be increased, but still in competition with the United States, and that production from other international stocks and from Strait of Georgia stocks will remain much as at present.

BRILL - Eopsetta jordani

Present stock:	15,000,000 lb.	Utilization by Canada:	1,500,000 lb.
		" " others:	3,500,000 lb.
Stock in 1980:	32,000,000 lb.	Utilization by Canada:	3,000,000 lb.
		" " others:	7,000,000 lb.

History

The fishery for this flatfish takes place almost entirely in international waters. It began in the middle 1930's when United States trawlers started fishing off Cape Flattery (8). Canadian vessels appeared on grounds off the lower west coast of Vancouver Island about 1938, but did not become active participants in the fishery for brill until the early forties. During the war, vessels of both countries began moving farther and farther northward along the British Columbia coast, reaching Queen Charlotte Sound and Hecate Strait around 1944-45. Production by Canadian trawlers reached a peak of 7.7 million pounds in 1948, mainly through the discovery of dense concentrations on banks in middle Hecate Strait. Following that year catch and catch/effort declined on nearly all grounds along the British Columbia coast. By 1954, as shown in the following table, the Canadian catch was less than a million pounds, and in 1955 it reached 0.5 million pounds, the lowest point in over a decade.

Years	Average catch in thousands of pounds
1931-35	..
1936-40	95
1941-45	430
1946-50	3172
1951	1585
1952	1828
1953	1049
1954	941

Concerning the total yield from the British Columbia banks, little is known for the years prior to 1948, since United States landings of flatfish were recorded neither by area nor species before that date. The division of the catch between Canadian and United States trawlers for the period 1948-54 is shown in Table B. Between 1948 and 1954 the total yield declined from 13.2 million pounds to 4.2 million pounds. The catches of the last two or three years would have been much lower had not the United States fleet discovered and exploited dense concentrations of spawning fish in deep water along the west coast of Vancouver Island. To date the Canadian fleet has not participated in this fishery, which occurs during the winter months.

In the 1948-54 period the Canadian share of the total catch has averaged about 41 per cent or 2.6 million pounds. But in the last two years it has amounted to only 20 per cent to 30 per cent. The Canadian share of the Hecate Strait and Queen Charlotte Sound catch has declined very sharply because of the failure of the brill to re-appear on the northern Hecate Strait grounds. The United States fleet on the other hand has been concentrating on the southern part of the Strait and on the Goose Island and Cape Scott grounds where Canadian vessels have been unable to compete effectively.

Present Status

For present purposes the brill inhabiting the British Columbia coast will be regarded as belonging to one stock. This is not entirely true, since there is strong evidence that populations which frequent north coast banks (Hecate Strait and Queen Charlotte Sound) during the summer months spend the winter months off the west coast of Vancouver Island (3). Those summering off the west coast of Vancouver Island appear to spend the winter off the coast of the United States.

Table B. Yield of brill (petrale sole) by Canadian and United States trawlers from banks along the British Columbia coast.

Year	Catch in thousands of pounds				
	W. Coast of Vancouver Island		Hecate Strait*		Total yield
	Canadian	U. S. A.	Canadian	U.S.A.	
1948	1459	3250	6163	2331	13203
1949	1329	1964	1956	2560	7809
1950	1411	1980	633	2079	6103
1951	826	2152	756	1436	5170
1952	1469	1311	360	1573	4713
1953	873	1012	175	1319	3379
1954	844	2225	91	1060	4220
Average	1173	1985	1448	1765	6371

* Includes Cape Scott and Queen Charlotte Sound.

Two factors make it difficult to assess the present stock level. In the first place, efforts to determine rates of exploitation have been frustrated by the fact that the brill is highly migratory and seemingly erratic in its availability to fishing gear. Secondly, to judge from catch/effort records the stock is undergoing a rapid decline in size (2), and this dynamic situation complicates description of the stock.

On the important grounds off the west coast of Vancouver Island the catch/effort in 1954 according to various estimates was 42 per cent to 47 per cent of its value in 1948. In this same period the total catch declined to 32 per cent of its 1948 value, but this is less reliable as an indication of the change in stock size. There is some basis for assuming that the annual rate of exploitation was about 20 per cent during the years when the brill was exploited in the spring and summer months only. With the advent of the winter fishery the annual rate has probably increased to 25 per cent. The catch in 1954 was 4.2 million pounds and one million pounds of this was taken in the winter fishery. If we assume that the summer catch of 3.2 million pounds was taken at a rate of 20 per cent (instantaneous rate 0.22) we obtain a stock estimate of 3.2/0.22 or 14.5 million pounds. On the basis of the decline in catch/effort in the 1948-54 period, the stock in 1954 was only about 45 per cent of that present in 1948. Hence, the 1948 stock is estimated as 32 million pounds.

Future Trends

It will be difficult to predict events of the next 25 years until a satisfactory explanation can be obtained of the current decline in abundance. In the years since 1948 there has been poor, if not negligible, recruitment of young fish to the stock. This is believed to be the main cause of the present decline in abundance. However, it is possible that the situation is being

aggravated by overfishing of the adult stock. While it is theoretically possible that overfishing of the adult (spawning) stock has been the cause of the decline in recruitment, this is not regarded as being likely.

If the current rate of exploitation (estimated to be about 25 per cent with the inclusion of the new winter fishery) is not too severe, and if recruitment returns to "normal" in the next decade, then it is possible that the annual yield will return to the magnitude of that in 1948 (about 13 million pounds). In view of the slow growth rate of the brill, it is probable that a rate of 20 per cent is more likely to produce the maximum sustained yield. This may be about 10 million pounds. On the basis of existing fishing practice, Canada's share might amount to 3 million pounds, annually. However, improved market conditions and more active competition with the United States fleet on the banks in Queen Charlotte Sound might increase Canada's share to 4 or 5 million pounds.

There is, however, no assurance that recruitment will improve in the immediate future, and hence that the stock will return to its 1948 level. As long as the population remains in its depressed state, a yield of much in excess of 3 million pounds is probably undesirable. At the current level of competition, this would give Canada an annual share of little more than one million pounds. Of course, if it becomes impossible to keep the catch to 3 million pounds, through lack of international control, then the eventual annual yield will probably be very much lower.

ROCK SOLE - Lepidopsetta bilineata

Present stock:	40,000,000 lb.	Utilization by Canada:	3,200,000 lb.
		" " others:	500,000 lb.
Stock in 1980:	30,000,000 lb.	Utilization by Canada:	7,000,000 lb.
		" " others:	2,000,000 lb.

History

The history of the trawl fishery for rock sole is somewhat similar to that of the lemon sole. In the period between the two World Wars the annual yield remained at a very low level, probably not exceeding 0.1 million pounds per year. This was taken almost entirely on various small banks within the confines of the Strait of Georgia. It was not until the middle years of World War II when trawlers began to take an interest in the grounds off the north coast (Queen Charlotte Sound and Hecate Strait) that there was a substantial increase in production of rock sole. Between 1943 and 1947, the Canadian catch rose from 0.5 million pounds to 2.6 million pounds, and then, after a brief recession, rose to a new peak of nearly 6 million pounds in 1952. Almost all of the Canadian catch has been taken on the Hecate Strait grounds.

The trend of the Canadian fishery is shown in the following table.

Years	Average catch in thousands of pounds
1931-35	110
1936-40	100
1941-45	557
1946-50	1929
1951	3548
1952	5955
1953	1851
1954	2588

Table C shows the division of the catch by major areas along the British Columbia coast and the way in which it has been shared by the Canadian and United States trawler fleets. The Canadian catch in the 1948-54 period averaged about 2.85 million pounds, which represented nearly 88 per cent of the total yield. Because of marketing difficulties the United States fleet continues to show little interest in the rock sole resource of British Columbia.

Present Status

On the basis of tagging studies and mortality rates revealed by age composition, it is estimated that the stock of rock sole in Hecate Strait during the late 1940's was in the neighbourhood of 20 million pounds. However, between 1947 and 1955 there has been a marked increase in catch/effort, at least part of which can be attributed to increased abundance resulting from the passage of several strong year-classes through the fishery. If all the increase in catch/effort can be attributed to this increased recruitment, then the present stock is probably in the vicinity of 40 million pounds. However, allowing for other factors which may have contributed to the increase in fishing success, a conservative estimate of the present stock would be 30 million pounds.

Table C. Yield of rock sole by Canadian and United States trawlers from banks along the British Columbia coast.

Year	Catch in thousands of pounds					
	Inshore grounds	Offshore grounds				Total yield
	Canadian	Hecate Strait		Other Areas*		
		Canadian	U.S.A.	Canadian	U.S.A.	
1948	27	2064	171	44	117	2423
1949	63	1520	31	95	14	1723
1950	107	1918	75	152	29	2281
1951	137	3230	331	181	69	3948
1952	117	5663	1101	175	166	7222
1953	60	1713	310	78	23	2184
1954	109	2228	420	251	1	3009
Average	89	2619	348	139	60	3256

*Includes Cape Scott and west coast of Vancouver Island.

Little is known of the stock in Queen Charlotte sound, but it is suspected that the stock size does not exceed 10 million pounds. In all other areas of the coast the stock is probably no greater than 2 million pounds. Thus, the total stock on British Columbia grounds is estimated to be about 40 million pounds.

Future Trends

Tagging results suggest that the present rate of exploitation of the rock sole stock of Hecate Strait and Queen Charlotte Sound is 10 per cent or less. Preliminary investigation suggests that the rate could be doubled or even trebled without endangering future yield. This would produce annual catches of 9 to 13 million pounds. Other areas might account for an additional 0.5 million pounds, under the current size restrictions used by the trade. But whether or not this could be achieved might depend on the development of gear which could be employed on large sections of the banks where the bottom is too rough for existing types of trawls.

There is fair evidence from age composition that the rock sole has a high natural death rate (ca. 40%) and that a greater yield could be sustained through exploitation of the species at an earlier age. Under such conditions yield approaching 15 million pounds are probably within reason. Yet, barring the possibility that the species could be utilized effectively in a large-scale reduction industry, there are market problems which even 25 years from now would present obstacles to full utilization. In the first place, the fillet yield from rock sole is relatively low in comparison with other flatfishes. Secondly, the species does not appear to keep well in the holds of vessels for any length of time. These factors limit the profit of fishing and restrict the fishery to vessels which have no great distance to travel to port. They probably account for the lack of interest by the United States fleet in the rock sole stocks of northern British Columbia. Of course, improved processing techniques could change the picture very quickly.

The strengths of rock sole year-classes appear to be related to water temperatures (as in the case of the lemon sole). The above mentioned pre-

dictions of yield are based on existing stock levels and on the assumption that the present climatic condition will prevail for the next 25 years. Such is probably unlikely. Any further decline in temperature would result in an increase in the stock and probably a southward extension of its present commercial range. On the other hand, a return to the conditions which prevailed about 1940 is likely to cause a decline in the stock (16). At present it is not possible to predict in a quantitative way the changes in stock which might result under such changes in climatic conditions.

GRAY COD - Gadus macrocephalus

Present stock:	53,000,000 lb.	Utilization by Canada:	4,600,000 lb.
		" " others:	6,200,000 lb.
Stock in 1980:	45,000,000 lb.	Utilization by Canada:	10,000,000 lb.
		" " others:	15,000,000 lb.

History

The Canadian fishery for gray cod began in the Strait of Georgia around the time of the first World War, but because of its low market value it was not pursued extensively or consistently. Between 1927 and 1940 annual catches rose somewhat irregularly from less than 100,000 pounds to more than 1 1/2 million pounds, mainly as a result of increased local demand. During World War II there was little or no increase in the demand for gray cod, which is in contrast to the higher-priced groundfish. However, the demand increased sharply in the 1950's, to such an extent that the gray cod is now the dominant species in the trawler landings. A similarly late development of interest in the gray cod is noted in the trend of United States landings. This has stemmed in part from the increased demand produced by "fish stick" industry. But the decline in abundance of other more desirable species may also have been a factor. There is also some suggestion that the gray cod may have increased in abundance within the past decade.

The trend in the Canadian catch of gray cod is summarized in the following table:

Years	Average catch in thousands of pounds
1931-35	781
1936-40	1480
1941-45	1203
1946-50	1952
1951	5678
1952	4913
1953	3454
1954	5700

Table D shows that the average total yield of gray cod from grounds along the British Columbia coast was 9 million pounds per year in 1948-54. In the 1951-54 period alone, the catch averaged close to 12 million pounds. The Canadian share has averaged about 40 per cent of the total production.

Present Status

Precise information on the rate of exploitation of the British Columbia stock of gray cod is lacking, since tagging studies have been limited to small and probably unrepresentative populations. On the Strait of Georgia grounds where the fishing effort is intense, seasonal rates as high as 30 per cent have been computed (10). For present purposes it is presumed that the rate in the 1951-54 period with respect to all fishing grounds has averaged close to 20 per cent per annum (instantaneous rate 0.22). During this period the average yield was 11.7 million pounds. Hence the stock is estimated as 11.7/0.22 or 53 million pounds.

Table D. Yield of gray cod by Canadian and United States trawlers from banks along the British Columbia coast.

Year	Catch in thousands of pounds					
	Inshore grounds	Offshore grounds				Total yield
	Canadian	Hecate Strait		Other Areas*		
		Canadian	U.S.A.	Canadian	U.S.A.	
1948	350	308	1922	375	2171	5126
1949	746	591	2454	552	1004	5347
1950	1497	1066	2903	478	1357	7301
1951	1565	3244	3397	869	2172	11247
1952	1716	1950	4880	1247	2697	12490
1953	1817	582	3627	1055	551	7632
1954	1993	1685	7254	2022	2568	15522
Average	1383	1347	3778	943	1790	9095

*West coast of Vancouver Island.

Despite the high rate of removal from Strait of Georgia grounds there is as yet no evidence that the fishery is an important factor governing the supply of fish (15). Preliminary study of the age composition of the gray cod stock shows a high growth rate and a high natural mortality rate. The latter is probably of the order of 50 per cent per annum.

Future Trends

In view of the high natural death rate it is probable that the rate of exploitation could be increased substantially without endangering future production. An annual yield of 25 million pounds does not seem unreasonable. It is uncertain whether or not this could be increased still further, say to 30-35 million pounds, by utilizing smaller sizes of fish. This must await a more detailed study of the growth-mortality problem.

Increased yield would of course depend on market demand, and on the stock maintaining its present productivity. Furthermore it might be necessary to develop other means of capture, since the gray cod is semi-pelagic and hence not always vulnerable to convential otter-trawls.

The effect of climatic trends on the abundance of gray cod is not as yet fully understood, but should not be overlooked. Since the gray cod is a cold water species, the recent decline in temperatures along the British Columbia coast may have led to increased survival of the pelagic fry, as well as changed the conditions governing growth and natural mortality among older individuals. Further recession in temperature conditions may increase recruitment to the stock, but to counter this there may be a decrease in growth rate and natural mortality rate which would change completely the basis for prediction of yield in 25 years.

However, neglecting radical changes in the environment, it is possible that with increased exploitation the yield of gray cod by 1980 will reach 25 million pounds per year and that Canada's share will amount to 10 million pounds.

LINGCOD - *Ophiodon elongatus*

Present stock:	120,000,000 lb.	Utilization by Canada:	3,900,000 lb.
		" " others:	2,300,000 lb.
Stock in 1980:	100,000,000 lb.	Utilization by Canada:	7,000,000 lb.
		" " others:	3,000,000 lb.

History

The fishery for lingcod began in the Strait of Georgia as a small boat operation employing hand-lines. In the decade prior to World War II the Canadian catch ranged between 4 and 6 million pounds, with the Strait of Georgia providing more than 90 per cent of this yield. During World War II the catch increased as a result of increased demand for fish protein and vitamin A from liver oil. It was during this period that the rapidly developing otter-trawl fishery began to take a significant share of the annual yield of lingcod, and extended the region of exploitation to more exposed sections of the coast.

Statistics of the Canadian catch (dressed weights) are contained in the following table:

Years	Average catch in thousands of pounds
1931-35	4838
1936-40	5068
1941-45	6109
1946-50	5953
1951	4741
1952	4233
1953	2740
1954	3805

In the decade following the war, the catch declined because of reduced demand. The hand-line fishery of the Strait of Georgia still contributed more than half of the total landings. The remainder was obtained mainly by the trawler fleet operating in international waters off the west coast of Vancouver Island and in Hecate Strait.

Off the west coast of Vancouver Island the Canadian trawlers and line vessels compete with those from the United States. As shown in Table E, the catch during the 1950-54 period was divided fairly evenly between the two countries. In Hecate Strait the United States catch is about twice as great as the Canadian catch, but only 10 per cent of the total yield from all grounds along the British Columbia coast. About 36 per cent of the total is taken by Canadian boats operating in territorial waters.

Present Status

A rate of exploitation of 10 per cent has been computed for the Strait of Georgia hand-line fishery from tagging conducted between 1939 and 1944 (6). It was during this period that the Strait of Georgia fishery reached its greatest production. On the basis of the average annual yield obtained in that period the stock is estimated at about 40 million pounds (dressed head-off weight).

Table E. Yield of lingcod by Canadian and United States vessels from banks along the British Columbia coast.

Catch in thousands of pounds

Year	Inshore grounds	Offshore grounds				Total yield by gear	Total yield all gear
	Canadian	Hecate Strait*		West Coast of V. I.			
		Canadian	U.S.A.	Canadian	U.S.A.		
1950 Trawl	(115)+	(275)	1029	(674)	1205	(3298)	(7470)
Line	(2461)	(126)	53	(1007)	525	(4172)	
1951 Trawl	94	445	599	1314	847	3299	7021
Line	2044	209	62	632	775	3722	
1952 Trawl	100	303	539	692	543	2177	6060
Line	2357	145	9	636	736	3883	
1953 Trawl	52	84	512	617	328	1593	4244
Line	1646	24	(60)	320	(600)	(2651)	
1954 Trawl	92	114	531	724	1007	2468	6232
Line	2189	56	(91)	629	(800)	(3764)	
Average Trawl	90	244	642	804	786	2567	
Line	2139	112	54	644	687	3628	
Average All Gear	2229	356	696	1448	1473		6195

*Includes Cape Scott and Queen Charlotte Sound.
+Bracketed figures are estimates.

It is impossible to estimate the stocks of lingcod inhabiting grounds off the open coast because of the lack of information on the rates of exploitation. Tagging has shown that these stocks are quite separate from that in the Strait of Georgia (7, 11). Large sections of the coast appear to provide the reef habitat required by the lingcod, but the type of fishery which could operate most effectively in such regions (i.e. hand-line) is non-existent. Strictly on the basis of area, in relation to that inhabited by the Strait of Georgia stock, it is estimated that the west coast of Vancouver Island stock amounts to 30 million pounds, while that in Queen Charlotte Sound and Hecate Strait may be close to 50 million pounds.

Thus, there is a possibility that the total stock of lingcod off the British Columbia coast is of the order of 120 million pounds.

Future Trends

It seems unlikely that the yield from British Columbia grounds will exceed 10 million pounds per year over the next 25 years, as long as there are no changes in fishing technique. As long as costs remain high, there is little

likelihood that the hand-line fishery will extend much beyond those grounds which are close to the Vancouver market (i.e. the Strait of Georgia). There is room however, for more effective use to be made of stocks on grounds along the northern mainland coast. If this could be accomplished, then yields of 15 to 20 million pounds would not be beyond reason.

It is as yet uncertain what rate of exploitation would produce the greatest yield, but it is presumed to lie between 10 per cent and 20 per cent. There is some suggestion that natural mortality rate is fairly high and that the stock could be more effectively utilized by exploiting fish at an earlier age.

The possible effects of further expansion of the trawl fishery are not as yet fully understood. Trawlers are able to catch lingcod of small size, but are prevented from landing such fish, by a minimum size regulation. The efficacy of this size limit is to be tested presently.

ROCKFISH or ROCK-COD - Sebastodes spp.

Present Stock:	30,000,000 lb.	Utilization by Canada:	900,000 lb.
		" " others:	8,100,000 lb.
Stock in 1980:	20,000,000 lb.	Utilization by Canada:	1,000,000 lb.
		" " others:	2,000,000 lb.

History

The fishery for rockfish is pursued on a relatively small scale by Canadian otter-trawlers and line vessels. Ten of the 23 or 24 species which are found off the British Columbia coast are used by the fresh and frozen fillet trade and by the newly developed "fish stick" industry.

The rockfishes, as their name implies, live in dense shoals on or near rocky bottom or reefs and are found over a wide range of depths from the inter-tidal zone to 250-300 fathoms. However, no one species extends over this entire range. Species inhabiting shallow water are taken by trawls and hand-line; those in intermediate depths mainly by trawls; and those in deep water mainly by long-line and trawls.

Prior to the expansion of the trawl fishery during World War II, almost all of the catch was landed as an incidental product of the hand-line fishery for lingcod and the long-line fishery for blackcod. As shown in the following table of Canadian landings, an interest developed in the trawl fishery specifically for rockfish during the war years; but this was short-lived. Between 1947 and 1953 the trawl landings of rockfish were merely incidental to those of other species. With the recent development of the "fish stick" market there has been some awakening of interest in a species known to the trade as Pacific "ocean perch" (Sebastodes alutus).

Years	Average catch in thousands of pounds
1931-35	252
1936-40	337
1941-45	1968
1946-50	1390
1951	938
1952	916
1953	955
1954	939

In contrast to the Canadian, the United States trawl fishery for rockfish has been very active along the British Columbia coast for more than a decade (See Table F). Since 1945 their average annual rockfish catch has been over 9 million pounds, and for the most part has predominated over catches of other species.

Present Status

There is very little information available for consideration of stock sizes of this group of species. It is known that the rockfishes are exceedingly slow growing and that maturity is probably not reached before 10 years of age.

Table F. Yield of rockfish by Canadian and United States vessels from banks along the British Columbia coast.

Year	Catch in thousands of pounds					
	Inshore grounds	Offshore grounds				Total yield
	Canadian	Hecate Strait+		Other Areas*		
		Canadian	U. S. A.	Canadian	U. S. A.	
1948	(308)	(654)	3545	(233)	5048	9788
1949	(402)	(855)	6855	(306)	4138	12556
1950	(174)	(370)	6037	(134)	4418	11133
1951	274	415	3967	(249)	1620	6525
1952	241	425	3113	(250)	1309	5338
1953	280	578	3779	(97)	552	5286
1954	168	630	6850	(141)	2279	10068
Average	264	561	4878	201	2767	8671

+Includes Queen Charlotte Sound and Cape Scott.
*West coast of Vancouver Island including Cape Flattery.

The United States fishery has presumably depended on accumulated stocks of very old fish. The fact that increasing interest has been shown recently in stocks of rockfish species which formerly were avoided (small species such as the "ocean perch"), suggests that the accumulated stocks of the larger species have now been considerably reduced. About 70 per cent of the United States catch of rockfish in 1954 was of "ocean perch". Furthermore, there has been a shift in fishing effort to deeper water, which suggests that stocks in shallower water are smaller.

Even at the present day there are no catch statistics of rockfish by species. Thus, it is impossible to assess the trends of exploitation as the emphasis of the fishery progressed from species to species. Without such information, and data on mortality rates, it is impossible to make much more than a guess at present stock sizes. Even if we presume that in 1945 the stock of all rockfish was as much as 100 million pounds, it is unlikely that the stock today is more than 30 million pounds.

