

# FISHERIES RESEARCH BOARD OF CANADA

Biological Station  
St. John's, Newfoundland

ANNUAL REPORT  
and  
INVESTIGATORS' SUMMARIES  
1971

W. TEMPLEMAN, Director



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## INTRODUCTION

The St. John's Biological Station's principal program of research is on the ecology and population dynamics of stocks in the Northwest Atlantic which are currently or potentially important to our national fisheries, particularly the fisheries of Newfoundland and Labrador.

During 1971 investigations on demersal species were directed to assessment of the status of principal commercial stocks. Species studied included cod, haddock, American plaice, yellowtail flounder, and Greenland halibut.

Herring is the most important of the pelagic species in the Newfoundland area, and the main research emphasis was on the identification of stocks which frequent Newfoundland coastal waters, particularly in southwestern Newfoundland. Limited studies were carried out on mackerel, capelin and launce.

The emphasis in anadromous fish studies was on various techniques for identification of the origin of mixed stocks of Atlantic salmon in the sea. Also, biological data were collected from the Newfoundland and Labrador commercial coastal fisheries for use in studies of the effects of distant fisheries on our national fisheries and spawning escapements. Research on the pink salmon transplant continued at a minimal level.

The principal invertebrate species studied in 1971 were lobster, snow crab, shrimp, and squid. The main emphasis on lobsters was on behaviour, productivity, and ecology. The effort in snow crab research was mainly on evaluation of different methods to obtain good estimates of abundance. Investigations on squid were directed to stock identity, mortality, growth, and migration of juveniles to our shores, and adults to the spawning grounds. The abundance of intertidal clams in northwestern Newfoundland was assessed. Spat of the European oyster were transferred to Newfoundland to begin an assessment of the suitability of the species for introduction on a commercial scale.

Limited hydrographic studies were continued, particularly on the strength of the Labrador Current in the area, measuring water temperatures and salinities.

Technological studies were concerned principally with the quality, storage life, and processing of marine fish, and exploratory research into marine carbohydrates.

For studies at sea three Fisheries Research Board vessels were used: the *A. T. Cameron* for work on groundfish, salmon, and snow crab; the *E. E. Prince* on herring and squid; the *Marinus* on groundfish, salmon, herring, shrimp and snow crab. Also, the Fisheries Service patrol vessel *Cape Freels* was made available by the Regional Director (Operations) in the Newfoundland area for hydrographic cruises (see Appendix 1).

Observations on the fisheries in the inshore region were carried out by staff of all the research divisions in many Newfoundland coastal areas and on Labrador.

In the conduct of various research projects we have been grateful for the assistance given the Station staff by fishermen, captains, processing plant personnel and managers. Various officers of Fisheries Service (Operations) have given valued assistance in many phases of our work.

The Station contributed to Canada's international fisheries work through participation of staff in the annual meetings of the International Council for Exploration of the Sea in Helsinki, Finland, and of the International Commission for the Northwest Atlantic Fisheries at Halifax, N.S. Research documents were presented to the meetings and staff participated in the work of subcommittees and were advisers to the Canadian delegates.

We were pleased to be able to accommodate visitors on various research vessel cruises: observers from the Programme Intégré de Recherches sur les Oiseaux Pélagiques (PIROP), and scientists from the Instituto de Investigaciones Pesqueras, Vigo; Centre de Recherches de l'Institut des Pêches, St.-Pierre et Miquelon; the Freshwater Fisheries Laboratory, London; and Resource Development Branch, Environment Canada, Halifax.