Future Trends

One cannot help but be pessimistic about the prospects of increased yield from the rockfish resource. The heavy fishery of the past decade has been dependent on accumulated virgin stocks. If the present catch is maintained it will only be through the discovery of new virgin stocks (probably beyond the depth range of the present fishery). But the United States fishery is already pressing on the outer boundary of the productive areas all along our coast.

In view of the very slow growth rate of the rockfishes the maximum sustainable yield is probably very much below the present yield--possibly no more than 3 to 4 million pounds In the absence of action to restrict fishing, it is highly probable that within the next decade the catch will fall below 2 million pounds.

If and when demand reaches the point where the Canadian fleet takes an active interest in the rockfishes, the pickings are bound to be very slim unless, of course, Hecate Strait and Queen Charlotte Sound become designated as Canadian waters.

BLACKCOD - Anoplopoma fimbria

Present stock:	14,000,000 lb.	Utilization by Canada:	1,300,000 lb.
		" " others:	2,700,000 lb.
Stock in 1980:	20,000,000 lb.	Utilization by Canada:	2,000,000 lb.
		" " others:	3,000,000 lb.

History

The blackcod fishery is one of the few ocean fisheries with a long history in British Columbia, having been in existence since before the turn of the present century. Its main characteristic is that it is pursued almost entirely by long-lining in relatively deep water (100 to 250 fathoms). The Canadian catch is taken entirely in international waters, and on the average over the past 40 years has amounted to about a quarter of the total production from waters of the northeast Pacific.

Demand for fish protein during World War I caused the catch to rise to a peak of 8 million pounds, but a sharp decline followed immediately thereafter. From 1920 to 1940 the landings fluctuated at a low level of less than 2 million pounds per annum, reaching a low point of 0.5 million pounds during the economic depression. (See table below).

Years	Average catch in thousands of pounds
1931-35	662
1936-40	1041
1941-45	1881
1946-50	1922
1951	1897
1952	1347
1953	1364
1954	1128

The demands for foodfish and vitamin oil resulted in an upward trend in catch after 1940 to about 2.4 million pounds in 1946. Since that time the fishery has fluctuated considerably because of unstable market conditions, but in 1949 the catch reached 2.8 million pounds, its highest point since 1918.

In comparison with the fisheries for other groundfishes, competition for blackcod between Canadian and United States fishermen is not great, since there is little over-lap in their respective fishing areas. The Americans fishing out of Washington ports concentrate their efforts off Cape Flattery and along the southwest coast of Vancouver Island. The Canadian fleet operates from the northwest coast of Vancouver Island northward along the Queen Charlotte Islands and the coast of Alaska. The United States fishermen operating out of Alaskan ports fish almost exclusively in channels inside their territorial waters.

Records of the Canadian and American catches of blackcod in recent years are shown in Table G.

Table G. Total catch of blackcod from banks in the vicinity of the British Columbia coast (dressed weights).

Year	Catch in thousands of pounds			
	Washington	British Columbia	Alaska	Total yield
1948	2072	2180	4582	8834
1949	2777	2786	4050	9613
1950	2218	955	668	3841
1951	3571	1897	4045	9513
1952	2302	1346	1329	4977
1953	2256	1364	2475	6095
1954	2667	1128	3300	7095
Average	2552	1665	2921	7138

Present Status

There is good evidence that the stock of blackcod fished by the United States fleet off Cape Flattery and Vancouver Island is overfished (4). Catch per "skate" of gear has now stabilized at a low level of about 50 pounds. It is only in this area that otter-trawlers compete with handliners for blackcod. United States trawlers take 20 per cent to 30 per cent of the fish removed from the Cape Flattery area.

At the northern end of the range, off the Alaska coast, the stock appears to be underfished. Average catch per skate on the various grounds in this area is about 100 pounds, and fluctuations in catch can be traced entirely to fluctuations in demand (9, 14).

As yet there are no good estimates of rates of exploitation, since it has not been possible to devise a satisfactory method of tagging. For present purposes it is presumed that the rate off southern Vancouver Island is at least 30 per cent, and that off the remainder of British Columbia and off Alaska is no more than 15 per cent (instantaneous rate 0.16). Since the Canadian catch in the 1950-54 period averaged 1.33 million pounds the stock is estimated as 1.33/0.16 or about 8 million pounds. If we add in the stock off the southern coast of Vancouver Island which is exploited almost exclusively by the United States fleet (estimated rate of exploitation 30%, or instantaneous rate 0.36) and take the average catch from that area as being about 2.0 million pounds, we obtain an estimate of 2.0/0.36 or 5.5 million pounds. The total stock for the British Columbia coast (and part of Alaska) is therefore estimated at about 14 million pounds.

Future Trends

If no special management is undertaken, and if market conditions improve in the next 25 years, the annual catch by the Canadian fleet might be increased to 4 million pounds. At present the market is interested in obtaining large fish (this is evident in grading and sale practices) and Canadian fishermen are prevented by regulation from landing fish less than 4 1/2 pounds in weight

(dressed). It is uncertain as yet whether this restriction is beneficial or wasteful. There is some suggestion that natural mortality is high among juvenile blackcod. If this is so, then a greater sustained yield might be achieved by subjecting them to a higher rate of exploitation. Until 1955 the United States otter-trawl fleet has been able to make use of smaller sizes of blackcod than has the Canadian fleet, but legislation has now been introduced which will minimize this practice.

It is possible that international agreement on blackcod fishing may be necessary before any real improvement can be made in the stock off the southern coast of Vancouver Island. However, in the light of existing fishing practice, it is unlikely that regulation would benefit the Canadian industry as much as it would the United States industry. Of course, increased abundance on the Vancouver Island grounds might induce Canadian fishermen to fish closer to home.

Activity in the blackcod fishery is very closely influenced by the halibut fishery. Under existing conditions, the blackcod fishery takes place in the off-season for halibut, since it involves part of the fleet of halibut vessels. Thus, extension or restriction of the halibut fishery would have considerable influence on the duration and intensity of the blackcod fishery. To some extent the blackcod fishery is subsidized by the halibut fishery, since blackcod fishermen are allowed to retain out-of-season one pound of halibut for every seven pounds of other species caught. Because of the high price paid for halibut, this "percentage" regulation creates considerable incentive to fishing for blackcod (and other species) during the off-season. Should the price of halibut fall drastically in the next 25 years, or should the International Halibut Commission revoke its regulation permitting out-of-season catches of halibut, the blackcod fishery might decline markedly, unless of course, there were a compensatory increase in the demand for blackcod.

BUTTER SOLE - Isopsetta isolepis

Present stock:	25,000,000 lb.	Utilization by Canada:	1,000,000 lb.
		" " others:	Nil
Stock in 1980:	22,000,000 lb.	Utilization by Canada:	5,000,000 lb.
		" " others:	Nil

History

The commercial stock of butter sole in British Columbia waters is restricted to the Hecate Strait bank. This species is considered of lower quality than most other flatfishes, and is exploited only when general market demand is high. The fishery, if it occurs at all, is concentrated in the first few months of the year in Skidegate Inlet (Queen Charlotte Islands). Butter sole enter the inlet from Hecate Strait and spawn during the months of January and February.

Commercial fishing began in 1943 with a catch of 0.5 million pounds. From 1944 to 1948 the catch ranged from as low as 0.1 million pounds to 1.75 million pounds. In 1949 and 1950 the fishery was a complete failure because the spawners failed to enter the Inlet. As shown in the following table the Canadian catch reached an all time high of 3.5 million pounds in 1952. In the last two years the bulk of the catch has been processed as mink feed.

Years	Average catch in thousands of pounds
1931-35	0
1936-40	0
1941-45	656
1946-50	313
1951	1700
1952	3500
1953	280
1954	211

There has been no international fishery for butter sole. However, the United States trawler fleet utilizes stocks which inhabit the territorial water of Puget Sound. Almost all of their catch is used for mink feed.

Present Status

While tagging has given some indication of the rate of exploitation of the stock of butter sole which enters Skidegate Inlet (18), it has not shed any light on the rate respecting the entire stock in Hecate Strait. There are several indications that the Skidegate Inlet spawning run may be only a minor segment of the adult stock in the Strait. If we assume that the rate of exploitation as computed by Manzer (18) in 1946 (30% or instantaneous rate of 0.36) applied also in 1952 when the catch was 3.5 million pounds, then the minimum stock size must be of the order of 3.5/0.36 or about 10 million pounds.

To judge from the abundance of adult butter sole on the Hecate Strait bank during the summer months, it would be safe to estimate the total adult stock at more than double the above amount, say, 25 million pounds.

Future Trends

There is every indication that the butter sole stock of Hecate Strait is underfished and that a yield of 7 million pounds per annum could be sustained. In view of the moderately high natural death rate, an even higher yield might be achieved by utilizing smaller sizes of fish than is now the custom.

However, there are a number of factors which probably would prevent this yield from being realized. The butter sole, being a low priced fish, must be very concentrated in order to make fishing worthwhile. Under present economic conditions, fishing is worthwhile only during the winter months in Skidegate Inlet. Certain small areas in the Strait are known to produce commercial quantities of butter sole during the summer months, but otherwise much of the adult stock remains, for economic reasons, unavailable to the trawlers.

Another factor which might frustrate efforts to achieve the maximum yield would be market demand, particularly for the smaller sizes of fish which possess an uneconomically low fillet/carcass ratio. Of course, the marketing problem changes completely, if we presume that the demand for mink food will continue to grow. If the present trend continues, the butter sole may be utilized entirely for this purpose, in which case it would be possible to exploit a wider range of sizes.

DOVER SOLE - *Microstomus pacificus*

Present stock:	40,000,000 lb.	Utilization by Canada:	700,000 lb.
		" " others:	600,000 lb.
Stock in 1980:	35,000,000 lb.	Utilization by Canada:	4,000,000 lb.
		" " others:	4,000,000 lb.

History

The dover sole is another species of flatfish which, since the inception of the otter-trawl fishery, has been in relatively poor demand--not because of poor quality, but because of processing difficulties. The Canadian catch has varied from 0.1 to 0.9 million pounds since 1946 (the first year of exploitation), and as shown in the table below has averaged about 0.7 million pounds in the period 1951-54. The bulk of the catch comes from grounds off the southern part of Vancouver Island and in Dixon Entrance.

Years	Average catch in thousands of pounds
1931-35	0
1936-40	0
1941-45	0
1946-50	420
1951	974
1952	941
1953	464
1954	402

The United States catch (known only since 1951) has averaged about 1.0 million pounds, but only about 60 per cent of this comes from grounds which are adjacent to British Columbia (see Table H).

Table H. Yield of dover sole by Canadian and United States trawlers from banks along the British Columbia coast.

	Catch in thousands of pounds				
	Hecate Strait		Other Areas		Total
Year	Canadian	U. S. A.	Canadian	U. S. A.	yield
1951	402	175	569	613	1759
1952	427	607	514	613	2161
1953	227	688	238	479	1632
1954	177	270	176	656	1279
Average	308	435	374	591	1708

Present Status

At the present day little interest is being shown in the dover sole, even though it appears to exist in considerable abundance along the British Columbia coast. No information is available on rates of exploitation or stock size,

but it is presumed that the stock is of the order of 40 million pounds.

Future Trends

If markets and (or) handling processes for dover sole improve in the next 25 years, it is possible that catches of 4 or 5 million pounds per year can be achieved by the Canadian fleet. This will, however, necessitate extension of the Canadian fishery to deep water (100 to 200 fathoms).

In California and Oregon where the otter-trawl fishery has been in existence for many years there has been a progressive increase in the utilization of dover sole as stocks of more desirable foodfishes became depleted. In these States the dover sole is now the dominant species in the otter-trawl landings. This same pattern may apply to the Washington and British Columbia fisheries in the near future.

DOGFISH - Squalus acanthias

Present stock:	600,000,000 lb.	Utilization by Canada:	~~960,000~~ 5,300,000 lb.
		" " others:	3,000,000 lb.
Stock in 1980:	800,000,000 lb.	Utilization by Canada:	50,000,000 lb.
		" " others:	10,000,000 lb.

N.B. Present utilization in terms of the whole fish, but usually only the livers are landed.

History

The fishery for dogfish began in the early part of the present century by means of seine nets and hook and line. The entire catch was reduced to meal and oil. About 1940 the discovery of high vitamin A concentrations in dogfish brought about a marked change in the industry. While interest in the reduction of dogfish carcasses was maintained until 1944, there was a sharp upward trend in the fishery solely for the livers, so that large quantities of carcasses were discarded (see the schedule below; the liver averages 15% of the body weight). This was accomplished by otter-trawls, sunken nets and long-lines. By 1945 it was no longer profitable to use dogfish for reduction, presumably because the stock had been reduced to such an extent that continuity of supply became uncertain. In some areas the catch of dogfish per unit effort declined by 50 per cent during the early 1940's (1).

Average catch in thousands of pounds

Period	Liver	Carcasses	Total utilization	Total captured
1926-30	0	15,597	15,597	15,597
1931-35	0	8,276	8,276	8,276
1936-40	3,131	12,904	16,035	20,900
1941-45	5,176	6,936	12,112	34,500
1946-50	2,835	0	2,835	18,900
1951	997	36	1,033	6,600
1952	760	199	959	5,100
1953	777	245	1,022	5,200
1954	626	211	837	4,200

Following the war declining demand for vitamin products and reduced abundance of dogfish caused the annual yield to decline. By 1950 the full effects of the production of synthetic vitamin A and the importation of foreign products was shown in the greatly reduced landing. Between 1950 and 1954 the landing of liver remained at a very low level, while there has been a slight increase in the landing of carcasses for reduction.

Present Status

In consequence of the cessation of fishing for dogfish, the stock now appears to be in the process of a strong recovery. Already, the dogfish has become a plague on many of the British Columbia fishing grounds--disrupting the trawl and seine fisheries for other species.

There are no accurate estimates of the rate of exploitation during the period of intense fishing during the 1940's. We know that the dogfish grows very slowly and that it reaches an advanced age (5). We know also that during

the period 1940-45 the accumulated catch by the Washington and British Columbia fleets was about 500 million pounds (see Table I). If we neglect the effects of recruitment and natural mortality and assume that the accumulated catch was half the stock present in 1940 (based on a 50% reduction in catch/effort), we conclude that the original stock was of the order of one billion pounds. The present stock is presumed to be somewhere between 500 million and a billion pounds.

Table I. Estimated poundage of dogfish removed from British Columbia fishing banks by the Canadian and United States fleet.

	Thousands of pounds		
Year	British Columbia	Washington	Total yield
1940	24,578	3,770	28,348
1941	37,938	15,693	53,676
1942	38,329	31,701	70,030
1943	42,033	44,378	86,411
1944	54,230	73,847	128,077
1945	38,812	42,113	80,925
1946	18,961	40,036	58,997
1947	25,062	11,882	36,944
1948	20,223	9,975	30,198
1949	26,593	12,071	38,664
1950	3,673	1,400	5,073

Future Trends

If as little interest is shown in the dogfish resource in the next 25 years as has been shown in the last 5 years, the stock will undoubtedly return to dominate most fishing banks along the British Columbia coast. This is already suggested by the growing abundance of young dogfish. However, there is evidence of a re-awakening interest in the value of dogfish for reduction into meal and oil. While there is little information available for computing the maximum sustainable yield which could be obtained from the rehabilitated stock, past experience suggests that a figure of 50 to 100 million pounds per year would not be beyond reason. Canada might be in a better position than the United States to exploit this resource since she is better equipped with reduction plants.

Because of the interference of dogfish with fishing for more valuable species, a wide-open policy of exploitation is likely to prevail in the immediate future to encourage maintenance of dogfish stocks at a level below that which permits maximum yield. On the other hand, the dogfish is an acceptable human food which is extensively used in Europe, and it might become so in America too. If this kind of demand develops, best utilization rather than maximum destruction would be in order.

SCRAPFISH FOR MINK FOOD

Turbot or arrow-tooth sole - *Atheresthes stomias*
Whiting or big-eye - *Theragra chalcogramma*
Hake - *Merluccius productus*
Small quantities of other species

Present stock:	40,000,000 lb.	Utilization by Canada:	2,400,000 lb.
		" " others:	1,000,000 lb.
Stock in 1980:	30,000,000 lb.	Utilization by Canada:	7,000,000 lb.
		" " others:	5,000,000 lb.

History

The fishery specifically for scrapfish is of very recent origin, having started in a small way in 1948. By 1955 it was the dominant feature of the British Columbia trawl fishery. The demand is being supplied mainly by turbot and whiting, and to a lesser extent by hake, butter sole, dover sole and gray cod.

Prior to the 1950's the needs of fur-farms were satisfied by the supplies of offal from fish filleting plants. By 1951 the demand for scrapfish had greatly exceeded the supply of fillet scraps, as well as of horsemeat. Thus, trawl fishermen began landing large quantities of whole fish of species unsalable on the foodfish market. The trend of the Canadian fishery is shown in the following table:

Year	Catch in thousands of pounds
1948	35
1949	59
1950	37
1951	414
1952	1392
1953	2298
1954	2843
1955	5676

Present Status

At present the fishery is concentrating on the turbot, which is found almost entirely on grounds in international waters. However, in the winter months, when weather prevents fishing on the exposed grounds, emphasis turns to the whiting.

It is impossible to estimate accurately the sizes of these stocks, as they have only recently been subjected to exploitation. For present purposes the stock is estimated as being about 40 million pounds.

Future Trends

It is probable that the present yield of turbot and whiting will be trebled or quadrupled in the next 25 years, providing the market for mink pelts continues to expand. Other species not now utilized or utilized to some extent only as food for human consumption, may eventually be included in the mink food industry.

At present there is little competition between the Canadian and United States fleets. But expansion of the mink farm industry in Washington may increase the activity of the Washington fleet along the British Columbia coast.

OTHER SPECIES OF GROUNDFISH ~~UTILIZED AS FOOD FISH~~

Rex sole	= Glyptocephalus zachirus
Starry flounder	= Platichthys stellatus
Sand sole	= Psettichthys melanostictus
Flathead sole	= Hippoglossoides elassodon
Yellow-fin sole	= Limanda aspera
Big skate	= Raja binoculata
Viviparous perch	= mainly Damalichthys vacca
Ratfish	= Hydrolagus colliei

Present stock:	20,000,000 lb.	Utilization by Canada:	700,000 lb.
		" " others:	900,000 lb. ?
Stock in 1980:	20,000,000 lb.	Utilization by Canada:	2,000,000 lb.
		" " others:	2,000,000 lb.

History

The above eight species of groundfishes are considered here as a group for the sake of brevity, even though such consideration may not be entirely meaningful. They are usually taken incidentally to the otter-trawl catches of other species and have been utilized in varying degrees for little more than a decade. The combined catch in the 1948-54 period has averaged 0.6 million pounds, but as shown in the table below, it has ranged from 0.3 million to 0.9 million pounds. Flounder and rex sole have comprised about three-quarters of the total yield.

Year	Catch in thousands of pounds
1948	321
1949	438
1950	692
1951	879
1952	928
1953	406
1954	516

Present Status

Some of the incidental trawl-caught species fetch good prices (rex sole, sand sole, yellow-fin sole, perch), but fisheries specifically for such species have never developed, presumably because they were of low abundance even when unexploited. The situation is less clear for low priced species (starry flounder, flathead sole, ratfish), as no information is available on rates of exploitation or changes in abundance.

The stock of all these species combined probably does not exceed 20 million pounds.

Future Trends

With improvement in market conditions, it is probable that the Canadian yield could be increased to 2 million pounds. If new markets and new methods of processing can be developed for skate and ratfish in the next 25 years, the yield could be increased to 4 million pounds.

The newly evolving market for mink food will probably increase the demand for starry flounder, flathead sole and yellow-fin sole.

SMELTS

Eulachon - Thaleichthys pacificus
Silver smelt - Hypomesus pretiosus
Capelin - Mallotus catervarius

Smelts are fish of a few ounces weight, which occur in dense shoals in spawning season. They are of minor commercial importance in British Columbia, but support important sport or subsistence fisheries. Three of the four species are of some importance. Their occurrence and utilization was summarized in 1944 by Hart and McHugh (1).

Eulachon. This species spawns in the lower reaches of large rivers, up to 50 miles or so upstream. The recent Fraser River catches have been as follows, in thousands of pounds:

1941	132	1948	363
1942	214	1949	298
1943	210	1950	189
1944	133	1951	311
1945	205	1952	744
1946	170	1953	218
1947	285	1954	334

Considerable quantities taken locally in dipnets are not included above. On other rivers eulachon are taken only on a subsistence basis, but the quantity is quite large, especially on the Nass (about 900,000 lb. estimated in 1940).

A recent study of Fraser River catch and effort statistics for 1941-53 suggested that somewhat greater utilization should be possible (2), but that year-to-year variations will persist. However the species is vulnerable to possible pollution of the lower Fraser by expanding industrialism.

For 1980 we predict a somewhat larger average commercial catch than at present--about 600,000 pounds per year. The subsistence and sport fishery will probably be about the same.

Silver smelt. This is or was the smelt of British Columbia fresh fish markets. It is taken mainly by gill nets on the ocean beaches where it spawns, from June to September. Commercial catches have decreased from a high of 450,000 pounds in 1902-08 to about 25,000-50,000 pounds in recent years (1). Causes of the decline may include contamination of preferred spawning beaches, especially in the Vancouver area, as well as possible overfishing.

Smelt occur at various places along the coast, and future production may increase somewhat if additional stocks are used. However, no very substantial increase in landings is anticipated.

Capelin. Usually called smelt in British Columbia, this species spawns in autumn in the Strait of Georgia, and in spring farther north. Some thousands of pounds of spawning fish are taken locally by dipnet, but it is not used commercially. Doubtless many stocks spawn in inaccessible places, so there is little idea of its abundance. It is of course much less abundant than in the Arctic. There is not likely to be commercial utilization in the next 25 years.

References

(1) Hart, J. L., and J. L. McHugh. 1944. The smelts (osmeridae) of British Columbia. Fish. Res. Bd. Canada, Bull. No. 64, 27 pp.

(2) Ricker, W. E., D. F. Manzer and E. A. Neave. MS(1954). The Fraser River eulachon fishery, 1941-1953. Fish. Res. Bd. Canada, MS Rept. Biol. Sta., No. 583, 35 pp.

TUNA or ALBACORE - Thunnus alalunga

Present stock: large, but inaccessible Present utilization: Nil

Utilization in 1980: zero to 5,000,000 lb.

History

The first albacore was recorded from British Columbia waters in 1938 and the first commercial catch was made in 1939. The fishery is by trolling with artificial lures. Canadian fishermen have operated south to waters off central California. The general eastern Pacific fishery is described by Brock (1), and that of British Columbia by Partlo (2).

The catch landed in British Columbia, in thousands of pounds, was as follows:

Year	Catch	Year	Catch
1939	284	1948	2175
1940	5	1949	2231
1941	76	1950	2119
1942	0	1951	190
1943	29	1952	157
1944	464	1953	11
1945	1289	1954	0
1946	432	1955	0
1947	796		

Albacore are caught in warm blue oceanic water during the months of July, August and September. The fish taken off our coast appear to be at the northern limit of the range of the eastern Pacific population, which is fished as far south as Baja California. The largest British Columbia catches were made from 1948 to 1950, with many caught offshore to the south. In 1951 only 14,000 pounds, out of 190,000 pounds landed, were caught off British Columbia, but in some of the earlier years a much higher fraction were local fish. Since 1951 none have been caught off British Columbia and a few have been taken north of California. None were landed here in 1954 or 1955.

There have been extreme periodic fluctuations in the eastern Pacific catch which as yet are unpredictable. The California fishery, which is the largest one, was good from 1915 to 1925 (peak of 30,000,000 lb. in 1917), almost negligible from 1928 to 1935 and good from 1938 to the present (record year 1950, with 62,000,000 lb.).

It has not been established whether the stocks that are fished off North America are separate from those fished off the Hawaiian Islands and Japan. Racial studies have suggested that they are distinct but recent tagging experiments show some trans-Pacific movement. Oceanographic surveys and exploratory fishing are now proceeding very actively in the north Pacific. To 1955 their results 1. indicate the association of albacore with water of the eastward North Pacific current having temperatures above about 14° C., and 2. suggest that the population which now supports a fishery extending from Japan to north of Midway Island reaches right across the Pacific until it meets the cold water near our coast.

Present Status

Since the ocean distribution of the populations which are now fished has not been determined, it is impossible to estimate the size of the stocks now being exploited. They are undoubtedly very large and there is no indication of the approach of overfishing. At the present time there is no definite prospect of catching many fish inshore north of California. There is, however, a fair possibility that current oceanographic surveys and exploratory fishing will discover albacore in commercial quantities within reach of sea-going boats such as the existing halibut fleet.

Future Prospects

(a) In the past our catches have been foreshadowed by good prospects off Oregon and Washington, which are absent at the moment. However, we can expect as large catches in the same areas as in the past (2,000,000 lb.), if and when the fish again move farther north in response to changing ocean conditions.

(b) The exploratory fishing and oceanographic surveys noted above may lead to much more important fishery. This depends on discovering stocks within reach and learning how to find and catch them in reference to oceanographic conditions which change from year to year. While a large-scale development is a real possibility we cannot make a reliable prediction on the basis of present knowledge.

References

(1) Brock, V. E. 1943. Contribution to the biology of the albacore (Germo alalunga) of the Oregon coast and other parts of the North Pacific. Stanford Ichthyol. Bull., 2(6): 199-248.

(2) Partlo, J. M. 1955. Distribution, age and growth of eastern Pacific albacore (Thunnus alalunga Gmelin). J. Fish. Res. Bd. Canada, 12(1): 35-60.

PILCHARD - Sardinops caerulea

Present stock: Relatively small, and too far south for utilization

Present Utilization: Nil.

Utilization in 1980: Zero to 50,000 tons

History and Present Status

A purse seine fishery for pilchards was begun in British Columbia waters in 1917. In the early years of the fishery, up until 1924, the small catch was mostly canned. Beginning in 1925 the catch greatly expanded, and an important industry was founded on the reduction of pilchards to meal and oil (1).

In the 30-year period of the fishery, the catch fluctuated widely. These fluctuations resulted from changes in the abundance of the fish, variations in the availability of fish to the fishery (independent of their abundance), and changes in market demands. Since 1947, no pilchard fishery has developed, as a result of drastically reduced abundance.

The pilchards of the British Columbia coast are part of a stock occurring as far south as California. Spawning occurs off California and the young remain in these waters. The adults migrate extensively, especially the larger ones, and in periods of high abundance sufficient numbers move into waters off British Columbia to provide a fishery. The recent decline in the abundance of pilchards has resulted from the failure of the population to reproduce itself during a period of heavy exploitation in California waters, and when ocean temperatures have been low.

The catches of pilchards in British Columbia waters were as follows:

	Average catch in tons
1917-20	2850
1921-25	4060
1926-30	71770
1931-35	42064
1936-40	35718
1941-45	61609
1946	3990
1947	440

Future Prospects

It is probable that pilchards will return to British Columbia waters, but it cannot be predicted when and in what abundance. Their return will not be possible until the main stock off California shows a substantial increase in abundance, and at the present time there are no clear-cut indications of when that may take place. Prospects for a large stock in the future depend partly on whether it was cool temperatures or excessive reduction of the spawning stock, which did most to cause the decline of the middle 1940's. On this point there is no agreement as yet (2). However, even if favourable temperatures

were to produce a series of large year-classes again, an intensive California fishery would prevent any large number from growing to the sizes which used to wander north and make up most of our catch. Thus any renewal of the British Columbia fishery implies a smaller annual rate of exploitation off California.

Assuming that the pilchards will return to British Columbia waters, it is evident that the fishery will always be an erratic one, since both the abundance of the fish and the extent of their migration are subject to great variation.

References

(1) Hart, J. L. 1933. The pilchard fishery of British Columbia. Biological Board of Canada, Bulletin No. 36 27 pp.

(2) Clark, Frances N., and John C. Marr. 1955. Population dynamics of the Pacific sardine. California Dept. Fish and Game, Marine Research Committee, California Cooperative Oceanic Fisheries Investigations, Progress Report, 1 July, 1953 to 31 March, 1955, pp. 11-48.

ANCHOVY - Engraulis mordax

Present stock:	25,000,000 lb.	Utilization:	230,000 lb. (1951-54 av.) (none in 1955)
Stock in 1980:	20,000,000 lb.	Utilization:	5,000,000 lb.

History and Present Status

Since 1939 a small fishery on anchovies has been carried on in coastal waters of British Columbia. Although anchovies were taken as far north as Ogden Channel, a large proportion of the catch was taken in southern waters of the province, mostly near shore on the west coast of Vancouver Island. The fishery has taken place on small, self-sustaining local populations which spawn in bays and inlets during June, July and August. These inshore stocks appear to be distinct from the large pelagically-spawning populations which occur off-shore from California to Washington and possibly as far north as British Columbia. These latter are not included in our estimates.

The average annual catch in recent years, in thousands of pounds, is as follows:

Years	Av. Catch
1939-40	4700
1941-45	4900
1946-50	1350
1951	Nil
1952	170
1953	750
1954	10
1955	Nil

During the early years of the fishery, a large part of the catch was reduced to oil and meal, but in recent years the catch has been mostly canned. It appears that the reduced catch in the past 10 years is a result of decreased demand.

Future Prospects

While little information exists on the future potential of the anchovy stocks, it appears unlikely that sustained yield would greatly exceed the catches of the early 1940's. This is from the inshore-spawning stocks. The oceanic-spawning population is of unknown size and distribution.

SHARKS OTHER THAN DOGFISH

Soupfin shark	- Galeorhinus galeus
Basking shark	- Cetorhinus maximus
Spotted cow shark	- Notorhynchus cepedianus
Mud shark	- Hexanchus griseus
Mackerel shark	- Isurus nasus
Blue shark	- Prionace glauca

Soupfin shark. This is a small shark, growing about 6 feet long. It is mainly a summer visitor to British Columbia. The stock is probably migratory along considerable lengths of the coast: a fish tagged in California was taken off British Columbia (2).

Because of the exceptionally high vitamin A potency of livers of soupfin sharks, a fishery for this species was actively pursued during and shortly after World War II (1). In the period 1941-45 the averaged landed quantity of soupfin shark livers was about 40,000 pounds per year. By 1947 the quantity had decreased to 10,300 pounds. At the present time few are taken, and then only incidental to other fishing operations.

The soupfin shark was caught mainly in Hecate Strait and off the west coast of Vancouver Island. A variety of fishing gear was used, but sunken gill nets set primarily for dogfish accounted for most of the catch. Catch per unit of effort reached a peak in 1944, the year when the largest catch (62,000 pounds of livers) was made. In subsequent years, when fishing effort was still high the catch per unit of effort decreased sharply, suggesting that abundance had been reduced by the fishery. However the Canadian catch was only part of the yield taken from the migratory stock.

Little is known of the present abundance of soupfin sharks, but it seems unlikely that they are yet as abundant as before the war. Presumably a future fishery could be maintained on a sustained basis only providing that exploitation is less intense than during the war years.

Future prospects for this species are bound up with those for dogfish, and depend on technological or economic developments. The soupfin shark by itself is not abundant enough to support a fishery in the foreseeable future.

Basking shark. The basking shark grows to about 40 feet long. It has never been specifically fished in British Columbia. During the war years it was taken incidentally in salmon gill nets and sunken dogfish nets. At that time the value received for the liver defrayed the cost of repairing the damaged nets, but to-day it is only a nuisance. In recent years some effort has been directed to destroying these sharks by shooting or ramming them, because of their damage to gill nets.

Whether or not these sharks will constitute a commercial fishery in the future depends upon developing a method of utilizing them. The skins may have a chance of being used if a suitable method of processing were developed.

Other sharks. The other species of sharks listed above are all fairly large. All are reported to be fairly common at some time or other in British Columbia waters, and are taken incidentally in other fishing operations--usually

interfering with the latter. Present indications, however, do not suggest that commercial operations for these species are likely to be profitable within 25 years.

References

(1) Barraclough, W. E. 1948. The decline of the soupfin shark fishery in British Columbia. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 77, pp. 91-94.

(2) Foerster, R. E. 1945. California soupfin shark captured in British Columbia. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 64, p. 64.

MISCELLANEOUS PELAGIC SPECIES

Pacific mackerel	- *Pneumatophorus diego*
Jack mackerel	- *Trachurus symmetricus*
Saury	- *Cololabis saira*
Ragfish	- *Acrotus willoughbyi*

The presence of these species in waters off the west coast of Vancouver Island is known chiefly from their occurrence mixed in catches of pilchards, or in the stomachs of sperm whales. Information on their abundance is lacking, but one or more may eventually support a commercial fishery, given appropriate advances in fishing technique or in market demand.

CRAB - *Cancer magister*

Present stock:	7,500,000 lb.	Utilization by Canada:	3,700,000 lb.
		" " others:	1,200,000 lb. (1953-54 av.)
Stock in 1980:	7,500,000 lb.	Utilization by Canada:	6,000,000 lb.
		" " others:	negligible

History

The commercial crab is generally found on a sand bottom at depths of ten fathoms or shallower. The mature crabs usually breed during the summer months. The eggs are spawned in the autumn, and retained on the abdomen of the female. She carries the eggs during the winter until they hatch in the spring as free swimming larvae. After about four months, the young crabs settle to the bottom to begin their adult lives (2).

Growth of the juveniles is accomplished by frequent moulting, and both sexes mature during the third year. The male usually reaches legal size during the fourth or fifth year.

Crabs were fished commercially in British Columbia before 1890. In 1915 crab fishing was being carried out at Victoria, Nanaimo, Boundary Bay, Burrard Inlet and Prince Rupert (4). In the Queen Charlotte Islands the commercial fishery was started in 1917 (3). More recent landings are shown in Table A.

Table A. Crab landings from British Columbia waters, 1921-1954, with United States catches from Hecate Strait, 1951-1954.

Year	Landings in thousands of pounds		
	Canada	U. S. A.	Total
1921-25	737		
1926-30	687		
1931-35	528		
1936-40	946		
1941-45	848		
1946-50	1886	880 (1950)	2766
1951	1811	961	2772
1952	1999	1169	3168
1953	3193	1396	4589
1954	4188	949	5138

Present Stocks

The major fishing grounds are around the Queen Charlotte Islands in Hecate Strait and Dixon Entrance, along the west coast of Vancouver Island, Boundary Bay and Burrard Inlet. Hecate Strait has been exploited jointly by Canadian and United States vessels since 1950; the share of the latter averaging 64 per cent of the total catch. The greater part of the crab catch is taken by traps; the remainder is caught by trawlers incidentally to

catches of groundfish. Since the female crab seldom reaches the legal size limit of 6 1/2 inches, the fishery in practice is limited to male crabs.

Considerable fluctuations in numbers of young crabs occur, at least in the Queen Charlotte Islands region. Tagging experiments (1, 3) have shown that crabs perform seasonal migrations in this region. Also tagging experiments and catch statistics indicate that the fishery is at present fairly heavily exploited (60-80% per year), and depends largely upon the annual recruitment.

From the above, the crab stock around the Queen Charlotte Islands is about 4 million pounds. In other regions of the province we may estimate the stock as about 3.5 million pounds on the basis of an exploitation rate of 50 per cent.

Future Prospects

The expected future trend, with no new types of management, will be an increase in production so that by 1980 landings should reach 6 million pounds. The increase is expected from two sources. (1) Grounds in southern British Columbia will increase their production with increasing demand due to population growth. (2) The Queen Charlotte Islands fishery is not expected to increase its total production, but it will probably yield a greater share to Canadian fishermen due to an anticipated decline in United States fishing effort. This decline is expected because of the increased number and efficiency of Canadian crab traps. United States vessels are not expected to be able to meet Canadian competition during the stormy spring and autumn seasons because of their lack of local harbours; and by summer, nowadays, most of the new crop of crabs has been taken. No important new crab stock is expected to be found in British Columbia waters.

The operation of important deleterious factors on the crab resource is not likely. Although the major fishing grounds in Hecate Strait are located in international waters, overfishing by foreign vessels is not expected.

References

(1) Butler, T. H. 1951. The 1949 and 1950 tagging experiments in the Graham Island crab fishery. Fish. Res. Bd. Canada, Pacific Prog. Rept., No. 89, pp. 84-87.

(2) MacKay, D. C. G. 1942. The Pacific edible crab, *Cancer magister*. Fish. Res. Bd. Canada, Bull. No. 62, 32 pp.

(3) McMynn, R. G. 1951. The crab fishery off Graham Island, British Columbia, to 1948. Fish. Res. Bd. Canada, Bull. No. 91, 21 pp.

(4) Weymouth, F. W. 1916. Contributions to the life history of the Pacific coast edible crab (*C. magister*). No. 1, Fishing methods and grounds. Rept. British Columbia Comm. Fish. for 1915, pp. 123-129.

SHRIMPS and PRAWNS - *Pandalus* spp.

Present stock:	5,000,000 lb.	Utilization:	1,100,000 lb. (1953-54 av.)
Stock in 1980:	5,000,000 lb.	Utilization:	2,500,000 lb.

History

Six species of commercial shrimps are found on the British Columbia coast. Five species are found on mud or sand bottoms, and are taken commercially by small-meshed trawls in depths up to 60 fathoms. The other species, the "prawn", is taken by traps on rock bottoms.

A fishery was in existence before 1890, when shrimps were being fished near Victoria (5). Practically no information regarding the development of the shrimp fishery is available, but trawling in Burrard Inlet began at a fairly early period, and this is still an important source of supply.

The main features of the life histories of the shrimps are known (1). Mature individuals of all species breed in the late autumn or early winter. The developing eggs appear on the abdomen of the female shortly after breeding, and are carried during the winter months. The young are hatched in the early spring and swim freely for about three months before settling to the bottom. The shrimps mature first as males in the first or second year, depending on the species. After one or two seasons as sexually active males, these shrimps change sex and function as females for the rest of their lives.

Table A. British Columbia shrimp and prawn landings, 1921-54, "green" weight in pounds.

Years	Landings
	lb.
1921-25	91,000
1926-30	111,600
1931-35	154,500
1936-40	107,800
1941-45	54,200
1946-50	280,200
1951	545,300
1952	824,700
1953	1,258,600
1954	951,000

Present Stocks

Shrimp fishing is carried on in Burrard Inlet, Howe Sound, the east coast of Vancouver Island, and in Chatham Sound, near Prince Rupert. A definite estimate of present stocks is unavailable, because recent exploratory fishing has discovered new stocks (2, 4), and further search is expected to locate additional supplies. Also, we can only guess at the rate of utilization of stocks currently in production--possibly 50 per cent per year.

Future Prospects

The predicted trend is for an increase in the fishery to 2 or 3 times the present production, to be achieved partly by the location of new stocks, partly by increased use of those already known.

Since relatively little is known concerning the biology of shrimps, no active management can yet be contemplated. There are no regulations at present. No major deleterious factors acting on the shrimp resource seem likely to turn up.

All currently exploited shrimp grounds are located within Canadian territorial waters. Exploratory fishing in international waters has not found shrimps in numbers sufficient to support a commercial operation (3).

References

(1) Berkeley, Alfreda A. 1930. The post-embryonic development of the common pandalids of British Columbia. Contr. Can. Biol., 6(6): 81-163.

(2) Butler, T. H., and G. V. Dubokovic. 1955a. Shrimp and prawn prospecting on the British Columbia coast, June to December, 1954. Pacific Biol. Station, Circ., No. 35, 92 pp.

(3) 1955b. Shrimp prospecting in the offshore region of the British Columbia coast, June to August, 1955. Pacific Biol. Station, Circ., No. 39, 23 pp.

(4) Butler, T. H., and H. E. J. Legare. 1954. Shrimp prospecting in regions of the British Columbia coast, November 1953 to March 1954. Pacific Biol. Station, Circ., No. 31, 42 pp.

(5) Rathbun, R. 1900. A review of the fisheries in the contiguous waters of the State of Washington and British Columbia. Rept. U. S. Comm. Fish. for 1899, pp. 251-350.

EDIBLE MOLLUSCS

The edible molluscs of British Columbia include oysters, various kinds of clams, scallops, abalones, squids and octopus. They have been described and figured by Quayle (2), who lists 21 species or groups of species. Most of these are not sufficiently abundant or sufficiently in demand to provide significant commercial production at the present time, but nearly all are used to some extent by a recreation or subsistence fishery.

Two introduced species are among those which provide commercial yields, and one of them, the Pacific or Japanese oyster, is our most important shellfish at the moment.

References for Molluscs

(1) Neave, Ferris. 1946. Condition of the butter-clam fishery in British Columbia. British Columbia Fisheries Department, Report for 1945, pp. 67-74.

(2) Quayle, D. B. 1941. The edible molluscs of British Columbia. British Columbia Fisheries Department, Report for 1940, pp. 75-87. Revised 1955(MS).

(3) Quayle, D. B. MS(1952). Pacific oyster culture in British Columbia. British Columbia Fisheries Department, Victoria. Mimeographed.

PACIFIC OYSTER - Crassostrea gigas

Present production: 80,000 U. S. gal. Production in 1980: 500,000 U.S. gal.

History and Present Status

The history of oyster production in British Columbia begins about 1913, but it is only for the last 15 years or so that accurate production figures are available (3). The yields shown below are in United States gallons, to the nearest hundred. (1 U.S. gallon is 5/6 of an Imperial gallon, or about 8 pounds of oyster meats. Prior to 1946 the quantities were reported in 200-pound barrels of whole oysters; they have been converted at the rate of 1 barrel = 2.5 U.S. gallons of meats.)

1940	21,700	1948	46,200
1941	91,200	1949	59,800
1942	37,400	1950	62,700
1943	37,700	1951	59,000
1944	49,700	1952	81,200
1945	35,200	1953	66,500
1946	65,800	1954	85,900
1947	61,700	1955	83,900

Nearly all this production comes from inter-tidal leased oyster grounds, mostly in the Strait of Georgia.

Formerly the native oyster, Ostrea lurida, supported a small commercial harvest.

Future Prospects

Potential oyster-growing capacity of suitable grounds in British Columbia is about 200 gallons per acre per year. Any individual first-class ground is best harvested every third year, at which time the crop is about 600 gallons per acre; poorer grounds are harvested less frequently. To-day there are about 1,500 acres of usable ground under lease, of which about 400 acres would be harvested in a year under full utilization. At present, however, some grounds are rarely harvested at all, and the average production of the 1,500 acres above is ~~220~~ 160 gallons per acre per year, or about a third of their potential.

The reason for the low production of present beds is inadequate seeding, since seeding in best commercial quantities must be done artificially. Prior to 1951 nearly all seed was imported from Japan, but since that time an adequate local source of seed has been discovered and is being utilized. This source is reliable in nearly all years.

With adequate seeding, the oysters produced on existing leases can be expanded to at least 250,000 gallons per year. With a growing demand for oysters, it is expected that this will be further increased, over the next 25 years, (1) by bringing into production new ground outside the Strait of Georgia; (2) by improvement and utilization of what is now marginal ground; (3) possibly by development of float culture techniques. The last-named has very large possibilities, if it proves economic. However our prediction of a harvest of 500,000 gallons in 1980 is based merely on the extension and intensification of conventional methods.

BUTTER CLAMS - *Saxidomus giganteus*

Present stock:	20,000,000 lb.	Present production:	3,500,000 lb.
Stock in 1980:	20,000,000 lb.	Production in 1980:	3,500,000 lb.

History and Present Status

The butter clam is found widely in British Columbia waters. A review of its occurrence and fishery has been made by Neave (1).

The catches of recent years are as follows, in thousands of pounds (including shells):

1940-41	2435
1941-42	3032
1942-43	2893
1943-44	2239
1944-45	3508
1945-46	4021
1946-47	6315
1947-48	?
1948-49	1626
1949-50	2640
1951	3500
1952	5492
1953	3691
1954	2897
1955	2762

No good information on present rate of utilization is available, but we estimate it at 20 per cent per year for the province as a whole. Individual areas, when dug, have up to 75 per cent of their commercial clams removed.

Future Prospects

Practically all the important beds of clams in the province are now being utilized. Clam growth is slow and reproduction uncertain, so no increase in yield can be predicted. "Farming" clams has been proposed, but will not become economic under foreseeable conditions.

LITTLE-NECK CLAMS - Prototheca staminea and Venerupis semidecussata

Present stock:	3,000,000 lb.	Utilization:	750,000 lb.
Stock in 1980:	3,500,000 lb.	Utilization:	1,000,000 lb.

History and Present Status

Up to the middle 1930's only the native little-neck (Prototheca) occurred in British Columbia. The Japanese little-neck or Manila clam was introduced accidentally with oyster seed, was first distinguished in the statistics in 1951, and now surpasses the native species in commercial importance. Both species occur, in commercial quantities, almost solely in the Strait of Georgia.

Recent production is as follows, in thousands of pounds (including shells):

	Native		Native	Manila
1941-42	200	1948-49	436	..
1942-43	249	1949-50	842	..
1943-44	238	1951	522	179
1944-45	369	1952	493	496
1945-46	548	1953	309	388
1946-47	?	1954	138	450
1947-48	?	1955	79	439

Future Prospects

No very substantial increase in production of little-necks seems likely. However the Manila clam is still extending its range somewhat, and better knowledge of the desirable frequency of cropping may increase production to say a third more than it is at present.

RAZOR CLAMS - *Siliqua patula*

Present stock: unknown, but large.

Present production: 170,000 lb.

Production in 1980: 500,000 lb.

History and Present Status

The razor clam inhabits sand beaches of our coast, especially around the Queen Charlotte Islands. Recent commercial production is as follows, in thousands of pounds (including shells):

1941-42	590	1948-49	223
1942-43	390	1949-50	176
1943-44	298	1951	136
1944-45	145	1952	126
1945-46	217	1953	154
1946-47	98	1954	272
1947-48	?	1955	178

Production to-day is limited by the weather and availability of diggers.

Future Prospects

Considerable increase in production seems possible, and will doubtless occur with increasing population and demand. However the extent of the resource is unknown, and the 500,000 pound figure for 1980 is strictly a guess.

OTHER MOLLUSCS

Abalone	= Haliotis kamtschatkana
Scallops	= Pecten caurinus
Horse clams	= Schizothaerus nuttalli
Geoducks	= Panope generosa
Mussels	= Mytilus edulis and M. californianus
Cockles	= Cardium corbis
Mud-clams	= Mya arenaria
Octopus	= Octopus hongkongensis
Squids	= Loligo opalescens and other species

Stocks: unknown; sometimes large

Present utilization: non-commercial or negligible

Utilization in 1980: some species have large possibilities

Abalones occur mostly on open coasts, from low tide level to several fathoms depth, and support a very small fishery. A recent limited survey failed to reveal densities which would permit expanded commercial utilization.

The scallop above is of commercial size, but exploration to date has not revealed commercial concentrations.