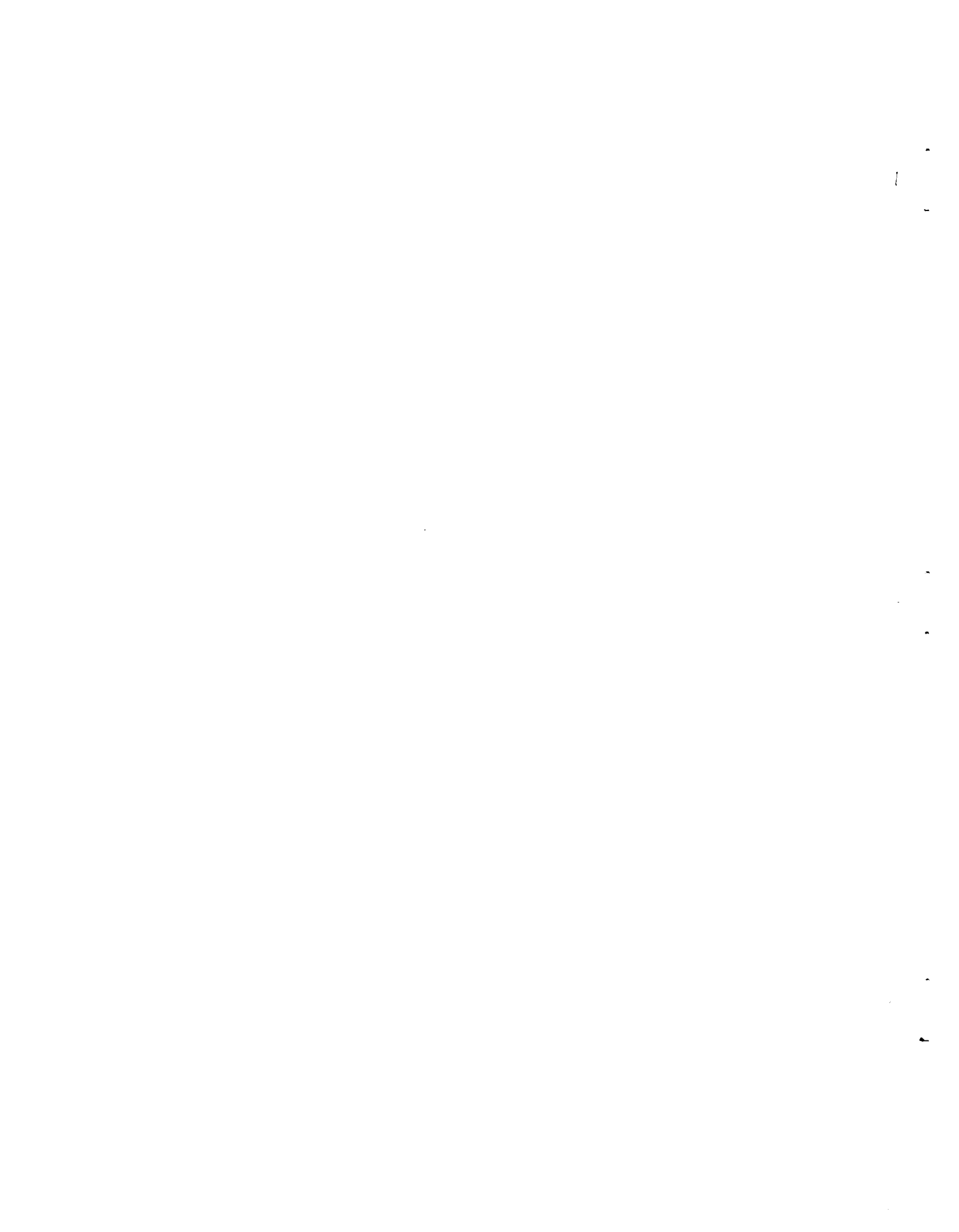
Public Service Long-Service Awards were presented on December 10 to Dr. W. Templeman, Mr. A. M. Fleming and Mr. E. L. Rowe. The Fisheries Research Board Long-Service Award was presented on December 10 to Mr. H. R. Mullett.

Mr. M. C. Mercer concluded educational leave at Harvard University on May 16. Mr. J.H.C. Pippy left to continue educational leave at the University of Guelph, August 27. Mr. G. H. Winters began educational leave at Dalhousie University, October 1.