Horse clams are abundant in parts of the Strait of Georgia and elsewhere, and were once an important part of the native diet. No market exists for this large and rather coarse species, but development of one within 25 years is quite possible--perhaps as a minced product.

Geoducks are too scarce in British Columbia to be of interest except to sportsmen. They occur in a few places in the Strait of Georgia.

Mussel stocks are very large, but demand does not permit commercial utilization at present.

Cockles are abundant on some sandy beaches, but are not usually marketable.

Mud-clams do not occur in sufficient concentrations in British Columbia to permit commercial utilization. (This is the commercial clam of the east coast.)

Octopus usually do not exceed 2 feet long in our waters, and are only occasionally used for food. They are found in rock crevices, usually below low-tide mark. About 75,000 pounds a year are used for bait.

Squids grow to about 8 inches long. The size of British Columbia stocks is not known and they are used in only insignificant quantities, though a fishery exists in California and they are extremely important in Asia. Small quantities of a large squid (Gonatus), about 2 feet long, are taken by trawlers in deep water and used in preparing oriental foods.

WHALES

Finback whale	- Balaenoptera physalus
Blue whale	- Balaenoptera musculus
Humpback whale	- Megaptera nodosa
Sei whale	- Balaenoptera borealis
Sperm whale	- Physeter catodon
Gray whale	- Eschrichtius glaucus
Right whale	- Eubalaena sieboldi
Minke whale	- Balaenoptera acutorostrata
Killer whale	- Grampus rectipinna
Dall porpoise	- Phocoenoides dalli

Present yearly catch (from one shore station): 10 blue whales, 140 finbacks, 60 humpbacks, 130 sei whales, 270 sperm whales: 610 in all. (Based on 1954 and 1955).

Estimated catch in 1980 (from one shore station): About 700 whales, including more sei whales and a few more sperm whales than at present, but fewer blues, finbacks and humpbacks.

Estimated catch in 1980 (from one medium-size factory ship): About 2,000 whales, of somewhat greater average size than are taken by a shore station.

History

The whaling industry along Canada's western coast is served by five major species: fin, humpback, blue, sei and sperm whales. From one to four whaling stations have operated on Vancouver Island or the Queen Charlotte Islands almost every year since the first station opened in 1906. Table I shows the catch by species in each 5-year period. Since 1919 the catch has totalled approximately 7,000 whales in the relative proportions of 4% blue, 33% fin, 12% humpback, 8% sei and 42% sperm. At least as many whales were taken prior to 1919. Complete statistics for these are not available, but it is known that early catches contained a large proportion of humpback whales.

Whales are pelagic and migratory animals, knowing no national boundaries. Canadian coastal waters include only a small part of their range of distribution. Evidence, based chiefly on analogy with whale stocks in other localities suggests that the whales serving the British Columbia industry are mostly transients alternating between winter breeding grounds in low latitudes and summer feeding grounds in high latitudes (1). Some interchange between stocks in the eastern and western sectors of the North Pacific may occur, but the extent of this interchange must be determined by whale marking and racial studies. Interchange across the equator is not great. Recent evidence places the northern limit of distribution of blue and sei whales as the Aleutian Islands. No male sperms have been seen north of 62° latitude and no female sperms have been taken north of 52° latitude (2). Fin and humpback whales are known to penetrate through Bering Straits into the Arctic Ocean but their main feeding grounds are probably farther south, near the Aleutian Islands.

Stocks of whales in the northeast Pacific have been exploited by shore stations operating along the coasts of California, Washington and Alaska as well as British Columbia, and by factory ships operating off Lower California, California and in Alaska waters (3, 4). Shore stations operating in Alaska took almost 9,000 whales, mostly fin and humpback, from 1910 to 1940. A shore station on the Washington coast took almost 3,000 whales, mostly humpbacks,

Table I. British Columbia total whale catch by species. For 1911-15 and 1916-20 a complete breakdown by species is not available. No whaling was done in 1921, 1931, 1932, 1939 and 1944-47.

Years	No. of whales							No. of whaling stations	
	Blue	Fin	Hump	Sei	Sperm	Others	Total	Vancouver Island	Queen Charlotte Islands
1911-1915	..	..	..	..	..	..	3805	2	2
1916-1920	78	460	227	195	102	48	2217	1	2
1921-1925	151	520	215	222	291	8	1507	1	2
1926-1930	97	632	88	201	538	3	1568	..	2
1931-1935	7	108	15	1	630	..	761	..	2
1936-1940	10	232	27	2	954	..	1225	..	2
1941-1943	2	107	41	..	432	..	582	..	2
1948-1950	6	292	286	29	137	1	751	1	..
1951-1955	55	909	302	311	1100	23	2710	1	..
							15126		

from 1911 to 1925. Shore stations and factory ships operating off California and Lower California took almost 6,000 whales, mostly humpback and blue, from 1919-1930. In 1954 a Japanese factory expedition conducted successful trial operations in the eastern Aleutian Islands, mostly within a 200 mile radius of Dutch Harbour. The catch of 1030 consisted of 73 per cent fin whales.

Historical evidence of whaling in the northeast Pacific shows that, as a whole, this region has sustained a sizeable whale fishery for 50 years. Humpbacks and blue whale catches have declined rapidly wherever these species were attacked in numbers. Whaling from all stations has contributed to the reduction of humpback stocks. Blue whale stocks were reduced chiefly by factory operations off California and by Alaska stations. Fin whales are distributed widely and abundantly in the northeast Pacific and appear not to have suffered greatly under the pressure of whaling. Sei whales have not been exploited heavily, relative to the other species, owing to their small size and poor yield of oil. Sperm whale stocks have not been greatly reduced because of the polygamous breeding habits of the species and the small size and limited geographical distribution of the females.

Whaling is regulated by the International Whaling Convention of 1946, the terms of which restrict the taking of certain species and female whales accompanied by calves, impose minimum length limits for each species, limit the length of the catching season and restrict factory operations in certain areas. The North Pacific remains open to factory ship whaling for baleen whales north of 20° latitude, except for a section between 20°and 38° latitude and east of the 150th meridian. Whaling for sperms remains open to factory ships and shore stations throughout the North Pacific. Right whales and gray whales, two species which were exploited in the North Pacific and Arctic Oceans near

to extinction during the last century, are now completely protected.

Present Status

The present status of the industry is represented by the catches of the Coal Harbour whaling station, which is located on the west coast of Vancouver Island. This plant, which began operations in 1948, is the only whaling station now operating along the west coast of North America. Its fleet of 6 catcher boats took 630 whales in 1954 and 629 in 1955. Annual catch and production figures are shown in Table II. These catches are taken during a six-month period from April through September, mostly within 150 miles of the station.

The Japanese catch of 1030 whales around the eastern Aleutians in 1954 comprised 73 per cent fin and 11 per cent blue whales. These were taken at a rate of 2.12 fin whales and 0.32 blue whales per catcher's day's work (2). In British Columbia waters the take per catcher day was 0.28 for fin whales and 0.02 for blue whales, in 1952-55. These figures indicate the much greater availability of these species in the Aleutian area. No attempt was made by the Japanese to take sperm whales. In British Columbia the catch of sperm whales for the years 1952 to 1955 was 2.12 per catcher's day's work. Catch per unit of effort figures for the 1954 catch of blue and fin whales in the Aleutian area are greater than corresponding figures for the Antarctic. The entire whale stock in the North Pacific is, however, probably small as compared to the Antarctic stocks (1), but is concentrated in a smaller area.

Whales taken by the British Columbia station are of a smaller size and consist of a higher proportion of immature animals than those taken in the Aleutian area. Immature fin whales comprised 60 per cent of the male and 50 per cent of the female catch of fin whales in British Columbia as compared to 16 per cent male and 13 per cent female immature whales in the Aleutian catch. Similar differences occur in the other species. The comparison suggests age differences in the migratory pattern, but the differences may be in part a result of differences in the minimum legal length limits adhered to.

Future Trends

No sizeable expansion of the whaling industry in British Columbia may be expected if the industry continues to operate exclusively from a shore station. Notwithstanding the addition of one or more new stations, an event which seems unlikely, it is anticipated that only minor changes will occur in the total annual catches or their species composition. Additions to the present catching fleet of 6 vessels would be without economic advantage. Increasing the range of operations from a shore station is unsound because longer towing times encourages deterioration of the carcass and consequently reduces the value of the oil and meat. International Whaling Regulations limit the catching season to 6 months for baleen whales. Subject to annual variations in weather, which affects both feeding conditions and the availability of whales on the grounds, the future catch is expected not to deviate greatly in numbers from the 1954 and 1955 catches. However the species composition will probably change somewhat.

Some improvements in catching equipment may be expected in the future. These include: faster and more efficient catchers, sonic aids to location and

Table II. Catch and production of Coal Harbour whaling station, 1948-1955.

Year	No. of whales							Oil yield (bbl)		Meal	Liver Oil	Solubles	Meat
	Blue	Fin	Hump	Sei	Sperm	Others	Total	Whale	Sperm	(long tons)	(million units)	(long tons)	(long tons)
1948	..	37	115	2	28	0	182	4509	1170	475	..	..	..
1949	2	105	76	3	69	0	255	5529	2312	930	..	670	..
1950	4	150	95	24	40	1	314	8130	1468	1098	..	2009	..
1951	9	216	51	5	153	3	437	9325	5108	1378	..	2373	..
1952	16	240	61	22	126	0	465	11643	4577	1945	..	..	..
1953	8	181	47	14	275	14	539	8426	9829	1786	969,190	3211	609
1954	11	150	106	134	226	3	630	9769	7738	2235	657,455	1953	905
1955	11	122	37	136	320	3	629						
	61	1201	588	340	1237	24	3451						

chasing, aircraft for spotting whales, and the electric harpoon. Any of these innovations would add little to the total catch as experienced in other localities has shown that in time whales tend to become wary of and avoid fields in which whale catchers operate. This tendency would offset advantages derived from improvements in catching equipment and techniques.

Under present whaling conditions there is little prospect of important extensions in the utilization of the raw material. Large investments in research work on new by-products of various kinds, in countries where whaling is a major industry, have been without outstanding results. Reduction in the decomposition of the meat during the interval between catching and processing, by means of faster towing and bio-chemical treatment of the carcasses, will result in more of the raw material being used for animal food. Increasingly larger proportions of the catch are being used for mink food, for which a good market exists. Conditions in British Columbia are not very favourable for the production of whale meat for human consumption.

An important expansion in the whaling industry in the Canadian economy requires the use of factory ships, which can operate at places and times when whales are most numerous and of best size and quality. The Japanese whale catch in the Aleutian area in 1954, when compared to British Columbia catches shows that the availability is greater, sizes are larger and the proportion of immature whales in the catch is smaller. Sperm whales also are more abundant and are larger in northern areas where they consist of mostly large and mature bulls.

Fin, sei and sperm whales are the species best able to sustain exploitation in the northeast Pacific. None of these species has yet shown signs of depletion. The sperm whale could withstand heavier exploitation than it is at present subjected to in this area, and will probably increase in the British Columbia catch. The catch from British Columbia and northward consists almost entirely of mature bulls. The few females taken are mostly sexually mature because of the minimum length limits of 35 feet for sperms taken by shore stations and 38 feet for sperms taken by factory ships. Fin whale stocks have withstood heavy exploitation on both sides of the North Pacific. It is expected that this species will carry the heaviest burden in the future, though possible excessive international competition might in time reduce it. The stock of sei whales, although abundant, has barely been touched because of the small size of this species.

Stocks of blue and humpback whales in the northeast Pacific have been reduced by factory and shore whaling in the past, and the remaining stocks will probably not withstand increased pressure. Japanese studies suggest that the stock of blue whales may now be fairly stable and would not be further reduced by whaling at the present rate (2). Nevertheless a long closed season might be recommended, in order to increase its abundance substantially.

Gray whales are reappearing along the west coast of North America in increasing numbers in recent years and it may soon be possible to take a limited number. However, in British Columbia waters this species is available during its northward spring migration, when the whales are lean and economically undesirable. At a more distant time, the Pacific right whale may recover its numbers to a point where exploitation is feasible.

At least three small species of whales occur in abundance in the coastal waters of British Columbia and offer small potential rewards in the form of

human or animal food and oil. These are the "minke" whale, the "killer" whale and the Dall porpoise. Fisheries for "minke" and "killer" whales, independent of the fishery for the larger commercial whale species, are conducted in the North Atlantic and in waters adjacent to Japan. The Japanese also utilize several species of porpoises as a source of human food.

References

(1) Mackintosh, N. A. The natural history of whalebone whales. Smithsonian Rept. for 1946, p. 235-264, 1946.

(2) Omura, Hideo. Whales in the northern part of the North Pacific. Norwegian Whaling Gazette, No. 6 and 7, June and July, 1955.

(3) Pike, G. C. Whaling on the coast of British Columbia. Norwegian Whaling Gazette, No. 3, March, 1954.

FUR SEALS - Callorhinus ursinus

Present stocks (includes newborn pups)		Utilization (1955)	
Pribilofs:	1,750,000	Canada:	13,100 skins
Asiatic herds:	100,000	U.S.A.:	52,500 "
		USSR :	5,900 "
Stocks in 1980:		**Utilization:**	
Pribilofs:	somewhat less than now	(Canada's share of the kill will probably not be greatly different from the present)	
Asiatic herds:	500,000(?)		

(Note that the present kill at the Pribilofs consists only of young males 41-45 inches long, and takes about 65 per cent of that category each year.)

History

Fur seals congregate in summer to breed on three groups of islands in the North Pacific Ocean; for the remainder of the year they live at sea, migrating as far south as southern California and central Japan. The breeding colonies are on the Pribilof Islands controlled by the United States of America, and on the Commander and Robben Islands controlled by the USSR. A fourth colony once existed on the Kuril Islands.

Fur seals had been subjected to one period of over-exploitation during the early Russian occupation of the north Pacific, but had to a considerable degree recuperated by 1867. After the Alaska purchase, from about 1870 onwards the herds were again increasingly exploited, and by 1911 the numbers were reduced to approximately 5 per cent of the probable original peak numbers. Seals were killed both on the islands and pelagically. In the 1870's and 1880's pelagic sealing was exclusively a United States and Canadian industry, and remained predominantly so till 1897, when the United States prohibited pelagic sealing by her nationals. Thereafter until 1911 pelagic sealing was carried on by Canada and Japan, who first entered the field in the 1890's. Pelagic sealing became an important factor in the sealing industry after 1885 and was the chief source of seal skins from 1890 to 1909.

In 1911, an international convention was signed by the United States of America, Russia, Japan and Great Britain (on behalf of Canada). This convention outlawed pelagic sealing except by aboriginals using native methods, and provided other measures for the protection of the seal herds. The right to regulate fully the taking of seals from a herd was given to the nation controlling the breeding island of that herd. To indemnify other nations for losses arising from the prohibition of pelagic sealing, the United States agreed to deliver to Canada and Japan 15 per cent each of the annual take of seals from the Pribilof Islands. Russia undertook to deliver a similar percentage of the Commander Island kill to Canada and Japan. Japan, which at that time controlled the Robben Island, agreed to deliver 10 per cent of their kill to Canada, Russia and the United States. For all herds certain minimum sizes were specified below which the above division of kills would not apply.

This convention remained in force until 1941 when it was abrogated by Japan. In 1942 a provisional agreement for continued protection of the fur seals was concluded between Canada and the United States. Under this agreement Canada received 20 per cent of the annual take of skins from the Pribilof Islands. In late 1955, Canada, Japan, the United States, and the USSR met again to draw up a new convention for regulated exploitation of the fur seals of the North Pacific. At the time of writing no agreement has yet been announced.

Table I shows for 5 year periods the average pelagic kill of seals by Canadian vessels from 1876 to 1910, and from 1911 to 1955 Canada's share of the kills from each breeding colony together with the average pelagic kill by her aboriginals.

Present Status

The excessive sealing of the last two decades of the 19th century and the first decade of the 20th century, which lead to the rapid decline of all herds, was halted by the Treaty of 1911. By this time the Pribilof herd numbered little more than 100,000 animals, the Robben Island herd about 7,200 animals and the Commander Island herd 10,000 to 15,000 animals. The Kuril herd had disappeared.

The recovery of the Pribilof and Robben herds began soon after the Treaty went into effect. Poaching was nearly eliminated and a conservative policy of killing only 3- and 4-year old males instituted. Under these conditions the Pribilof and Robben herds grew rapidly until the early 1940's, when both herds began to approach their natural growth ceiling and a state of equilibrium. The latest available figures (1955) show that the Pribilof herd numbers about 1,750,000 animals and the Robben herd about 50,000 animals. The Commander herd was not given an opportunity to recover until much later than the other two. Intensive sealing continued on and about the islands after 1911. Raiding and haphazard management prevailed as a result of the Russo-Japanese war and the Russian Revolution. Poaching went on until at least 1922 when the herd was reduced to less than 18,000 animals. Russian figures published in 1934 indicated that the Commander herd then numbered only 15,200 animals. Since that time growth has apparently been more rapid for the latest Soviet figures show that in 1955 the Commander herd numbered between 50,000 and 55,000 animals. The Russians consider that the Commander herd is still in a state of rapid growth and has not yet reached its mature population ceiling.

Future Prospects

If existing methods of management and conservation are continued, little increase in the sizes of and kills from the Pribilof and Robben herds can be expected. However, if properly managed the Commander herd should continue to grow in size. If allowed to reach its growth ceiling it could contain 300,000-500,000 animals, which is its estimated size during the early era of exploitation from 1871-1891. If, therefore, present management policies continue Canada cannot expect any increase in the number of seal skins received, as under agreements in force in 1955 Canada shares only in the Pribilof kill.

Best information on fur seal management indicates that maximum sustained yield may be obtained from a population somewhat below the size which could be reached by exempting all females from capture. That is, the present kill of males could probably be obtained from a somewhat smaller herd; and to reduce the herd to this size and to maintain it there would call for the annual killing

Table I. Canada's share in the North Pacific fur seal kill from 1876 to 1955

Period	Pelagic kill		Land kill			Total
	Canadian sealing vessels	Aboriginals	Pribilof Islands	Robben Island	Commander Islands	
1876-80	8,798	...	...	...	...	8,798
1881-85	13,478	...	...	...	...	13,478
1886-90	35,802	...	...	...	...	35,802
1891-95	67,104	...	...	...	...	67,104
1896-1900	37,102	...	...	...	...	37,102
1901-05	18,049	...	...	...	...	18,049
1906-10	5,739	...	...	...	...	5,739
1911-15	...	815	1,000[a]	45	...	1,051
1916-20	...	319	3,601[b]	33	72[c]	3,276
1921-25	...	2,880	3,235	76	...	5,991
1926-30	...	2,406	4,754	157	...	7,317
1931-35	...	1,266	7,927	182	...	9,375
1936-40	...	1,300	8,758	252	...	10,310
1941-45	...	15[d]	12,522	...	...	12,536
1946-50	...	124	13,084	...	...	13,206
1951	...	534	12,138	...	...	12,672
1952	...	28	12,784	...	...	12,812
1953	...	54	13,334	...	...	13,388
1954	...	...[e]	12,776	...	...	12,776
1955	...	...	13,128	...	...	13,128

[a]Canada received 1,000 Pribilof Island skins in 1912. From August 24, 1912 to August 25, 1917 the killing of fur seals on the Pribilof Islands except for essential food use by natives was prohibited. During this period Canada did not receive a share of the skins.

[b]In 1917 Canada received 1,000 skins as her share of the kill taken after August 25, 1917. The average of 3,601 skins from the Pribilof Islands for 1916-20 represents the average of the kills from 1917-20. The average of 3,276 in the total column represents the full 5 year average of 1916-20. This explains why the number in the total column is less than the average number received from the Pribilof Islands.

[c]A share of the Commander Island kill was received from the USSR in 1917, 1918 and 1919 only. Apparently thereafter no further skins were received from this source.

[d]The low kill reflects interference due to wartime conditions.

[e]Surveys by the Department of Fisheries in 1954 and 1955 revealed that the Canadian coastal Indians possessed no serviceable aboriginal equipment (canoes and spears) suitable for taking fur seals.

of a certain number of female seals. This increased kill might be in the neighbourhood of 80,000 to 85,000 males and females a year, as compared with the present 65,000-70,000.

The relationship between fur seals and other marine resources may be an important factor in determining the optimum size of the seal population. About 30 per cent by volume of the food consumed by seals consists of species of some direct commercial importance (4). A considerable proportion of the remainder consisted of species for which seals compete with food fish. Whether this predation and competition is sufficient to warrant a serious reduction in the size of the seal herd has yet to be determined. There would be a temporary increase in skins taken, followed by a period of somewhat lower sustained yield.

Because of this uncertainty concerning desirable management policy, concerning the ultimate sizes of the various herds, and what share of their harvests Canada may obtain in future, our best tentative prediction is for a 1980 Canadian yield of the same size as to-day.

References

(1) Ann. Rept. (Fisheries), Canada Dept. Mar. and Fish., 1876 to 1913-14.

Ann. Rept. Fisheries Branch, Dept. Naval Service, 1914-15 to 1919.

Ann. Rept. Fisheries Branch, Dept. Mar. and Fish., 1920 to 1929-30.

Ann. Rept. Dept. Fish., 1930-31 to 1953.

(2) Canadian Bureau of Statistics Fisheries Statistics, 1917 to 1950. Ottawa.

(3) Alaska Fisheries and Fur Seal Industry. U. S. Dept. Comm. Bur. Fish., 1920 to 1939, and U. S. Dept. Int. Fish and Wildlife Service, 1940-1953.

(4) Taylor, F. H. C., M. Fujinaga and Ford Wilke. 1955. Distribution and food habits of the fur seals of the North Pacific Ocean. February-July, 1952. U. S. Dept. Int. Fish and Wildlife Service, Washington, D.C., 86 pp.

(5) Tomasevitch, J. 1943. International agreements on conservation of marine resources. Food Research Institute, Stanford Univ. Press, Stanford California, 297 pp.

SEA OTTER - *Enhydra lutris*

Present Canadian stock: none

Stock in 1980: up to 500 otters Catch: none

History

The sea otter is one of the two marine fur-bearers of the Pacific coast. Unlike the fur seal, it does not perform long migrations, and its food consists of molluscs and crustaceans taken on the sea bottom.

Unrestrained hunting by pelagic sealers in the late 19th century and the first decade of the 20th century exterminated sea otters in British Columbia and almost exterminated them in Alaska. The Treaty of 1911 for the conservation of fur seals and sea otters signed by Russia, Japan, the United States of America and Great Britain (for Canada) prohibited completely the taking of sea otters. The following table shows the average number of sea otter skins per year taken by Canadian vessels in waters off British Columbia, Alaska and probably also Siberia. The first year for which statistics are available is 1879.

Years included	Av. no. of skins	Av. price per skin
1879-1881	98	$ 40
1882, 1883, 1885, 1886	97	$ 53
1887-1890	98	$ 84
1892-1896	16	$120
1897, 1898, 1900, 1901	28	$325
1902, 1904, 1906	10	$437
1907, 1911	21	$552

The average catch declined suddenly about 1891, probably as a result of the *modus vivendi* of 1891 and 1892 which prohibited pelagic sealing in the Bering Sea, and of the Paris Tribunal of 1893 which prohibited pelagic sealing and sea otter hunting in the Bering Sea within the 3-mile limit and within 60 miles of the Pribilof Islands. The largest catch of 170 skins was reported in 1882 and the smallest of 7 skins in 1904 and 1911. The price per skin rose to a high of $800 in 1911.

The catches above, however, give no idea of the original abundance of the sea otter, for by 1879 it had already been subjected to more than 50 years of unrestricted utilization, and relatively few survived.

Present Status

The only known colonies of sea otters in North America are (1) several hundred individuals off California; and (2) several thousand individuals on Amchitka Island in the Aleutian chain. No colonies are known to survive in Canadian waters.

The colony on Amchitka Island is being studied intensively by the United States Fish and Wildlife Service to determine whether sea otters can be transplanted to other regions, how this should be done and what type of locality is most suitable; similar experiments have been or are being tried in the USSR.

Future Prospects

If transplantation of sea otters proves successful, the possibility exists that these animals could be re-introduced into Canada from Alaskan or Siberian sources. However, a long period of complete protection would be necessary after transplantation, to allow the colony to become established and to grow. Thus even if a trial could be made in the near future, it is unlikely that any colonies established would become large enough to warrant harvesting within the next 25 years. Over a longer period, we may look forward to having a large stock and annual return from this valuable fur-bearer.

SEA-LIONS - Eumetopias jubata

Present stock: 10,000-15,000 | Utilization: 90-100 animals (1952-54)

Stock in 1980: somewhat less | Utilization: 1,500 animals

History

Steller sea lions are large animals, males reaching more than a ton in weight. They range along the entire British Columbia coast, and congregate to breed on a number of rocky islands offshore. This species has no history of extensive utilization and at present is of minor commercial value as a source of mink food. Small attempts at utilization for this purpose were made in 1952, 1953 and 1954 when 3, 14 and 4 tons of meat were landed, respectively. About 1915, one manufacturer used the hides for making gloves, boots and mocassins. He found them to be fine-grained, pliable and water resistant.

The sea lion is a nuisance to fishermen by damaging nets and feeding on fish in the nets and on trolls. Accordingly attempts have been made to reduce the size of breeding colonies near important fishing areas. The average number reported killed per year is as follows (for some years data are not available):

Years	Av. no. killed
1915	2,875
1922-26	1,919
1927-30	1,308
1935-39	2,202
1940-44	125
1945-49	268
1950-51	329

Present Status

At the present time there is little information on sea lions in British Columbia waters. An investigation is planned for 1956 aimed at improving knowledge of their food and population dynamics. Observations made on one colony of 3,000-4,000 animals in 1953 showed that about 70 per cent were females, 10 per cent harem males, and 20 per cent idle males, either young or past their prime. Harems mostly contained from 1 to 14 cows.

Three censuses have been reported, as follows:

Year	Agency	Estimate	Remarks
1913	B. C. Fisheries Dept.	11,000	One large and several small colonies overlooked
1938	Canada Fisheries Dept.	14,000	
1955	" " "	9,000	

These figures do not include animals which are not hauled out on the rocks at the time of the census.

Future Prospects

The 1952-54 trial harvests of sea lions for mink food appear to offer some promise for the establishment of a minor industry. So far the operations have not been a great financial success, but more experience and improved equipment are expected to correct this. The difficulties stem mainly from the remote and exposed situation of the rookeries. An eventual utilization of 1,000-2,000 animals per year seems feasible, particularly if the harvest is directed primarily at the males, as with fur seals. Renewed attempts to use the skins may be made.

Reference

(1) Newcombe, C. F., W. H. Greenwood and C. McL.Fraser. 1918. I. Preliminary report of the Commission in the sea lion investigation, 1915. II. Report and conclusions of the sea lion investigation, 1916. Contr. Canadian Biol., 1917-18, pp. 5-39.

SEAWEEDS

Large kelps - Macrocystis and Nereocystis
Small kelps - Laminaria, Alaria, Hedophyllum, etc.
Red algae - Gracilaria, etc.

Present stock:	1,000,000 tons of large kelps 500,000 tons of small kelps "large quantities" of red algae	Utilization: nil
Stock in 1980:	no change	Utilization: unpredictable

Present Status

Kelps are a source of algin, while red algae supply agaragar. Preliminary surveys of the abundance of kelps in British Columbia waters have revealed large quantities of Macrocystis and Nereocystis (1, 2, 3). Ideally, the whole of a year's crop could be harvested, though of course scattered colonies would not be profitable to work with.

Less information is available on the abundance of agar-producing plants, but it is known to be considerable. At present there is little utilization of either type in British Columbia.

Future Prospects

The seaweeds are a marine resource of great potential importance. Agar and algin have numerous industrial uses. Exploitation of our stocks will be possible if demand increases or if improved processing methods are discovered.

References

(1) Scagel, R. F. MS, 1941. A report of a seaweed survey of the coast of British Columbia. Fish. Res. Bd. Canada, Nanaimo, B. C.

(2) Scagel, R. F. 1947. An investigation on marine plants near Hardy Bay, B. C. No. I. B. C. Dept. of Fisheries, Victoria.

(3) Neave, F., J. L. Hart and D. B. Quayle. 1949. (A brief concerning fisheries resources of British Columbia.) Transactions of the 2nd Resources Conference, 1949. pp. 90-123. Dept. of Lands and Forests, Victoria, B. C.

NEW SPECIES (Pacific Area)

Occasional successful transplantation of marine organisms here and in other parts of the world have stimulated interest in other possibilities. The two significant imports which we have to-day are the Pacific oyster and the Manila clam, both introduced from Japan (the clam accidentally). Though these two may to some extent have suppressed the native oyster and native little-neck clam, respectively, there has been a net gain in both cases because of the greater abundance and adaptability of the newcomers.

As far as fish are concerned, the north Pacific has already by far the richest fauna of any temperate region of the earth, so that it is difficult or impossible to propose any species that would fill an ecological gap and which would be unlikely to damage native species. The Atlantic shad occurs sparingly in our large rivers, having moved north after successful introductions in California (1). Unlike nearly all other temperate parts of the world, the eastern shore of the north Pacific has no freshwater eels, but this omission is one that we are anxious to maintain, because of their possible predation on salmon and trout. Atlantic salmon have been proposed for British Columbia, mainly as a basis for summer freshwater angling, but they would have difficulty in establishing themselves in the face of competition from the numerous native salmonids, especially coho salmon, steelhead and cutthroat trout. Transplantations to date have failed.

The only obvious weakness in the actual and potential fisheries picture of British Columbia is the relative unimportance of crustaceans, as compared with eastern Canada and other parts of the world. The Pacific crab supports a minor though important fishery, but we miss the king crabs to the north and the spiny lobsters to the south. Two kinds of animals have been proposed to augment this branch of the industry: the eastern lobster, Homarus americanus, and a spiny lobster, Jasus lalandei.

Lobsters: The eastern lobster is the more familiar of these and seems to offer greatest opportunities. There is little likelihood that it would ever become as abundant as in eastern Canada, because much of the Pacific coast lacks the shelving coastal underwater terrain which makes good lobster ground; nevertheless, there are considerable areas which seem suitable.

It has been shown that adult lobsters survive well in enclosures in the Strait of Georgia, but no survival of larvae has been observed, possibly because of periodic low surface salinity in late spring and summer. Following three earlier failures in 1898-1909, the possibilities of this area were again tested, by a large-scale introduction to Lasqueti Island in 1946, with negative results (3). Females were observed carrying eggs a year later (2), but no young lobsters were ever found. Any future trials should probably be in a region less affected by river run-off, such as the west coast of Vancouver Island or somewhere in the Queen Charlotte Islands area. There is as yet no reason to presume that success is impossible, though it seems clear that it will not come easily.

Lobsters do not favor the sandy bottom preferred by our Pacific crab, so little competition between the two would be likely.

Spiny lobster or crayfish. The native spiny "lobster" of the North American coast (Panulirus) is abundant in southern California, but does not range north to British Columbia. In the southern hemisphere a species of the related genus Jasus supports a large fishery in temperate waters. (Most species occur in warm water.) This might prove adapted to our conditions. Though it would be unlikely to support any really large fishery here, catches of the same order as the present crab fishery might be possible. Spiny lobsters tend to frequent rocky coasts.

References

(1) Neave, F. 1954. Introduction of anadromous fishes on the Pacific coast. Canadian Fish Culturist, No. 16, pp. 25-26.

(2) Fisheries Research Board of Canada, Pacific Prog. Rept., No. 72, p. 43, 1947.

(3) Adams, James R. MS, 1948. An interim report on an experiment to introduce Atlantic lobster into Canadian Pacific coast waters. Fisheries Research Board of Canada, Nanaimo.

(4) Chace, F. A., and W. H. Dumont. 1949. Spiny lobsters--identification, world distribution, and U. S. trade. U. S. Fish and Wildlife Serv., Commercial Fisheries Review, 11(5): 1-12.

APPENDIX: COMPILATION OF POTENTIAL EXTENSIONS TO SALMON SPAWNING GROUNDS IN BRITISH COLUMBIA

Prepared by the Department of Fisheries,
Vancouver Office, February, 1956.

The economic aspects of increasing the production of salmon by application of fish culture technique involving the removal or laddering of obstructions which limit the spawning and rearing areas in streams presently available to salmon and the removal or laddering of obstructions which are so located as to make streams completely inaccessible to salmon has been examined by the Fish Culture and Development Branch of the Department.

Complete information on all such streams was submitted by the Fishery Officer in each area. This included information on the type of obstruction, its height, its distance from the mouth of the stream, and its accessibility. In those streams which presently support runs of salmon the average number of each species which spawned during the past 10 years was given and the length of stream which would be made available for spawning and rearing by removal or laddering the obstruction was estimated.

The information was then tabulated and each stream was subjected to preliminary biological and engineering analysis. With the exception of major streams, a height of 30 feet was set as the maximum height of obstruction which could be economically laddered. Factors such as the present or potential use of the water above the obstruction for industrial or other purposes and the ratio between the cost of laddering or improving the obstruction and the length of stream that would be made available were also considered.

A total of 99 streams which presently support runs of salmon were analyzed on the above basis. Of these 70 were selected as being economically possible to develop within the next twenty-five year period. The removal or laddering of the obstructions on these streams would make available an additional 263 miles of spawning and rearing area. These streams are presently supporting, on 202 miles of spawning and rearing area, an estimated population of 1,300,000 salmon. Assuming a direct relationship between population and spawning and rearing area, it is estimated that the spawning population would be increased by 1,700,000 salmon by making available the additional 263 miles of spawning and rearing area. On the basis of a 1:1 catch escapement ratio, which is considered conservative, the commercial catch would be increased by the same amount, i.e. 1,700,000 salmon.

The landed value of salmon caught during the past five years has averaged $22,400,000.00. Based on the analysis of species which would utilize the 263 miles of spawning and rearing area, it has been estimated that this annual landed value would be increased by $1,500,000, or $36,600,000 during the next twenty-five year period. This represents a net increase of almost 7%.

To make these areas accessible a total of 86 separate projects would be involved and the approximate total height of fishways to be built would amount to 1,343 feet. At present costs this would require a total expenditure of $2\frac{1}{2}$ to $3\frac{1}{2}$ million dollars or an annual expenditure of $100,000 to $150,000 over the twenty-five year period.

The analysis of 19 streams which are presently inaccessible to salmon indicated that 17 might possibly be economically opened up. The potential salmon production of these streams could not be assessed due to the lack of quantitative data. It is estimated these streams would involve 19 separate projects and the total height of fishways to be built would amount to 375 feet. This would require a total expenditure of $750,000.00 to $1,120,000.00 or an annual expenditure of $30,000.00 to $45,000.00 over the twenty-five year period.

The implementation of this program in the twenty-five year period would require the completion of four projects per year. It is estimated that to carry out the necessary engineering surveys, to complete the structural designs, to prepare plans and specifications and to supervise construction would require the full time attention of four engineers and four technicians. Biological personnel requirements to carry out detailed surveys, investigate and implement necessary fish culture techniques and assess results are estimated to be three biologists and three technicians.

Since nearly all projects are in coastal locations, special survey and construction boats to be used exclusively for this work would probably be necessary, and special communication equipment would be desirable. Travel by chartered aircraft and survey by helicopter would be required frequently. In view of these extraordinary expenditures, the overhead cost in salaries, travel, equipment, etc. in addition to maintenance of the structures, could easily approach 50% of the construction costs cited above.

Tables summarizing the streams in each district and related data pertinent to the survey are attached. (with this ltr)

A R C T I C R E G I O N

INTRODUCTION

Exploration and evaluation of Arctic resources is in an early stage. On the basis of present knowledge it is convenient to treat the stocks of marine mammals as a unit, but to divide the account of fishes into an eastern and a western sector. This is followed by some discussion of plankton as a potential resource.

In general, the slow growth and low metabolism which prevails in true Arctic waters precludes the expectation of large sustained yields of fishes on a commercial basis, such as those we regularly obtain from more southern waters. Thus marine Arctic resources cannot on the whole be expected to be the basis of much more than "subsistence" fisheries. As such, there is room for very considerable increase in utilization. There is some evidence, too, that exploitation of certain whales and fishes in the Arctic could approach minor commercial levels, under careful management (4, 5).

Climatic Change

The climatic warming which began about 1920, manifested in the North Atlantic by increased Drift (Gulf Stream) influence, made itself felt principally in west Spitsbergen, Iceland, and west Greenland, areas dominated by Drift water. The effect in Canada has been very much less, especially in the sea (marine climate as opposed to atmospheric climate). This might be expected on general grounds, since an increased delivery of Atlantic water into the Polar Sea, which appears to have been happening, would inevitably result in an increased outpouring of arctic water from the Polar Sea; and one of the two main outlets from the Polar Sea is by way of the Canadian Current coming down the east coast of Baffin Island and contributing a great deal of the water of the Labrador Current. Eastern Canadian waters would thus be buffered against the increased Atlantic influence by the increased arctic element.

It is not probable therefore that the recent climatic change has had any important effect on the resources of the waters of the Canadian eastern arctic and subarctic. And it follows that, if the cycle has now reached its peak, the subsequent cooling will probably affect the Canadian eastern arctic as little as the warming has.

There is also another point. If the Atlantic Drift system relaxes, then the velocity of the west Greenland Current, and probably also its mass, will decrease, in which case the effect of the earth's rotation (Coriolis force) upon it will decrease, and it will not be pressed so strongly in to the Greenland coast. It may thus be expected to swing more and more to the west, towards Labrador and the eastern end of Hudson Strait, so that even though the marine climate of the North Atlantic in general may cool, the waters of the Canadian seaboard may be unaffected by this cooling for a few years, and may even continue in the very gradual warming which they have been showing.

There is evidence that this is in fact happening at present. The waters of Spitsbergen, the Faeroes, Iceland and possibly also west Greenland, have been less warm during very recent years, and there is no evidence of warming in west Greenland since the middle 1930's. On the other hand, the Nova Scotian waters are continuing, at least up to the present (1955), the slow warming which has been observed there for several years.

The conclusion is that whatever may happen to climate generally, in the next

few decades, the effects on the Canadian arctic and subarctic waters will not be spectacular and will have little influence on their economic possibilities. The distribution of the capelin, for instance, may change one way or the other to a small extent, and the position of planktonic indicators will no doubt show similar fluctuations, but it is very unlikely that any significant variations in resources will occur as the result of climatic change.

Farther south, of course, in the Newfoundland and Nova Scotian areas, changes might have quite important effects, even in the short span of one decade.

References (for whole Arctic section)

(1) Doan, K. H. 1948. Speckled trout in the lower Nelson River, Manitoba. Bull. Fish. Res. Bd. Canada, No. 79, 12 pp.

(2) Doan, K. H. 1953. Beluga of the Churchill region of Hudson Bay. Bull. Fish. Res. Bd. Canada, No. 98, 27 pp.

(3) Dunbar, M. J. 1949. The Pinnipedia (seals) of the Arctic and Subarctic. Bull. Fish. Res. Bd. Canada, No. 85, 22 pp.

(4) Dunbar, M. J. 1951. Resources of Arctic and Subarctic seas. Trans. Roy. Soc. Canada, Ser. III, 45: 61-67.

(5) Dunbar, M. J. 1953. Arctic and Subarctic marine ecology: Immediate problems. Arctic, 6(2): 75-90.

(6) Dunbar, M. J., and H. H. Hildebrand. 1952. Contribution to the study of fishes of Ungava Bay. J. Fish. Res. Bd. Canada, 9(2): 83-128.

(7) Grainger, E. H. 1953. On the age, growth, migration, reproductive potential and feeding habits of the Arctic char (Salvelinus alpinus) of Frobisher Bay, Baffin Island. J. Fish. Res. Bd. Canada, 10(6): 326-370.

(8) Sprules, W. M. 1952. The Arctic char of the west coast of Hudson Bay. J. Fish. Res. Bd. Canada, 9(1): 1-15.

(9) Vladykov, V. D. 1944. Chasse, biologie et valeur économique du marsouin blanc ou béluga (Delphinapterus leucas) du fleuve et du golfe Saint-Laurent. Dept. des Pêcheries, Québec, 194 pp.

(10) Wynne-Edwards, V. C. 1952. Freshwater vertebrates of the Arctic and Subarctic. Bull. Fish. Res. Bd. Canada, No. 94, 28 pp.

ARCTIC MARINE MAMMALS

Atlantic walrus	= Odobenus rosmarus
Ringed or jar seal	= Phoca hispida
Bearded seal or square flipper	= Erignathus barbatus
White whale or beluga	= Delphinapterus leucas
Narwhal	= Monodon monoceros
Greenland right whale or bowhead	= Balaena mysticetus

Atlantic Walrus

The walrus is one of the most important factors in the living economy of the people in the eastern Arctic. Commercial exploitation by civilized men was active in the past, largely contributing to a drastic reduction in range in the last 200-300 years. (It was once abundant on Sable Island off Nova Scotia.) Scientific study of the Atlantic walrus has only recently begun, and little can be said of its possibilities, except that renewed commercial exploitation is not possible. On present results, the northern Hudson Bay stock is estimated at 2,000-3,000 animals. The Foxe Basin stock is not known, but probably is somewhat larger. Nothing is known of the size of stocks along the east and north coasts of Baffin Island, or in the waters of the Arctic Islands. Nor is it known to what extent the several groups are in contact with each other, or what migrations occur. It is unlikely that the native kill can safely be raised much if any above its present level, which is between 500 and 1,000 animals per year, with yearly variations.

For the long view, as we become more familiar with habits and management of walruses, consideration can be given to re-establishing the species in the more out-of-the-way parts of its former range. Its food being mostly molluscs, worms, etc., of no value to man, there would be no competition with fisheries.

Ringed Seal

This is the commonest seal of the north and the mainstay of the native economy over considerable areas of the total Eskimo range. It is most abundant along complex coastlines, where there is sheltered water, with early-forming and late-melting ice. The type of coastline thus largely determines the distribution of this seal. Hudson Bay is poor in ringed seals, especially in summer. Northern shores of Hudson Strait are rich in ringed seal, and the Baffin Island coast as a whole is well stocked. Ungava Bay is poor.

An estimate of the total stock cannot be made at present. Reliable figures for the annual take are not available; the catch probably is of the order of 10,000-30,000. There is no real evidence that the numbers are declining, but it is not likely that a much larger kill could be sustained in the areas where it is now regularly used. The more southerly Eskimos give some cause for concern through irresponsible shooting habits, where large numbers of seals are wasted because they are shot from too far away and cannot be harpooned and retrieved.

Sealskins are bought by Hudson's Bay Company posts where sealing is best (Baffin Island, especially Pangnirtung). Raising of the numbers bought probably would be unwise, although it is too early to tell what the effect of such purchasing is on the stock.

White Whale

This small whale (13 feet) is fairly widely distributed throughout the Arctic. Known centers of abundance have been mapped by Vladykov (9). The size of the stocks is unknown. It is used by Eskimos and Indians, especially near the mouths of large rivers, and supports a small-scale commercial enterprise at Churchill, Manitoba (2). Catch statistics and estimates of belugas taken in the eastern Arctic are as follows:

Year	Churchill	Pangnirtung[a]	Other Areas[b]
1948	?	107	?
1949	206	191	?
1950	326	87	?
1951	584	292	?
1952	699	204	More than 121
1953	559	213	" " 90
1954	595	186	" " 55
1955	498	255	" " 75

[a]Catches estimated from oil yield (at a rate of 30 gallons per animal, the mean yield at Churchill).

[b]From R.C.M.P. reports.

At Churchill, the two main products of the industry are oil, and meat for mink food. The carcass is "hogged" entire so that little is wasted. Improvements in the machinery used could lead to a yield of 750 pounds per animal, about 250 pounds more than at present. There is a quota of 800 animals yearly for the area, but it has not yet been reached. Recent aerial surveys show no decline, possibly an increase, around Churchill.

Elsewhere in the Arctic the chase for beluga is by and for the native population. Much more research is needed in Hudson Bay and at other points.

In the Western Arctic, estimates of the stock vary from 3,000 to 10,000 in the Mackenzie delta and adjacent regions. A large year's catch would be 400 whales for this area. Probably more could be taken.

Narwhal

Very little is known about this small whale, which ranges farther north than the beluga, but overlaps the latter. It is taken whenever possible by natives, usually with white whales. No more than 100-200 a year are taken at present. Experiments with hunting methods may lead to more being caught.

Bowhead Whale

This large baleen whale was hunted almost to extinction by commercial whalers between 1612 and 1887 in the eastern Arctic. The same happened in the

Western Arctic between 1888 and 1912. The species has been protected ever since, and scattered individuals can now be seen in parts of Davis Strait. The Eskimos have forgotten how to hunt it, but it should be possible before long to use it again the Arctic human economy. Large-scale commercial utilization does not seem likely within 25 years.

EASTERN ARCTIC FISHES

Atlantic cod	= *Gadus callarias*
Arctic char	= *Salvelinus alpinus*
Greenland halibut	= *Reinhardtius hippoglossoides*
Greenland shark	= *Somniosus microcephalus*
Atlantic salmon	= *Salmo salar*
Speckled trout	= *Salvelinus fontinalis*
Whitefishes and ciscoes	= *Coregonus* and *Leucichthys*

Atlantic Cod

Cod become available from late July to September in the Port Burwell region, northeast Ungava Bay. Exploitation in this area is virtually nil, but the cod can be caught by hand line (jig) at the rate of about 20 per man per hour. The size of the stock is unknown, but it is considered adequate to support a local fishery which could serve settlements on the Ungava Bay coast, including any new mining developments. The present human population of Burwell is about twenty. The economy of this small native group is in good shape, since sea mammals are in good supply. Native fishermen from other settlements where the native economy is poor could be brought to Burwell with the development of a small cod fishery. The Burwell natives could be encouraged to fish for cash profit, the fish being distributed to other posts. The cod would have to be salted or frozen, since the moist foggy climate would not permit successful drying (6).

Arctic Char

The Arctic char is widely distributed all over the Arctic and to a lesser extent in the subarctic (7, 8, 10). It is present as an anadromous migrant in far more rivers and streams than are normally visited by the Eskimos. Sizes of stocks and potential sustained yields are largely unknown. Accurate figures on the present take and utilization, and detailed information on methods, are not yet available or are very sketchy. A take of over 10,000 fish a year by a given post at present is not very common. A large take would be that of, for example, Pelly Bay in 1953-54, when about 60,000 pounds (approximately 30,000 fish) were taken.

The char offers a resource which can stand considerable increase in exploitation, provided the increase is spread over many rivers and is not concentrated on a few, for the species grows and breeds slowly. The use of the char by the Eskimos could be increased greatly (perhaps more than doubled) by providing more boats for mobility, and smoking plants and instructions in the use of them. There is almost no effort at present to preserve char for winter use.