Mr. V. M. Hodder, Head of the Pelagic Fish Division for 6 years left in September to join the staff of ICNAF in Dartmouth as Assistant Executive Secretary.

Additions to the staff were Dr. R. J. Miller who joined the Commercial Invertebrate Division in April with responsibilities for snow crab research, and Mr. R. H. Payne joined the Anadromous Fish Division, in August, with responsibilities for genetic composition studies on Atlantic salmon.

## **INVESTIGATORS' SUMMARIES**



GROUND FISH

1. Summary of sampling collections from the inshore cod fishery in Newfoundland and Labrador

R. Wells, A. M. Fleming,  
A. T. Pinhorn

Biological samples and catch and effort data were collected at a number of localities in coastal areas of Newfoundland and Labrador in a continuing program of monitoring the inshore cod fishery. Sampling occurred where possible during the principal fishing season. The data collected are used extensively in national and international background documents and reports concerned with assessment and management of stocks. A summary is listed below.

Summary of inshore cod sampling, 1971.

ICNAF Division	Sampling locality	Dates	Gear	Measurements	Pairs of otoliths
2K	Railroads	August 28-31	Trap	1116	268
2J	Gready and Indian Tickle	July 19-28	Trap	2235	368
	Smokey and Black Tickle	September 2-6	Gillnet	514	477
3K	Twillingate	June 23-July 17	Trap	5286	295
		June 22-July 17	Gillnet	4018	333
		June 23-July 16	Longline	1543	148
3L	Bonavista	July 5-14	Trap	2329	74
		July 5-14	Handline	2416	120
		July 5-14	Gillnet	2303	455
	St. John's	February 15-17	Gillnet	121	121
		June 5-23	Trap	1988	153
		June 5-23	Gillnet	1605	205
Admirals Beach	June 15-25	Trap	1874	140	
	June 15-25	Gillnet	2018	206	
3Ps	Red Harbour	June 30	Trap	444	90
	Marystown	June 24-July 7	Trap	2434	109
	Burin	May 11-20	Gillnet	1009	154
		June 25-July 7	Trap	890	67
		June 25-July 8	Gillnet	2506	314
	St. Lawrence	July 2	Trap	410	82
Lawn	July 1-6	Trap	970	204	

2. Inshore cod fishery, Labrador and northern Newfoundland

R. Wells

Sampling of the inshore cod fishery was continued at selected communities in Labrador and northeast Newfoundland (see table in Groundfish Summary 1).

In Labrador the fishery was considered to be a failure in the Hopedale area and in the areas sampled in southern Labrador, the fishery, although somewhat better than in 1970, was considered poor. In northeast Newfoundland, cod landings at Twillingate during the sampling period were a little higher than in 1970. Here the larger boats use gillnets in water of 100 fath or deeper and these have been fishing for the past few years mainly for flatfish. At Port Saunders on the northwest coast, fishing effort by the larger inshore boats has been diverted to shrimp.

3. Virtual population assessments of cod in ICNAF Divisions 3K and 3L

R. Wells

In Division 3K (northeast Newfoundland), estimates of average  $F$  in fully recruited age-groups ranged between 0.24 and 0.40 in 1961-66 except for 1964 for which the estimate was 0.63. Very few 3-year-old fish were caught but fish were fully recruited at 7 years of age, the 50% recruitment age being about 5 years.

Yield per recruit calculations incorporating partial recruitment indicated that in the 1961-66 period the fishing mortality was within 95-100% of that necessary to generate the maximum sustainable yield per recruit at about  $F = 0.4$ . Only in 1964 did the level exceed the maximum point. Extrapolation based on the correlation between catch and  $F$  indicated that for the years 1967-70 only the 1968 level was beyond the maximum and even at this level the yield per recruit was still within 98% of maximum.