Char can be taken on spoons and spinners, and they fight energetically. It is possible therefore that they will be of some importance as an object of sport fishing as the Arctic continues to open up and become easier of access.

Greenland Halibut

This flounder is known along the Labrador, and the young have been taken around Port Burwell. Studies on the feeding habits of the large colonies of Murres on Akpatok Island in northwest Ungava Bay revealed that the nestlings of these colonies are fed, among many other things, young Greenland halibut. Stocks are unknown. There is a great deal of exploratory fishing to be done before the economic potential of this fish can be established. There is hope that there may be a usable supply off the east coast of Baffin Island. It is a very useful fish, easy to smoke, fat and of excellent flavour. It is an important item in the Greenland economy.

Greenland Shark

This shark is found all over the eastern Arctic with the probable exception of Hudson Bay, especially in good sealing areas. It is very simple to catch on long lines or hand lines, using seal fat as bait. It has never been used in the Canadian north, but has long been an important fish in Greenland. Its meat, dried and mixed with seal oil can be used for dog-food, an important problem in Arctic living. The skin, though difficult to tan, is very strong. The liver is rich in oil and Vitamin A. Sizes of stocks are unknown, but the fish is available and catchable, and forms a resource of potential value.

Atlantic Salmon

Salmon were at one time fished commercially in the Koksoak and George Rivers of Ungava Bay, but the take declined rapidly and the operation was stopped about 1934. Probably because of slow growth and low metabolism as in the Arctic char, salmon cannot support heavy commercial exploitation at the northerly limit of their range. But they (and also the lake trout and speckled trout) offer opportunities for sport fishing in the north up to Hudson Strait. With the increasing use of aircraft for private hunting and fishing expeditions, this perhaps is not a negligible economic factor. There has been no recent work done to establish the present stocks, and a sustained yield figure cannot be estimated at present.

Speckled Trout and Whitefishes

Speckled trout occur in rivers entering Hudson Bay and James Bay, south of 58° latitude, approximately. Their habits in the larger rivers resembles those of the arctic char to the northward: a summer feeding excursion in the sea, followed by spawning and wintering in fresh water. They are netted by local populations, and also pursued for sport by occasional visitors.

Whitefishes of one species or another occur rather generally in Arctic and Subarctic fresh waters. They run to brackish or salt water in such rivers as

Nelson, Churchill, Winisk, Attawapiskat, etc., but the general distribution of these anadromous stocks has not yet been mapped. Utilization is mainly by local Indian or Eskimo villagers.

WESTERN ARCTIC FISHES

Whitefish	= *Coregonus* spp.
Inconnu	= *Stenodus*
Cisco or tullibee	= *Leucichthys*
Loche or burbot	= *Lota*
Jackfish or pike	= *Esox*
Suckers	= *Catostomus*
Lake trout	= *Salvelinus namaycush*
Grayling	= *Thymallus*
Capelin	= *Mallotus villosus*
Cod	= at least two species
Flatfishes	= *Platichthys* and at least one other

The Canadian western Arctic mainland coast, east to the Mackenzie delta and somewhat beyond, has warmer water than the central area. The fisheries are however mainly for species of typically freshwater aspect, which enter brackish or salt water in summer. At low temperatures freshwater fish have a much greater tolerance for salt water, which explains their frequent marine excursions in the north.

Whitefish, inconnu, lake herring, loche, jackfish, suckers, trout, grayling. These species are caught and utilized in the lower Mackenzie River and its tributaries, and are listed in order of importance. On the coast many of these largely freshwater species persist since the fresh water of the Mackenzie strongly influences adjacent coastal waters.

In the region of Tuktoyaktuk, about 70 miles east of the Delta, "herring" flatfish and smelt (capelin) are taken in addition. The most common method of fishing is by gill net. Some jigging and gill netting is carried on through holes cut in the ice, and sweep nets are used on certain species.

The local people, mostly Eskimo and Indian, and their dogs depend to a large degree on the fish in this region for their food supply. An estimate of the present utilization for the peoples of the coastal region and up the Mackenzie River as far as Great Slave Lake is 3,000,000 fish annually (about 6 million lb.). It appears that more fish could be taken, probably at least twice the present catch, providing some changes in technique and use of additional gear can be instituted.

Apart from greater production from the Mackenzie River, an increase in the catch of marine smelt may be feasible, and there may be a considerable flatfish stock offshore. Exploration is required to establish this point.

PLANKTON

The standing summer crop of plankton organisms is very heavy in northern waters especially in the subarctic belt where both polar and Atlantic water are found together. Efforts to make direct use of this enormous resource in various parts of the world havenot so far met with much success, because of the technological difficulties of harvesting the plankton in large enough quantities to make it economically workable. Methods of using algal material for food, however, have already been devised and will no doubt improve, and there should be no great difficulty in using the zooplankton, especially the crustacean elements which are often taken in plankton nets to the exclusion of almost all else. The difficulties are in the actual large-scale collection of the plankton, and since they are purely technological problems, it seems reasonable to predict that the subarctic plankton will one day make a valuable direct contribution to the northern economy.

Utilization of plankton is more promising and more desirable in northern seas than anywhere else. On the one hand, the cold water, slow growth and scarcity of enemies permits the accumulation of dense plankton suspensions, so that harvesting will be easier than in temperate waters. On the other hand, the Arctic largely lacks the kinds of fish which, in other climates, convert plankton to a form usable by man. In the long run this may even be an advantage, since direct utilization of plankton should give us a much greater yield of protein and oil.

INCREASED POPULATION AND ARCTIC RESOURCES

Air bases, weather stations, radar stations and mining camps have increased the "steady state" population of the north very greatly. In the present context the following points can be made:

1. Eskimos are employed on many of these developments and become, at least for a time, unskilled labour leading a non-Eskimo life. This is a matter of policy about which there is much controversy. Presumably it relieves the hunting pressure on local seal stocks, etc., to some extent.

2. Non-native personnel are not allowed to hunt sea mammals (with the exception of beluga at Churchill); but they may fish. Such sport fishing should not have any significant effect on the stocks unless the number of fishermen were to increase enormously over the present level.

3. Certain resources offer possibilities of supplying local fresh food for the camp and station personnel, which is good for general health and also reduces the cost of the commissariat as a whole. Properly organized, the arctic char could fill such a role as this, and a lucrative char fishery could be developed for the natives. The Atlantic cod at Port Burwell could also be used in this way to supply towns at iron ore development. In both cases, however, purposeful organization and planning, and priming with capital in the beginning, would be necessary.

4. The larger operations, such as air bases, create a disturbance large enough to alter the distribution of the sea mammals. This has happened, according to report, at Thule in northwest Greenland. The Thule Eskimos have moved north, away from the base. Bases in Canada are smaller than Thule, and it is doubtful if this has occurred in this country as yet. The most likely point for such an effect would be Frobisher Bay.

INLAND REGION

INTRODUCTION

No really comprehensive review of Canadian freshwater fisheries could be attempted in the time available, mainly because their diversity makes it a formidable task. The number of species is no greater than in the sea, but the kinds and numbers of bodies of water involved is very great. In addition, freshwater fisheries administration is divided among even more authorities than there are political units involved, because of the separation of sport and commercial fishing in some provinces.

Canada's Freshwater Area

One of the most informative ways to consider fish production is in relation to the area of the bodies of water in question. The freshwater area of Canada has of course not been determined with any precision. We will use mainly figures given in the Canada Year Book, 1951 edition, which include a total for each province and estimates of the larger lakes separately. The total is apparently not meant to include running water, so 0.5 per cent of the land area of each province is added to take care of that type of environment. (Much angling is done in streams; in fact, they are probably better harvested than are lakes, on the whole.) For other modifications, see under the separate provinces.

Commercial Fishing

Catch statistics of freshwater net fisheries are usually fairly well collected, exceptions being the "subsistence" and "fur-farm" fishing in some provinces. Statistics show the kinds of fish caught and to a large extent their origin, so that possible future yields can be projected upon a basis of knowledge of the past performance of the bodies of water in question. There have also been individual studies and summaries of statistics for special regions, notably the Great Lakes and Great Slave Lake.

Sport Fishing

It is impossible to collect complete statistics of sport catches, and no comprehensive sampling or "survey" estimates have been attempted in Canada. There are two general approaches to an estimate of yield. One is by reference to water area and data on yield per unit area. The other is from local creel censuses showing catch per angler, combined with information on number of anglers.

Half of the provinces of Canada do not require fishing licenses for residents, but estimates of number of anglers over 18 years of age are shown in Table A. In most provinces the licences sold, or the estimate received, is not far from 10 per cent of the population. The principal exception is Quebec where resident licences were sold to only 4.4 per cent of the population in 1954. For Alberta an estimate of 150,000 was received (apparently including anglers of all ages), or 17.2 per cent of the 1949 census; we feel justified in reducing this to 80,000 anglers over age 18, for our purposes, by comparison with adjacent provinces.

Table A. Estimates of number of freshwater anglers (only those over 18 years of age, except for non-residents).

Province	Population[a] (thousands)	Resident licences sold	Estimated resident anglers	Non-resident licences sold	Estimated total anglers (over 18 years)	Year
British Columbia	1,114	91,155	..	28,495	119,650	1954
Alberta	871	b	80,000[d]	b	95,000	1955
Saskatchewan	861	65,792	..	6,147	71,939	1954/5
Manitoba	778	54,000[c]	..	10,000[c]	64,000[c]	1955
Ontario	4,411	..	450,000	366,150	816,150	1954
Quebec	3,887	171,351	..	44,170	215,521	1954
New Brunswick	516	..	50,000	5,366	55,366	1954
Nova Scotia	645	..	60,000	1,653	61,653	1954
Prince Edward Island	94	..	10,000	?	10,000+	1954
Newfoundland	348	..	25,000	268	25,268	1954

[a] 1949 intercensus estimate (Canada Year Book).

[b] About 30,000 licences were sold in 1955 to residents and non-residents; residents require licences only when fishing for trout, etc.

[c] Approximate.

[d] Estimated by comparison with other provinces.

BRITISH COLUMBIA

Present catch:

Subsistence	105,000 lb. (1954)
Sport	5,500,000 lb.

Catch in 1980:

Subsistence	100,000 lb.
Sport	11,000,000 lb.

The freshwater area of British Columbia given in the Canada Year Book is 6,976 square miles, but this does not include smaller lakes, apparently. Another estimate gives 2,576 square miles in lakes over 20 square miles in area and 6,250 square miles in smaller lakes, the latter estimate being from sample map areas (1). We will use this total of 8,800 square miles for lakes. Adding 0.5 per cent of the land area (1,800 sq. mi.) for streams gives 10,600 square miles of fresh water in all.

The eight largest lakes are Atlin (in B. C., 307 sq. mi.), Babine (194), Kootenay (168), Stuart (139), Okanagan (136), Shuswap (120), Takla (102) and Quesnel (100).

Subsistence Fishing

There is no regular commercial fishing in British Columbia fresh waters. Apart from the take of anadromous fish by the native population, subsistence fishing consists of small-scale netting of some lakes and rivers by local residents. In 1954/55 there were 12 lakes and 3 rivers for which licences were issued and a catch reported. The total catch was estimated as 105,000 pounds (2). Largest poundages were for suckers, carp, kokanee and whitefish, in that order.

British Columbia policy is not to actively promote netting of inland waters, and where nets are used, to avoid their taking trout or salmon as far as possible. Thus no substantial increase in subsistence or commercial fishing is likely in the foreseeable future.

Sport Fishing (see also under "Steelhead Trout")

Present Status

In 1954 there were issued 91,155 resident and 28,495 non-resident sport fishing licences, 119,650 in all. An additional 25,000 residents angled only in tidal waters, where no licence is required (estimate based on a telephone survey by the British Columbia Game Commission). These latter would take such fish as sea-run cutthroat trout, as well as rock fish, sea perch and other marine species.

Creel censuses have been conducted on a few waters: for example, the trout taken annually from Paul Lake (1.5 sq. mi.) weighed 9,200-11,300 pounds during 1933-36, and 11,100 pounds in 1949; the latter quantity is 11.6 pounds per acre (4). A 6-year check of autumn anglers (Sept. 15-Dec. 15, 1949-54) at Cache Creek, when returning south after a fishing or fishing-plus-hunting excursion, showed catches per angler of 12 to 21 fish each, or 6,300 to 11,800 fish in all, almost wholly trout (6). At an average weight of 0.75 pound, this is 9 to 16 pounds per angler. Preliminary records of catch per hour indicate no significant difference in success between autumn and summer fishing, so the very much larger number of anglers who fished during the summer were presumably rewarded equally in proportion to the (much longer) time they spent fishing.

An unofficial estimate of total catch, by the Game Commission, is 7.4 million fish or 5.5 million pounds, and an approximate breakdown is as follows:

	Number	Pounds
Kamloops trout	6,000,000	4,500,000
Other trout	700,000	600,000
Kokanee	500,000	200,000
Others	200,000	200,000
Total	7,400,000	5,500,000

The "other trout" are mainly cutthroat, rainbow and dolly varden; also a few lake trout, eastern speckled trout and brown trout. "Others" include pike, grayling and burbot in the north; the introduced perch, smallmouth bass, largemouth bass, walleye, and a few crappies and sunfish in the south; and rocky mountain whitefish everywhere. The predominance of kamloops trout reflects the fact that it is the only important species, sometimes the only species, inhabiting the productive interior lakes and rivers, where chemical nutrients and fish populations are large (5).

Future Prospects

The present estimated sport catch is 46 pounds per licence. Even if this were to prove somewhat too large an estimate, fishing success would still be very attractive for a predominantly trout fishery. A considerably larger total yield can be taken from waters already accessible, as the number of anglers increases, though catch per angler may decrease somewhat. In addition, many more lakes and rivers will become accessible as time goes on. The present estimated harvest is 0.81 pounds per acre of estimated water surface. This will probably at least double by 1980, and still leave room for considerable increase.

References

(1) Estimates by Dr. C. C. Lindsey of the B. C. Game Commission.

(2) Reports of the B. C. Fisheries Department. Victoria, B. C.

(3) Reports of the B. C. Game Commission. Victoria, B. C.

(4) Larkin, P. A., G. C. Anderson, W. A. Clemens and D. C. G. MacKay, 1950. The production of Kamloops trout (Salmo gairdneri kamloops) in Paul Lake, British Columbia. Sci. Pub. B. C. Game Dept., No. 1, 37 pp.

(5) Northcote, T. G., and P. A. Larkin. 1956. Indices of productivity in British Columbia lakes. J. Fish. Res. Bd. Canada, 13(4) - in press.

(6) Smith, S. B. 1955. Summary of autumn sport-fishing records, 1949-54, from the B. C. Game Commission checking-station at Cache Creek, B. C. British Columbia Game Comm., Management Pub. No. 3, 11 pp.

ALBERTA

Present catch:

Commercial	9,500,000 lb.
Sport	4,800,000 lb.

Catch in 1980:

Commercial	15,000,000 lb.
Sport	10,000,000 lb.

The water area of Alberta is given as 6,485 square miles in the Canada Year Book, and the estimated running water is 1,244 square miles; the total is 8,729 square miles. The largest lakes are Athabaska, Claire and Lesser Slave; these plus 9 others larger than 50 square miles total 2,570 square miles (area in Alberta only).

Commercial Fisheries

History and Present Status

The recent catches are shown in Table A. Commercial fishing was done on 65 lakes in the fiscal year 1954/55. The 1954/55 catches from three individual lakes were as follows:

Lake	Area sq. mi.	Catch lb.	Catch lb./acre
La Biche	94	238,680	3.97
Calling	55	172,476	4.90
Lesser Slave	461	4,903,723	16.6

The Lesser Slave Lake catch, which comprised more than half of the province's total, included tullibee to the extent of two-thirds of its total, the remainder mostly whitefish and pickerel. This high tullibee catch is a result of unrestricted fishing which was designed originally to reduce the abundance of tullibees and hence, it was hoped, of the Triaenophorus parasite of tullibee and whitefish (1). However the lake has been yielding 3 1/2 million pounds of tullibee yearly since 1946/47.

Whitefish production of Pigeon Lake has been discussed by Miller (2). This lake, of 40 square miles, produced an average of 179,000 pounds or 7.0 pounds per acre fairly steadily from 1918 to 1939. An attempt at more intensive utilization subsequently produced an average of 251,000 pounds or 9.8 pounds per acre over 15 years, but with considerable fluctuations because of small year-classes, including two years when fish were quite scarce and fishing was closed.

Not all Alberta lakes are apt to prove as productive as the ones described above. Some lie in the soft-water part of the country, others are so shallow that they are regarded more as wild fowl areas than as fish producers. However the general average for the province would be high.

Table A. Alberta commercial catches for the fiscal year ending March 31: averages to 1950/51 by years thereafter. Unit: thousands of pounds.

	1931/32 -1935/36	1936/37 -1940/41	1941/42 -1945/46	1946/47 -1950/51	1951/52	1952/53	1953/54	1954/55
Whitefish	1,642	2,826	2,499	2,033	2,745	3,113	3,161	3,471
Lake trout	146	51	35	32	8	11	6	35
Pickerel (yellow walleye)	711	486	641	354	224	142	408	719
Pike (Jackfish)	674	754	534	514	513	475	503	395
Perch	60	116	122	113	59	193	151	217
Ciscoes (tullibee)	249	2,357	3,217	4,859	5,004	5,703	5,970	3,992
Suckers, ling, etc.	267	493	181	313	356	298	661	393
Total	3,720	7,084	7,229	8,217	8,910	9,936	10,860	9,222

Future Prospects

Additional commercial production in Alberta will come from increased accessibility of northern and northeastern lakes, and from more intensive fishing of accessible lakes. The latter will mean, principally, increased use of tullibees, ling, suckers and other less-favoured species.

In the prairie provinces and much of northern Ontario ciscoes (tullibee) are not utilized for human food to the extent they could be, because of the occurrence of the tapeworm parasite Triaenophorus (3). Research currently in progress may eventually unearth a means of reducing or eliminating this nuisance, which affects whitefish also; however there is no present indication of success. Meantime many ciscoes are used for mink food.

Sport Fishing

Present Status

In 1955 about 30,000 sport fishing licences were issued to residents and non-residents; however residents require a licence only to fish for trout, grayling and rocky mountain whitefish. The total number of resident anglers is taken as 80,000, and of all anglers as 95,000.

The principal game fish taken are:

Pike or jackfish (Esox)
Pickerel (yellow walleye)
Trout (rainbow, cutthroat, dolly varden, speckled brown)
Perch
Rocky mountain whitefish
Grayling (Thymallus)
Lake trout
Goldeye

No comprehensive creel census information is available, but a catch of 50 pounds per angler would yield 4,800,000 pounds. (N.B. The unofficial estimate received from Alberta was 50,427,000 pounds, of which 40,000,000 pounds were pike; but this seems much too high by comparison with other provinces and by comparison with the commercial yield.)

Future Prospects

Increase in the sport fish yield can be expected, largely from increased use of less-favoured species, and from opening up of unaccessible lakes. Trout production may not increase: more fishing, improved management, and possible increase of fish-culture may not do much more than offset losses from increased use of mountain streams for power developments and for storing irrigation water.

The total yield, sport plus commercial, is probably about 14.5 million pounds per year at present, or 2.6 pounds per acre of water estimated in the province. An increase to 25,000,000 pounds by 1980 seems a conservative estimate, of which about 15,000,000 pounds would be commercially caught.

References

(1) Miller, R. B. 1952. The role of research in fisheries management in the prairie provinces. Canadian Fish Culturist, No. 12, pp. 13-19.

(2) Miller, R. B. 1956. The collapse and recovery of a small whitefish fishery. J. Fish. Res. Bd. Canada, 13(1): 135-146.

(3) Miller, R. B. 1952. A review of the Triaenophorus problem in Canadian lakes. Bull. Fish. Res. Bd. Canada, No. 95, 42 pp.

SASKATCHEWAN

Present catch:

Commercial and subsistence	12,800,000 lb.
Animal food	2,000,000 lb.
Sport fishery	3,600,000 lb.

Catch in 1980:

Commercial and subsistence	20,000,000 lb.
Animal food	up to 10,000,000 lb.
Sport fishery	7,000,000 lb.

Saskatchewan's Canada Year Book water area is 13,725 square miles. Sixteen large lakes, 90 square miles and up, account for 7,730 square miles of this, the largest being Athabaska (2,165 square mi. in Saskatchewan) and Reindeer (2,058 sq. mi. in Saskatchewan). We add only 1,200 square miles of running water, for a total of 15,000, approximately.

While many lakes lie in the Precambrian Shield and so presumably are rather low in productivity, much of Saskatchewan overlies sedimentary rocks and has waters rich in dissolved substances (3).

Saskatchewan's fisheries were recently the subject of a survey by a Royal Commission (4).

Commercial, Subsistence and Fur Farm Fisheries

History and Present Status

Production in recent fiscal years (ending March 31) has been as follows, in thousands of pounds:

	Commercial	Subsistence	Animal food	Total
1939/40-40/41	7,695	2,992	173	10,860
1941/42-45/46	10,101	2,441	271	12,813
1946/47-50/51	8,020	2,361	1,330	11,711
1951/52	11,513	2,525	1,548	15,586
1952/53	10,612	2,650	1,593	14,855
1953/54	8,481	2,426	2,199	13,106
1954/55	10,500	..	..	..

The principal species taken for human use are whitefish, trout, pickerel, pike, ciscoes and suckers. Sturgeon are low in volume but high in value per pound. Species composition of the 1953/54 catch was as follows:

Species	Poundage taken	Lake value	Market value
Whitefish	3,888,802	$303,857.47	$ 689,445.28
Trout	1,207,690	88,528.95	245,035.37
Pickerel	979,601	76,294.28	178,356.19
Pike	869,504	31,064.29	64,371.95
Ciscoes	888,819	26,401.17	53,217.95
Suckers	179,839	1,942.66	5,340.72
Sturgeon	12,269	12,269.00	14,722.80
Others	454,487	13,153.61	30,531.64
Total	8,481,011	$553,511.43	$1,281,021.90

The above catch is taken mainly from lakes, including 16 large lakes (90 sq. mi. and up) and 104 lakes of medium size. Small lakes are not fished commercially. Sturgeon are taken partly in rivers.

The 1954/55 commercial catches per acre have been computed for a number of lakes. "Normal" yield ranges from about 0.6 to 5.5 lb./acre, with an average of about 1.5. The largest is 13.2 lb./acre from Last Mountain Lake, which represents intensive fishing for the purpose of removal of "rough" fish (ciscoes, suckers, redhorses).

Most lakes at present have quotas on commercial production of whitefish, trout and pickerel. Increased utilization in future will consist mainly of (1) production from lakes now too remote from markets; (2) increased use of ciscoes and coarse fish both for mink and for human food. As an example of the potentialities, Churchill Lake (213 sq. mi.) already produces (1954/55) 1.12 lb./acre of fish commercially for human use and 9.2 lb./acre of mink food, plus some sport catch. Nevertheless, it has "a very large resource of ciscoes which is not being used", and "only one-eighth of the shore line is at present being fished for pike" (1). This is probably a richer lake than average. Sustained yield potential at Lac la Ronge (450 sq. mi.) is tentatively estimated as 2 lb./acre, or 600,000 pounds in all (2). Possible production of lake Athabaska has been estimated as at least 1.5 lb./acre or 3,000,000 lb. in all, most of it whitefish (4).

Though some trout, pickerel and pike stocks may be increasingly reserved for anglers, we estimate that improved transportation and more use of less favoured species will increase the commercial plus subsistence yield by 1980 to at least 20,000,000 pounds of human food. The mink-food fishery might take up to 10,000,000 pounds, if mink continue in demand.

Sport Fishing

Present Status

In 1954/55 there were 65,792 resident angling licences and 6,147 non-resident licences issued. Favoured species are pike (jackfish), pickerel (walleye), lake trout and grayling. No province-wide estimates of take have been made, but there have been local creel censuses. Number of anglers and fishing success at Lac la Ronge in 1950-52 was as follows, from (2):

	Anglers	Catch lb.	Catch per angler lb.
1950	3,500	204,000	54.4
1951	5,700	280,000	52.5
1952	6,250	251,000	40.1

Though it is now accessible by road, Lac la Ronge is somewhat remote and presumably provides better than average fishing; on the other hand, some of the anglers above stayed on the lake only a short time. If the province-wide average for a whole year were 50 pounds per angler, the 1954/55 take becomes 3,600,000 pounds.

Future Prospects

Number of licenced anglers is expected to increase steadily, and by 1980 it may be up to 150,000. Fishing success may decline somewhat on individual lakes, but is expected not to fall seriously for the province as a whole. This is because additional lakes and streams will be fished, and because competing commercial fisheries may be curtailed in places. The sport catch in 1980 is estimated to become 7,000,000 pounds, and could go much higher.

The combined sport plus commercial yield predicted for 1980 is 37,000,000 pounds, or about 3.8 pounds per acre.

References

(1) 1955. Annual Report of the Saskatchewan Department of Natural Resources for 1953-54, pp. 109-124. Regina.

(2) Rawson, D. S., and F. M. Atton. 1953. Biological Investigation and fisheries management at Lac la Ronge, Saskatchewan. Saskatchewan Department Natural Resources, 39 pp. Regina.

(3) Rawson, D. S. 1951. The total mineral content of lake waters. Ecology, 32: 667-672.

(4) Report of the Royal Commission on the Fisheries of Saskatchewan. 1947, 131 pp. Regina.

MANITOBA

Present catch:

Commercial	30,400,000 lb.
Sport	3,200,000 lb.

Catch in 1980:

Commercial	45,000,000 lb.
Sport	7,000,000 lb.

Manitoba's freshwater area in the Canada Year Book is 26,789 square miles, but 20,492 sq. miles are included in lakes 50 square miles or greater. Since most of the province lies in the Canadian shield, where small lakes are abundant, we estimate these to be about 10,000 square miles, and add another 1,100 sq. mi. for running water, making nearly 31,000 sq. miles in all.

The three largest lakes--Winnipeg, Winnipegosis and Manitoba, comprising 13,403 square miles, all are fed mainly by rivers high in dissolved solids, which come from agricultural regions characterized by drift overlying sedimentary rocks (2). Hence they are rather fertile and, being shallow also, have supported good fisheries. In the Precambrian area the largest lake is Southern Indian (1,200 sq. mi.); there are four which range between 375 and 560 square miles, about 200 that average 50 square miles, and a multitude of smaller ones. Most of these must tend to be low in nutrients, and hence lower in potential productivity than the big three.

Commercial and Subsistence Fisheries

History and Present Status

About 200 Manitoba lakes are or have been of importance in commercial and subsistence fishing, though less than half of them are fished in any given year. Recent commercial production is shown in Tables A and B. The take has averaged 29 million pounds over the past 25 years, varying from 17 million (1931/32) to 39 million (1940/41). Earlier yields of whitefish are discussed by Bajkov (3). Yield from the big three averaged 2.8 pounds per acre over 4 years, whereas for Southern Indian Lake in northern Manitoba it was 0.8 pounds per acre in 1953/54 (the only year available).

Future Prospects

(a) Big three. The yields of the three largest lakes over 25 years were summarized by Rawson (5), as follows: Lake Winnipeg, 2.66 lb./acre; Lake Winnipegosis, 3.88 lb./acre, and Lake Manitoba, 4.75 lb./acre. These are large yields, but not exceptionally large for fertile shallow lakes. All seem agreed the utilization of "coarse" fish from these and similar (smaller) lakes could be considerably increased, especially of suckers, ciscoes, burbot (maria) and carp. Utilization of burbot for human food requires "only" the overcoming of public prejudice against its appearance. Ciscoes would automatically become more acceptable if their Triaenophorus infestation could be reduced, but that is not yet in sight. Possibly 6 million additional pounds of coarse species will be harvested in 1980.

Table A. Manitoba fish production in thousands of pounds. Data from (1).

Year	Lake Winnipeg	Lake Manitoba	L. Winni-pegosis	Southern Indian L.	Northern[a] lakes	Total
1950/51	18,329	3,209	4,361	..	4,529	31,468
1951/52	18,770	5,080	4,477	..	5,926	35,458
1952/53	16,625	4,448	4,029	..	5,382	31,338
1953/54	11,829	2,769	3,740	604	4,195	23,360
4-yr. av.	16,388	3,876	4,152		5,008	30,406
Area in square miles	9,500	1,817	2,086	1,200	..	..
Lb./mi.^{2} (1953/54)	1,240	1,530	1,790	503	..	..
Lb./acre " "	1.94	2.39	2.80	0.83	..	..
Lb./mi.^{2} (4-yr. av.)	1,730	2,130	1,990	..	..	..
Lb./acre " "	2.70	3.33	3.11	..	..	..

[a]Includes Southern Indian Lake

Table B. Quantity and value of the Manitoba commercial fishery for 1953/54, by species. From (1).

Species	Poundage taken (dressed wt.)	Landed value	Market value
Pickerel (walleye)	9,585,400	$1,444,063	$2,405,731
Whitefish	4,538,900	690,094	1,271,146
Pike	2,813,800	137,173	297,601
Sauger	2,412,800	244,146	414,377
Suckers	1,440,300	18,136	51,681
Tullibee (ciscoes)	867,600	29,565	53,269
Perch	610,200	50,628	93,864
Sheepshead ("bass")	414,000	11,888	32,862
Bullheads	318,900	16,630	62,302
Lake trout	150,600	19,992	43,335
Goldeyes	83,400	15,400	25,318
Sturgeon	45,700	36,560	61,695
Carp	50,100	1,198	2,834
Burbot (maria)	18,200	187	349
Channel catfish	9,300	1,116	1,860

The situation in respect to the favoured species is less clear. In this category we have included goldeye, whitefish, pickerel and sauger. 1. Goldeye, once moderately numerous in the Red River delta area of Lake Winnipeg, are no longer important commercially. 2. Kennedy's (4) review of the Lake Winnipeg whitefish situation suggested that some degree of under-utilization may exist at present, and hence that greater yields would be possible in future. On the other hand, whitefish have almost disappeared from the shallow southern part of Lake Winnipeg, and from Lakes Manitoba and Winnipegosis, where they were formerly abundant--perhaps because they could not stand up to fishing in what seems to be a marginal habitat. 3. The well-adapted yellow pickerel (walleye) and sauger are to-day the major commercial species in all three lakes. On Lake Erie, more intensive fishing harvests a considerably larger poundage per acre of fish of these types. On the other hand, longer winters and cooler summers in Manitoba suggests a smaller rate of basic production than in Lake Erie. For the 1980 prediction, the moderate increase of 2,700,000 pounds of the "favoured" species is postulated.

(b) Smaller lakes. Most of the remaining lakes are in the northern part of the province. The area of those likely to be commercially fished is about 7000 square miles, so the potential commercial and subsistence catch, of all species, would be about 21,000,000 pounds at the rather conservative rate of 3 pounds per acre--as compared with 6,000,000 pounds at present. Better transportation by 1980 will open many of these lakes to fishing, or to more consistent fishing, but their full utilization is unlikely to come within that period. An actual harvest of 12,000,000 pounds may be a good guess for 25 years hence. About two-thirds of it would consist of the currently favoured species mainly lake trout, whitefish and yellow pickerel.

Sport Fishing

Present Status

Angling licences for residents were introduced in Manitoba in 1955, when about 54,000 resident and 10,000 non-resident licences were sold. Species taken include pike, pickerel (walleye), perch, sauger, lake trout, speckled trout, rainbow trout, grayling, goldeye, mooneye, bass, sheepshead, channel catfish and bullhead; rarely whitefish and arctic char. No creel census data are available. Using the 50 pounds per angler basis (see under Saskatchewan) gives a figure of 3,200,000 pounds for the sport catch.

Future Prospects

Number of licenced anglers is expected to at least be doubled by 1980. Their individual fishing success will probably be no less than at present, because of greater accessibility of fishing waters, and greater utilization of species like pike which are not in high favour to-day. The 1980 sport catch is tentatively estimated as 7,000,000 pounds. Sport fishing competes very little with commercial operations, since a great part of it is done on small lakes and rivers where commercial fishermen do not operate.

A summary of the present situation and future expectations is as follows:

	Catch in thousands of lb.	
	Present	1980
Commercial (3 large lakes)		
Favoured species	15,340	18,000
"Coarse" species	9,076	15,000
Commercial (other lakes)		
Favoured species	4,740	8,000
"Coarse" species	1,250	4,000
Sport fishery		
All species	3,200	7,000
Total	33,606	52,000

The total catch predicted for 1980--52 million pounds--is 2.5 pounds per acre of total water surface estimated for the province.

Manitoba's Hudson Bay fisheries and beluga industry are discussed in the "Arctic" section.

References

(1) Annual Reports of the Department of Mines and Natural Resources, Manitoba, for 1951/52 to 1953/54.

(2) Bajkov, A. 1930. Biological conditions of Manitoban lakes. Contr. Canadian Biol. and Fish., 5(12): 381-422.

(3) Bajkov, A. 1930. A study of the whitefish (Coregonus clupeaformis) in Manitoban lakes. Contr. Canadian Biol. and Fish., 5(15): 442-455.

(4) Kennedy, W. A. 1954. Tagging returns, age studies and fluctuations in abundance of Lake Winnipeg whitefish, 1931-1951. J. Fish. Res. Bd. Canada, 11(3): 284-309.

(5) Rawson, D. S. 1952. Mean depth and the fish production of large lakes. Ecology, 33(4): 513-521.

ONTARIO

Present catch:

Commercial	40,000,000 lb.
Sport	10,000,000 lb.

Catch in 1980:

Commercial	50,000,000 lb.
Sport	15,000,000 lb.

Ontario's water area as shown in the Canada Year Book is 49,300 square miles, but this is almost certainly too small a figure for our purposes. The Canadian portions of the Great Lakes (including St. Clair) comprise 33,966 square miles, and there are 25 fairly large lakes, from about 50 to 1,870 square miles, whose combined extent is 6,377 square miles. Lakes between 100 acres and 50 square miles must number at least 50,000, and at an average area of half a square mile would comprise 25,000 square miles. Smaller lakes must comprise at least 5,000 square miles, and if the stream total is estimated as 0.5 per cent of the land area, that adds 2,000 square miles. The total on this basis is about 72,000 square miles, or 17 per cent of the total area of the province. Though this may seem high, there are extensive parts of the province where aerial inspection shows small lakes to be so numerous that there is more water than land on the terrain below.

Commercial Fishing

Total landings for recent years are as follows:

	Av. landings (thousands of pounds)	Value in thousands of dollars	
		Landed	Marketed
1936-40	33,413	2,756	3,245
1941-45	29,846	4,436	5,029
1946-50	30,767	5,565	6,263
1951	30,969	7,035	7,925
1952	38,044	7,417	8,344
1953	44,836	7,027	7,916
1954	47,679	7,013	..

Present landings are apparently about as high as at any earlier time in the history of the province. However there have been considerable variations in the kinds of fish taken, and in the amounts taken from different waters. The 1954 breakdown by species is shown in Table A.

(a) Great Lakes (including St. Clair). Great Lakes fishing has a long history, whose statistics were summarized up to 1940 by an International Board of Enquiry (5). Canadian landings have been summarized to 1953 (6); the 1954 landings are shown in Table A. While the total take from the various lakes has been reasonably stable, the catch of individual species has fluctuated. Catch and catch per

Table A. Statistics of the fishing industry in the public waters of Ontario, for the year ending December 31, 1954. Quantities of fish taken, in pounds; values in thousands of dollars.

	Northern inland waters	Lake Superior	Lake Huron	Lake St. Clair	Lake Erie	Lake Ontario	Southern inland waters	Total	Landed value (thousands of dollars
Sturgeon	79,790	4,643	39,707	10,551	6,856	9,925	20,371	171,843	114
Caviar	816		681	294	87		266	2,144	5
Lake trout	120,093	1,266,237	168,360		13	7,219		1,561,922	515
Whitefish	1,673,795	328,254	4,057,711		556,281	227,599		6,843,640	2,290
Ciscoes	287,492	1,010,939	635,717		280,845	79,966		2,294,959	252
Menominee (round whitefish)		5,643	6,655			405		12,703	1
Gold eyes	87,076							87,076	17
Smelt	5,000	100	7,638		1,265,584	264,601	7,000	1,549,923	92
Perch	8,950	3,455	334,038	23,438	7,748,641	80,425	3,620	8,202,567	653
Yellow pickerel	1,567,580	134,905	383,905	70,935	2,925,004	113,604		5,195,933	1,005
Blue pickerel					8,150,937	58,893		8,209,830	1,231
Saugers	36,631	72,397	2,164	14,203	87,004			212,399	27
White bass	3,628		10,508	24,665	6,152,850	8,085	2,499	6,202,235	373
Sunfish			3,337	35,374	29,743	172,533	135,439	376,426	31
Northern pike	1,008,450	5,023	87,626	18,599	2,736	23,119	2,563	1,148,116	91
Rock bass & crappies	8,583		164	16,580	15,708	18,337	6,499	65,871	7
Sheepshead	37,030		5,407	35,306	773,245	710	1,796	853,494	17
Suckers	679,233	48,645	227,743	137,487	219,911	68,744	102,931	1,484,694	34
Carp	325		120,152	522,788	263,592	308,989	211,941	1,427,787	78
Catfish	6	296	40,769	74,085	172,175	31,940	12,516	331,787	59
Bullheads	87,408		3,031	15,498	194,812	344,132	191,762	836,643	110
Ling	386,452	9,657	14,168	345	13,625		1,981	426,228	2
Eels	4				36	77,676	2,399	80,115	8
Dogfish, gar & alewives	1,851		420	20,442	52,371	17,251	8,233	100,568	2
Total	6,080,193	2,890,194	6,149,901	1,020,590	28,912,056	1,914,153	711,816	47,678,903	
Landed value (thousands of dollars)	789	565	1,822	88	3,407	268	74		7,013

unit of fishing effort show that there has been a tendency for many of the more valuable species to decrease in abundance. For example, the Atlantic salmon of Lake Ontario was exterminated by about 1870. In Lake Erie, sturgeon and muskellunge practically disappeared from the catches early in the present century, the northern pike and the never-abundant lake trout followed them during the 1920's, and to-day ciscoes have reached a very low ebb. The catch has been maintained mostly by spiny rayed species like perch, yellow pickerel, blue pickerel and white bass.

Has the abundance of these latter species actually increased, or are they merely better utilized since the formerly abundant species declined? What share of responsibility for the shift in species caught should be assigned to selective fishing, what share to climatic change, and what share to increased sediment and nutrients from intensified agriculture and from urban sewage? These are questions on which varying opinions exist.

Two newcomers have profoundly affected some Great Lakes fisheries. The smelt has recently become a fairly important commercial species, especially in Lakes Erie and Huron. The "sea" lamprey, which ascended above Niagara in the 1920's, became abundant in Lake Huron during the late 1930's and early 1940's, and is now invading Lake Superior. Its arrival has been followed by collapse of lake trout fisheries everywhere, and in some cases by increases in deepwater "chubs" on which the trout feed. The lamprey attacks other fish besides trout, but its effects on them are less easy to assess. A decrease in Lake Huron whitefish production during the 1940's might possible be connected with lampreys, but it was followed by an increase: the Georgian Bay whitefish catch rose from a few hundred thousand pounds per year up to 7 million pounds in 1953 and 4 million in 1954.

Fish productions of large lakes have been considered in relation to their area and depth, by Rawson (7). Gross production of the Canadian portions of the Great Lakes is related to their area as follows:

Lake	Area square miles	Canadian catch in 1954 Thousands of pounds	Lb. per sq. mi.	Lb. per acre	25-year average (whole lake, from (7)) lb./acre
Superior	11,200	2,890	258	0.40	0.83
Huron	13,675	6,150	450	0.70	1.38
St. Clair	270	1,021	3,780	5.92	5.72
Erie	5,094	28,912	5,670	8.86	7.30
Ontario	3,727	1,914	513	0.80	0.99

The superior productions of Erie and St. Clair are presumably mainly a result of their shallowness or high temperature, or both; since Lake Ontario, with water of much the same mineral content, produces far less. Lake Superior water has a lower mineral content than the lower lakes, is deeper, and is more difficult to fish.

(b) Other lakes. Other lakes commercially fished are divided in Table A into a northern and a southern group, the latter having much less area and production, though probably a greater yield per square mile. However commercial fishing in the north is often restricted by inaccessibility of the lakes, and in both regions by a desire to minimize competition with sport fishermen.

Separate 1954 productions for a few of the larger "inland" lakes are as follows:

Lake	Area (in Ontario only) square miles	Catch in 1954 Thousands of pounds	Lb. per sq. mi.	Lb. per acre
Nipissing	330	110	332	0.52
Nipigon	1,870	715	383	0.60
Seul	416	467	1,123	1.76
Rainy	292	889	3,050	4.76
Mille Lacs	102	76	743	1.16
Lake of the Woods	1,127	1,632	1,458	2.26
Sand and Finger	270	76	282	0.44

Future Prospects

A rather conservative prediction for overall landings in 1980 is perhaps 50 million pounds--a quarter larger than the 1951-54 average of 40 million pounds. The increase might stem partly from increased fishing in the less accessible northern lakes (perhaps 2,000,000 lb.), partly from international cooperation in management of the Great Lakes (3,000,000 lb.), and partly from increased utilization of less desirable or unused species (e.g., gizzard shad), especially on Lake Erie (5,000,000 lb.).

The influence of possible international regulation upon the Great Lakes fisheries may prove to be not so much an increase in total yield, as a shift back to greater landings of the more favoured species. Success in lamprey control should permit trout production in the upper lakes to return to the level of (say) the 1930's, while selective management may permit greater yields of whitefish in all lakes.

Sport Fishing

Present Status

Ontario non-resident angling licences numbered 366,150 in 1954, and an estimate of the number of resident anglers over 18 years of age is 400,000-500,000 total anglers, about 800,000.

Only a few local creel censuses have been published for Ontario. Yearly take of speckled trout in a series of 4 hard-water ponds (8.1 acres in all) in 1922-31 averaged 1,112 fish, or possibly 370 pounds, which comes to 4.6 pounds per acre (8). Fry (2) gives statistics of the lake trout catch in Lake Opeongo (20.1 square miles) for the years 1936-47, showing an average catch of 1,425 fish or 4,170 pounds, which is 0.3 pound per acre. For smaller Algonquin Park lakes, trout yields of 1.3-2.8 pounds per acre are given (4). Another lake trout harvest, for South Bay, Manitoulin Island, gave an average catch of 1,350 trout for 1948-49 (3). At an estimated 3 pounds average weight, this is 4,050 pounds or 0.21 pound per acre. However this census occurred after the sea lamprey had damaged the Lake Huron trout fishery; lamprey activities were evident in South Bay during the above years, and subsequently its trout fishery collapsed. The smallmouth bass taken in the same bay averaged 1,680 pounds per year during 1947-52, or 0.09 pound per acre (1).

Though the censuses above usually suggest rather small harvest per unit area, most of them include only the larger and more prized fishes in the waters concerned. None of the good pickerel or pike fishing waters of the province have been censused.

The estimated yields given below are based on unofficial estimates from Ontario, but are considerably increased in categories other than trout and various rare species. (The figures as submitted come to 3.8 million pounds for major game species, say 5 million in all, or only 6 pounds per angler: this seems too low for catches consisting predominantly of warm-water species. In fact, our augmented estimates may still be too low.)

	Estimated numbers	Catch pounds
Speckled trout	500,000	200,000
Rainbow and kamloops trout	15,000	8,000
Brown trout	5,000	3,000
Lake trout	25,000	100,000
Smallmouth bass	500,000	1,000,000
Largemouth bass	10,000	25,000
Yellow pickerel	3,000,000	6,000,000
Blue pickerel	30,000	25,000
Maskinonge	5,000	75,000
Pike (northern pike)	500,000	1,500,000
Whitefish	20,000	40,000
Ciscoes	100,000	40,000
Smelt	2,000,000	400,000
Perch	1,000,000	250,000
Others[a]	1,000,000	500,000
Total	8,710,000	10,166,000

[a]Includes rock bass, pumpkinseed sunfish, bullheads, channel catfish, sheepshead, white bass, carp, suckers, etc.

The total poundage above comes to about 13 pounds for each of the estimated 800,000 anglers. This is a much lower figure than the 50 pounds per licenced angler used for the prairie provinces. Western fishing is probably better because of the sparser population, and non-residents who travel long distances from United States centers of population to fish in northern Saskatchewan or Manitoba probably angle more assiduously than the very much larger number who are guests of nearby Ontario. Nevertheless, we would be prepared to find that better methods of estimation would show a smaller difference in individual return.

Future Prospects

There is little question that the number of anglers in Ontario will increase, possibly to 1,200,000 by 1980. The catch per angler may fall somewhat, but not seriously, with the increased fishing pressure. Estimating the 1980 take as 12.5 pounds per angler gives a total sport catch of 15,000,000 pounds.

The combined estimate of 65 million pounds of fish taken by all methods in 1980 is 1.4 lb. per acre of estimated water surface.

References

(1) Fraser, J.M. 1955. The smallmouth bass fishery of South Bay, Lake Huron. J. Fish. Res. Bd. Canada, 12(1): 147-177.

(2) Fry, F.E.J. 1949. Statistics of a lake trout fishery. Biometrics, 5(1): 27-67.

(3) Fry, F.E.J. 1953. The 1944 year-class of lake trout in South Bay, Lake Huron. Trans. Amer. Fish. Soc. for 1952, 82: 178-192.

(4) Fry, F.E.J. 1939. A comparative study of lake trout fisheries in Algonquin Park, Ontario. Univ. Toronto Stud., Biol. Ser. No. 46, pp. 1-69. (Pub. Ontario Fish. Res. Lab., No. 58.)

(5) Report and supplement, International Board of Enquiry for the Great Lakes fisheries. U.S. Govt. Printing Office, 1943, 213 pp.

(6) Anon. 1955. The Canadian commercial fisheries of the Great Lakes. Canada. Department of Fisheries, Markets and Economics Service, Basebook on Fishery Statistics, No. 2, 221 pp.

(7) Rawson, D.S. 1952. Mean depth and the fish production of large lakes. Ecology, 33(4): 513-522.

(8) Ricker, W. E. 1932. Trout-producing lakes and ponds. Univ. Toronto Stud. Biol., No. 36, pp. 111-167. (Pub. Ontario Fish. Res. Lab., No. 45.)

QUEBEC

Present catch:

Commercial	3,000,000 lb.
Sport	4,300,000 lb.

Catch in 1980:

Commercial	3,000,000 lb.
Sport	12,000,000 lb.