In Division 3L (eastern Newfoundland), estimates of  $F$  ranged between 0.19 and 0.39 during 1955-63 but increased to 0.67 and 0.63 in 1964-65 coincident with an increase in landings in these years.  $F$  in 1966 was again low (0.36) although landings were still high. Very few 3-year-olds are caught but cod are fully recruited at 7 years of age, the 50% recruitment age being slightly less than 5 years.

Yield per recruit calculations indicate that in the period 1959-66 the level of  $F$  was at or beyond that necessary to generate the maximum sustainable yield per recruit at about  $F = 0.3$ . Extrapolation based on the correlation between catch and  $F$  indicated that for the years 1967-70, the level of  $F$  was beyond that necessary to generate the maximum.

In both these divisions, the growth curve used was for the period 1960-62 and is therefore outdated. Some increase in growth has apparently taken place since then and will undoubtedly affect the yield curve somewhat but it is felt that the general conclusions will not be altered.

4. Research vessel cruise to northern  
Newfoundland and Labrador, April-May 1971

R. Wells

During a cruise of the *A. T. Cameron* (April 13-May 3) the distribution and abundance of cod with depth and temperature were investigated. No large concentration of cod was located on Hamilton Inlet Bank, Belle Isle Bank or Funk Island Bank; fishing was, however, restricted by the presence of ice. Bottom water temperatures were generally within the range in which large catches of cod have previously been taken in these areas. Most of the cod taken were less than 40 cm in length; 4-year-olds made up the bulk of the catches in all areas. This year-class (1967) of cod should reach a length of about 40 cm in the spring of 1972 and can be expected to contribute to the commercial fishery in fair numbers in that year. In ICNAF Division 2J the average length increased by about 6.7 cm per year from ages 2 to 6 years and by about 4.7 cm from ages 7 to 11. In ICNAF Division 3K average length increased by about 7.8 cm from ages 2 to 6 years. The total mortality was estimated to be about 0.9 for ICNAF Division 2J over ages 6-11, and about 0.8 for ICNAF Division 3K over the ages 6-10. About 15% of the cod were mature. Of the mature cod about 80% had completed spawning. The length at which 50% of the males had spawned in ICNAF Division 2J was about 42 cm whereas 50% of the females had spawned at about 49 cm. The corresponding lengths in ICNAF Division 3K were 45 and 52 cm respectively. The length of the smallest mature male was 30 cm, that of the smallest mature female was 39 cm. The gills of about 4% of the cod in ICNAF Division 2J and about 3% in ICNAF Division 3K were infested with the copepod *Lernaeocera*. Cod were feeding heavily on the deepwater shrimp *Gennadas* and deep sea fish on Hamilton Inlet Bank but only lightly on various food items on Belle Isle Bank.

5. Research vessel cruise to the Gulf of  
St. Lawrence, January-February 1971

R. Wells

A very large concentration of cod was located off Bay of Islands in February 1971 by the *A. T. Cameron*. The largest catch was 31,300 lb taken in one half-hour haul by otter trawl. Best catches were taken between 80 and 140 fath of water, but bottom water temperature was apparently not critical in determining concentration of cod. Average length and age increased from north to south in the Gulf. Cod of ages 5-7 made up about 80% of the catch. The growth rate appeared to be uniform over the eastern part of the Gulf; the average fork length increased by about 8.5 cm per year from ages 2 to 6 and by 5.5 cm per year from ages 7 to 10. The total mortality was estimated to be in the range 0.7-0.8. About 60% of the cod were mature, most of which were considered to be maturing to spawn in the spring but 10-20% would probably not spawn until the summer or fall. The length at which 50% of the cod were mature was about 47 cm for males and 53 cm for females. Gonad volumes varied widely between maturity stages. There were distinct differences in volume of testes of cod maturing to spawn in the present year and these differences tend to confirm the presence of a small group of late spawners. Of cod examined, 4% were infested with *Lernaeocera* and 26% with nematodes. Cod were not feeding heavily. The

major food items were baby redfish and euphausiids for the smaller fish and herring, baby redfish and euphausiids for the larger ones.