The Canada Year Book's freshwater area of Quebec is 71,000 square miles, out of a total of 594,860 square miles. Thirty-seven large lakes (50 sq. mi. and up) account for 5,900 square miles of water. The largest is Mistassini, with 840 square miles. Most of the water area consists of medium and small lakes, which are very numerous because most of Quebec lies on the Laurentian shield. Adding 2,600 square miles of running water brings the total close to 74,000 square miles. Even though nearly all lakes are in the Precambrian area and hence poor in nutrients, much greater utilization would be possible if better transportation were available. Lakes and rivers out of reach of road or railway can support fisheries only for high-priced species, especially sturgeon.

The St. Lawrence River and associated lakes (St. Francis, St. Louis, St. Peter) are exceptions to the above; they have a high mineral content and, being shallow, have a potential productivity somewhat similar to Lake Erie. There is however a region of pollution below the city of Montreal.

Commercial Fishing

Commercial fishing is carried on in most counties, in the larger lakes and in the St. Lawrence River. Recent total landings and values are given as follows:

	Landings in pounds	Landed value
1936-40	7,640,000	$513,000
1941-45	5,426,000	403,000
1946-50	3,146,000	401,000
1951	2,911,000	505,000
1952	3,043,000	449,000
1953	3,324,000	534,000

The above figures are from the 1955 Canadian Fisheries Annual. A breakdown by species for "interior waters", supplied by the Quebec Department of Fish and Game, includes some anadromous species, but shows a smaller total than those just quoted:

English name	French name	Landings in thousands of pounds 1952	1953	1954
Shad, alewives	Alose	34	19	25
Eel	Anguille	54	91	94
White bass	Bar	5	4	2
Pike	Brochet	131	155	107
Carp, buffalo, redhorses, suckers	Carpe	295	345	317
Pickerel or walleye (including sauger)	Doré	197	220	171
Smelt	Eperlan	2	9	...
Sturgeon	Esturgeon	97	194	157
Whitefish, ciscoes	Poisson blanc	40	30	14
Bullheads, catfish	Barbotte	403	351	322
Sunfishes, rock bass, crappies	Crapet	70	114	58
Perch	Perchaude	161	170	130
?	Vairons	189	245	213
Others	Divers	23	59	20
Total	Total	1699	2008	1628

In the future, freshwater commercial fishing in Quebec will probably not change greatly in total poundage taken. New fisheries may be established, or old ones intensified, as interior lakes become more accessible. However there will probably also be some tendency to restrict netting in favour of sport fishing. For the 1980 yield we estimate 2,000,000 pounds (Department of Fisheries basis) or 3,300,000 pounds (Fisheries Annual basis).

Sport Fishing (other than for Sea-Run Salmon)

Quebec issued 171,351 resident fishing licences in 1954, also 44,170 for non-residents, 215,521 in all. As no creel-censuses are available, we have estimated the catch as 20 pounds per angler, or about 4,300,000 pounds in all.

The more favored kinds of fish taken, more or less in order of importance, are:

Speckled trout
Smallmouth bass
Yellow walleye
Pike
Lake trout
Rainbow trout
Maskinonge
Landlocked salmon
Brown trout
Quebec red trout

Sea-run Atlantic salmon taken by sportsmen are treated elsewhere. Other species taken on a sporting or semi-subsistence basis include suckers, carp, sunfish, crappies.

Future prospects are that sport fishing will increase, possibly to 3 times the present number of fishermen by 1980. Catch per fisherman should not change significantly, as many new waters will become accessible and more attention will be given to the less valued species. A sport catch of 12 million pounds in 1980 is predicted.

Even by 1980, many or even most Quebec waters are likely to be fished lightly or not at all. The total estimated yield--commercial plus sport--in 1980 is about 15 million pounds, as compared with a water area of 74,000 square miles: this is an overall yield of only 0.3 pound per acre, and indicates the possibilities of further expansion.

NEW BRUNSWICK, NOVA SCOTIA and PRINCE EDWARD ISLAND

Present catch (anadromous salmon excluded):

Sport fishing	427,000 lb.

Catch in 1980:

Sport fishing	770,000 lb.

A summary of freshwater areas in the three provinces is as follows, in square miles:

	N.B.	N.S.	P.E.I.
"Year-book" water area	512	325	0
Estimated lake and pond area	512	500	2
Estimated stream area	140	106	11
Total estimated water area	652	606	35

New Brunswick's largest lakes are Grand (65 sq. mi.), Northwest Oromocto (16 sq. mi.) and Magaguadavic (11 sq. mi.). It has an additional 332 lakes larger than about 100 acres, and possibly 1,000 smaller. Nova Scotia's Bras d'Or Lakes (360 sq. mi.) are tidal and fairly salt, so are not included in the fresh waters. It has about 3,000 smaller lakes. There are few or no natural lakes or ponds on Prince Edward Island, but a number of mill ponds and fishing ponds have been constructed.

The waters of the three provinces divide rather sharply into two types. Soft waters draining from poor soils over hard rock formation occupy southwestern and central New Brunswick, and the western part of Nova Scotia. These are the principal lake districts. Elsewhere there are hard waters from sedimentary rocks and usually richer soils, especially along the Gulf of St. Lawrence coast and in Prince Edward Island. In these areas stream productivity is much greater, as is that of lakes insofar as they occur.

Commercial Fishing

Nova Scotia and Prince Edward Island apparently have no commercial freshwater fisheries. New Brunswick has a catch listed in the Canadian Fisheries Annual, as follows:

	Catch in pounds	Landed value
1936-40	603,000	$ 25,000
1941-45	652,000	29,000
1946-50	649,000	36,000
1951	1,629,000	62,000
1952	3,193,000	93,000
1953	8,655,000	146,000

No information on the species involved is at hand; possibly they are anadromous forms that have been considered elsewhere.

Freshwater Sport Fishing (other than for Sea-Run Salmon)

Present Status

In 1954 New Brunswick had 5,366 non-resident licenced anglers and an estimated 50,000 resident anglers over 18 years old. In Nova Scotia the figures are 1,653 non-resident and an estimate of 60,000 resident. In Prince Edward Island 10,000 resident anglers are estimated. The estimated catch of various fish in 1954 is shown in Table A.

Table A. Estimated catches of Maritime Provinces freshwater sport fishing, other than for anadromous salmon (from Department of Fisheries, Halifax Office).

	New Brunswick		Nova Scotia		Prince Edward Island	
	No.	Pounds	No.	Pounds	No.	Pounds
Speckled trout (Salvelinus fontinalis)	455,000	175,000	250,000	135,000	65,000	21,720
Rainbow trout (Salmo gairdneri)	1,600	610	1,390	2,140	600	200
Brown trout (Salmo trutta)	2,100	970	1,740	3,560	0	0
Lake trout (togue) (Salvelinus namaycush)	45	102	790	1,840	0	0
Landlocked salmon (Salmon salar)	1,000	2,000	1,000	2,000	0	0
Smallmouth bass (Micropterus salmoides)	10,050	22,200	330	640	0	0
Total		201,000		165,000		22,000

Another estimator puts the Prince Edward Island trout catch much higher: 300,000 trout weighing 60,000 pounds. We have used the latter figure, since it amounts to only 3.3 pounds per acre if our water area estimate is at all reasonable, and Prince Edward Island trout waters are among the most productive anywhere. In Nova Scotia there are also some striped bass caught in fresh water, especially in the Shubenacadie River system (2).

Other species taken in one or both of the mainland provinces include white perch (Morone americana), yellow perch (Perca flavescens), arctic char (Salvelinus alpinus), chain pickerel (Esox niger), pumpkinseed sunfish (Lepomis gibbosus).

Some of these species are abundant and could support large fisheries, especially white and yellow perch. The yellow walleye, sauger and northern pike are also known from New Brunswick (1).

The present estimated catch is 3.4 pounds per estimated angler, but of course salmon add considerably to the total sport-fish take. Even so, the yield is low; it reflects mainly the scarcity of warm-water fishes and the preoccupation with trout.

Future Prospects

1. In the soft-water region, the yield of trout from lakes under natural conditions is usually low--1 or 2 pounds per acre--though considerable increases are possible using a combination of artificial stocking, fertilization and predator control (3). Poisoning of the shallows has also been used experimentally to increase trout production (4).

Another development which may increase trout stocks and catches considerably, especially on large rivers like the Miramichi, is the increased use of merganser control as a means of improving salmon production. This has been shown to increase stocks of trout and other fish, as well as the output of salmon smolts.

Over the next 25 years, increase in game fish utilization will come from some extension of methods such as are outlined above, also from introduction of smallmouth bass to waters marginal for trout, from greater utilization of less favored species like perch, and from greater accessibility of some lakes. Little increase is expected in the catch of lake trout, landlocked salmon, or arctic char.

2. In hard-water areas, characterized by few lakes and mostly stream fishing, considerable increase in the speckled trout harvest is possible. This is especially true of Prince Edward Island, where not only are stream-raised fish available, but there are large sea-run specimens which spend the summer in creeks while ocean temperatures are high (5). Small fishing ponds are increasingly being built on Prince Edward Island streams, and are very productive of trout: 22-44 pounds per acre per year were taken over 8 years from a representative 23-acre pond (6).

The rainbow trout, which is increasing in Prince Edward Island, may partially or wholly replace speckled trout in some streams.

A summary of possible 1980 catches of the more important species in the three provinces is as follows:

	Soft-water areas	Hard-water areas	Total
	lb.	lb.	lb.
Speckled trout	150,000	500,000	700,000
Rainbow trout	0	5,000	5,000
Other trout and landlocked salmon	12,000	1,000	13,000
Smallmouth bass	35,000	0	35,000
Others	50,000	20,000	70,000
Total	247,000	526,000	773,000

This total is 1.6 pounds per acre, as compared with the estimated 0.5 pound per acre at present.

References

(1) Scott, W. B. 1954. Freshwater fishes of eastern Canada. Univ. of Toronto Press, Toronto.

(2) Vladykov, V. D., and R. A. McKenzie. 1935. The marine fishes of Nova Scotia. Proc. Nova Scotia Inst. Sci., 19(1): 17-113.

(3) Smith, M. W. 1955. Fertilization and predator control to improve trout angling in natural lakes. J. Fish. Res. Bd. Canada, 12(2): 210-237.

(4) Hayes, F. R., and D. A. Livingstone. 1955. The trout population of a Nova Scotia lake as affected by habitable water, poisoning of the shallows and stocking. J. Fish. Res. Bd. Canada, 12(4): 618-635.

(5) Saunders, J. W., and M. W. Smith. 1955. Standing crops of trout in a small Prince Edward Island stream. Canadian Fish Culturist, No. 17, pp. 32-39.

(6) Smith, M. W. 1951. The speckled trout fishery of Prince Edward Island. Canadian Fish Culturist, No. 11, pp. 1-6.

NEWFOUNDLAND

Present yield (excluding sea-run salmon and arctic char):

Island	250,000 lb.
Labrador	1,000 lb.

Yield in 1980:

Island	1,000,000 lb.
Labrador	100,000 lb.

The Canada Year Book gives 5,721 square miles as the water area of the Island of Newfoundland; to which we add 185 square miles (0.5% of the land area) for streams, or 5,906 square miles in all. No estimate is given of the water included in the (much larger) expanse of the Newfoundland Labrador: 10,000 square miles does not seem extravagant (about 1/11 of its total area).

There are no freshwater commercial fisheries in Newfoundland, though small subsistence fisheries exist along the Labrador coast and in remote areas generally.

Sport Fishing (other than for Anadromous Salmon)

Present Status

The sport fishing most in the public eye--for sea-run salmon--is treated separately. A few landlocked salmon are taken, but the great bulk of the remaining sport fishing is for trout (Salvelinus fontinalis). No resident licence is required for trout. About 25,000 anglers older than 18 years is estimated, and there were 268 non-resident licenced trout anglers in 1954.

The trout catch is estimated as about 250,000 pounds, or 10 pounds per adult angler. A few streams on the Avalon Peninsula have brown trout, which are at least partly anadromous. However the brown trout catch is inconsequential. Rainbow trout occur rarely. Lake salmon are much less common than trout.

Future Prospects

Restricted communications are the principal limiting factor in holding catches to present levels. Improvements over 25 years will probably raise the catch to 1,000,000 pounds on the island, which is 0.25 pounds per acre of water--still a very low figure. Labrador development will presumably come more slowly, and emphasis will for long be on salmon fishing. Up to 100,000 pounds of trout per year is predicted for the Labrador in 1980.

YUKON, MACKENZIE, KEEWATIN and FRANKLIN

Present catches:

Subsistence	11,000,000 lb.
Commercial	9,000,000 lb.
Sport	20,000 lb.

Catch in 1980:

Subsistence	13,000,000 lb.
Commercial	12,000,000 lb.
Sport	500,000 lb.

The Canada Year-Book's freshwater area for the above is 53,195 square miles, most of it in Mackenzie. The largest lakes are Great Bear (12,000 sq. mi.) and Great Slave (11,170 sq. mi.). The total of these and 33 other lakes (nearly all over 100 sq. mi.) is 33,882 square miles.

Best information on arctic fresh waters in general is given in the report of surveys conducted by the Fisheries Research Board in 1944-45 (1).

Subsistence, Dog-food and Fur-Farm Fishing

The line between subsistence and commercial fishing cannot be too sharply drawn, but the former is the prevailing type in the north.

Yukon. In 1945 most fishing was done in the larger lakes: Teslin, Tagish, Marsh, Lebarge, Ethel, Tatlmain, Kathleen, Dezadeash and Kluane (1). Formerly (1925-35) there were many fur ranches, which used "some thousands of pounds a week" of fish, but most of these closed down when fish became scarcer (prior to 1945). The 1945 estimated subsistence catch included only 10,000 pounds of freshwater species, but this may be low. The total was as follows:

Chinook (king) salmon	25,000 lb.
Chum (dog) salmon	10,000
Other salmon	10,000
Whitefish	4,000
Cisco	4,000
Others	2,000

Mackenzie. Estimates of subsistence catch are as follows, in pounds round weight:

	Mackenzie River-1944	Great Bear Lake-1945	Great Slave Lake (1954-55)	Elsewhere
Whitefish	2,000,000	1,700,000	400,000	2,500,000
Cisco	1,000,000	300,000	2,000	...
Inconnu	500,000	few	50,000	...
Trout	few	200,000	10,000	...
Pike	500,000	few	150,000	...
Others	500,000	10,000	3,000	...
Not classified	...	...	...	1,500,000
Total	4,500,000	2,210,000	615,000	3,000,000

Keewatin and Franklin. Subsistence fishing in Keewatin probably takes at least 1,000,000 pounds per year, but no definite information is available. The inland waters of Franklin are fished locally by Eskimos, but only in very few places.

Commercial Fishing

The principal commercial fishery in the north is in Great Slave Lake. It began in 1945, and has been studied continuously (3). Catches have been as follows, in thousands of pounds round weight:

	Trout	Whitefish	Others
1945	1065	502	..
1946	1617	1255	..
1947	1665	1984	..
1948	2187	4831	..
1949	4015	5430	..
1950	2546	5737	..
1951	2769	4208	..
1952	3274	3993	..
1953	2434	3352	..
1954	2389	4490	2030
Av.	2396	3578	1290
Lb./mi.^{2}/yr.	229	343	123

"Others" in 1954 included: inconnu (335,000 lb.), cisco (381,000 lb.), burbot (734,000 lb.), pike (135,000 lb.), suckers (435,000 lb.), walleye (9,000 lb.) and grayling (1,000 lb.). However not much fish of these species is actually sold.

The 10-year average catch per acre has been 0.36 pound of trout, 0.54 pound of whitefish and 0.09 pound of other species. Total yield in recent years (1951-54), including about 600,000 pounds subsistence catch, is close to 8.7 million pounds, or 1.19 pounds per acre.

The lake is still in an early stage of exploitation, in the sense that the trout and whitefish taken to date are almost all from year-classes spawned before the commercial fishery started. It is still too soon to have information on possible change in the recruitment, but most of the trout and whitefish eggs have always been produced by fish smaller than present commercial sizes (4, 5), hence spawning has been little affected. Growth rates show little change.

Commercial fisheries on a much smaller scale exist in four lakes, whose 1955 catches were, in pounds round weight:

Lake	Trout	Whitefish	Walleye
Kakisa	0	0	30,000
McDonald	9,648	29,100	0
Nonacho	1,760	2,960	0
Thuban	18,086	32,704	0

Outside the district of Mackenzie, the only true commercial production has been from Nueltin Lake, on the Keewatin-Manitoba border, where 8,300 pounds of trout and whitefish were shipped in 1950.

Future Prospects

Obviously there is a large unused fish potential in the north, but it lies mostly in inaccessible places, and development of communications is bound to be slow.

Great Slave Lake's present yield is good for a cool northern body of water, even one with a fairly high mineral content. A cautious policy is likely to permit a slow increase in yield. The fish must remain abundant enough to be caught easily, so that transportation charges on the long haul to market can be met; hence the practicable yield may be considerably less than what is biologically possible. With this in mind, we predict only a small increase, to 12,000,000 pounds per year of all species in 1980.

Great Bear Lake is very poor in nutrients and the present subsistence fishery may not be too far from maximum sustained yield (1). We estimate 3,000,000 pounds a year in 1980. The upper Mackenzie River fisheries also seem relatively well developed. Downriver, considerable expansion may be possible, but probably mainly for local use because of remoteness.

Lakes not now fished for export may provide up to 3 million extra pounds per year by 1980, but this would depend on their being made accessible by roads built primarily for other commercial development. The potential supply is much greater.

Sport Fishing

Sport fishing licences sold in the northwest territories are only a few hundred a year, and catches may be no more than 20,000 pounds per year. However sport and "subsistence" fishing grade into one another. Favoured species are lake trout, walleye, grayling and arctic char.

A very considerable increase in sport fishing, by tourists and others, should occur by 1980, but the total take will probably be less than 500,000 pounds.

References

(1) Various authors. 1947. Northwest Canadian fisheries surveys. Bull. Fish. Res. Bd. Canada, No. 72, 94 pp.

(2) Wynne-Edwards, V. C. 1952. Freshwater vertebrates of the Arctic and Subarctic. Bull. Fish. Res. Bd. Canada, No. 94, 28 pp.

(3) Kennedy, W. A. MS, 1956. The first ten years of fishing on Great Slave Lake. To be published as a Bulletin by the Fisheries Research Board of Canada.

(4) Kennedy, W. A. 1953. Growth, maturity, fecundity and mortality in the relatively unexploited whitefish, Coregonus clupeaformis, of Great Slave Lake. J. Fish. Res. Bd. Canada, 10: 413-441.

A copy should go into the Royal Commission Report as an unofficial appendix. (in the library).

D.E.S. January, 1959.

Northern Affairs request about sea mammals

I am answering this request as if it were phrased more or less so: "What increase in utilisation can be expected from the various species of sea mammals in the next 10 years, so as to produce a yield sustained in perpetuo at this level of hunting". This presupposes not only a knowledge of stocks, but also some idea of what exploitation is intended. I think we have improved ideas on both points since 1955, but we can still use the Royal Commission Report on Canada's Economic Future, which demanded prophecy up to 1980 (or for 25 years) as a basis.

A.W.M.

Atlantic walrus

The first six lines of the R.C. report can stand. I would amend the remainder as follows: On present results the northern Hudson Bay stock is estimated at about 3000 animals. The average annual kill in this area is about 200 animals and this appears to be a full utilisation. In Foxe Basin, the reproductive potential appears to be much greater in spite of an average annual kill of 400, and the herds there are probably in no danger of depletion at the present level of hunting. There is little utilisation of the stocks on the Canadian side in northern Baffin Bay, Lancaster and Jones sounds and Davis Strait, and the annual kill probably could be considerably enlarged. However all these areas act as natural reservoirs for the species, and in time surplus populations will develop. Then the walrus may become re-established over much of its former range. No great increase over the average annual Canadian kill of 1600 animals should be contemplated if the stocks are to increase.

As the initial step in any program of walrus management, the natives should be educated in better hunting practices, since wastage in some areas is high.

DES

Ringed Seal

In I. A. McLaren's absence, I would think his summary in the R. C. Report still holds, and is well amplified by his new Circular on "the Economics of Seals in the eastern Canadian Arctic". N'n Affairs should be directed to the summary of this Circular (pp. 1-3) and to the worked examples (pp. 76-83) if they are too busy to read the whole report.

We should also direct our thinking and perhaps that of our Department to the question of obtaining more accurate statistics of kill of ringed seals. RCMP game reports should be a good start. Perhaps I. A. McLaren could work at this in the spring and indicate area by area what in all probability is the catch level in relation to the order of stock size.

DES

Bearded seal

The R. C. Report had nothing on this species. My second paragraph above holds true here too. In the report I. A. McLaren suggests that the total stock of Dojuk in the Eastern Canadian Arctic might be 185,000 animals. What is the order of catch, overall? In what areas is the catch probably at a maximum? negligible?

DES

White whale

The catch at Churchill has not increased since 1955 (1956- 421 animals, 1957- 517, 1958- 338 up to Aug. 26, final statistics not yet available). I think that unless capital is ploughed in to enlarge and modernise the factory, few more whales could be caught, because production is limited by the 2 month season (if 30 or more whales are caught in a day, there is a glut). Hence I do not expect an increase, and if it should occur the 800 (?900) whale quota already limits it.

At the Tha-Anne River, Edwards' report (Arctic Division, Dec. 1958) indicates that few more whales could be taken than the present level of 65 (1957) or 43 (1958) because this type of small estuary is too rocky and tidal for easy boat operation.

There should thus be considerable room for further exploitation around Tavani, if that is what N'n Affairs envisages. We should have enough knowledge to advise on a total take for W'n Hudson Bay in a year or two, assuming that this is a distinct population (which the small size of the animals suggests). We expect to gain information on numbers from our aerial survey this summer, and on local movements etc. from the projected visit of the "Calanus" to this area in 1960.

All that I can say about the stocks of white whales in Baffin Bay, Lancaster Sound and Smith Sound is that they are probably large and presently almost unexploited. They are reinforced by stocks of narwhals which penetrate somewhat further to the north and west.

As to exploitation of the small whales, I think that the Churchill factory, tho' its machinery is outdated, is well laid out and could profitably be closely examined if there is any thought of industrial hunting (with dried meat meal or refrigerated meat as a product) elsewhere. The small whalers now operated by the Dept. of Fisheries and Co-operatives of the Province of Newfoundland might also be examined. It seems to me unlikely that hand harpooning from canoes or Peterheads, or netting, could catch enough small whales for an industrial fishery. The use of harpoon guns from a relatively fast boat, such as a well powered Peterhead or a Norwegian type small catcher might, however, just be warranted for beluga where found in good numbers. More important, development of a small whaling factory supplied by powered catchers would be essential for re-opening the catching of:

Bowhead or Greenland Whale

Reports of this species in the western arctic are now so numerous that thoughts of a fishery seem in order. There is no point in suggesting a detailed survey by us as the Bowhead is too oceanic a species to be counted, except possibly where it passes close between ice and shore at Point Barrow, but this is in Alaska of course. We might just as well recommend N'n Affairs to try out an industrial hunt with small whale catchers, keeping statistics for our Dept. and letting us examine the catch. But International whaling Regulations would have to be changed if anything more is contemplated than native hunting and locally used products. This would be for the Dept. of Fisheries to take action for Canada.

In the Eastern Arctic, Greenland whales seem to be recovering more slowly, with most frequent reports from Cumberland Sound.