6. Monitoring the inshore groundfish fishery in eastern Newfoundland (ICNAF Division 3L) A. M. Fleming

Observations were continued in Bonavista, St. John's and Admirals Beach, 3 widely separated communities chosen as monitoring areas. Biological samples and catch and effort data were collected from landings of boats fishing lines, traps and gillnets (see table in Groundfish Summary 1). Although at St. John's and Admirals Beach the inshore groundfish fishery is directed entirely to cod with all gears, in Bonavista the trend continued in the deepwater gillnet fishery to increased landings of other species, especially Greenland halibut, plaice and greysole. In 1970 species other than cod amounted up to 60% of the gillnet catch and in 1971 to 68% of the catch.

In 1971 the Newfoundland cod landings (preliminary figures, round weight) were about 9% below the 1970 landings of 338 million lb, which in turn were 15% below the 1969 landings of 396 million lb. As usual the decrease is principally the result of generally low catches in the inshore fishery. The trap fishery generally accounts for about 50% of the inshore cod catch. In each of the monitoring areas the average catch per haul was less than half the 1970 level. There was a decrease, also, in the average catch of cod by gillnet, particularly in the Bonavista and St. John's area, but not as marked in St. Mary's Bay (Admirals Beach). The decrease is even greater than is indicated for all areas because difficulties are experienced in obtaining accurate records on the number of days that nets have been fished before being hauled. It is certain, particularly for the smaller boats, that nets are often fished up to 3 or 4 days before being hauled.

The trap fishery takes the youngest recruits to the commercial fishery; the 1966 to 1968 year-classes dominated in 1971, contributing 70-90% of the numbers caught, although in Admirals Beach the 1968 year-class was considerably weaker than in the other areas. The deepwater gillnet fishery off Bonavista (140-160 fath) caught a much larger proportion of older fish, with 40% being over 10 years of age, and the 1955, 1961 and 1966 year-classes were still contributing fairly strongly. However, off St. John's and in Admirals Beach, where the gillnet fishery is much shallower, the 1963 to 1965 year-classes made up about 65-70% of the numbers caught, and there were relatively few fish over 10 years of age.

In research otter-trawl catches (with fine-mesh liner in the codend) on the northern part of the Grand Bank (Division 3L) in June and October 1971, the 1968 year-class made up 45-50%; there were relatively few cod older than 6 years in the catches.

7. Monitoring the offshore groundfish fishery

A. M. Fleming

Sampling of otter-trawler catches landed at processing plants on the Burin Peninsula and at Fermeuse was carried out in 1971 with length measurements and otoliths being obtained from representative catch samples, and records of catches and landings being collected from ships and processing plants. The otter-trawler fishery for plaice on the eastern part of the Grand Bank was the most important offshore fishery by Newfoundland trawlers, particularly in ICNAF Division 3L (northern Grand Bank) and the landings contributed the bulk of our samples. The catches of yellowtail were much higher in 1971 than in any previous year and were distributed more widely in Divisions 3L and 3N (eastern Grand Bank). Because of the heavy concentration of effort on flounders in 3L, cod sometimes formed a sufficient portion of a trawler's catch to allow adequate samples to be obtained.

<u>Species</u>	<u>Division 3L</u>		<u>Division 3N</u>	
	<u>Measurements</u>	<u>Otoliths</u>	<u>Measurements</u>	<u>Otoliths</u>
Plaice	9633	962		
Yellowtail	1012	199	1257	185
Cod	5569	366		

Obviously, biological sampling is still principally of major species and major areas fished. It is inadequate for many areas, lacking for others, particularly for ICNAF Division 3Ps (St. Pierre Bank) and for Division 4R (east Gulf of St. Lawrence). Through co-operation of trawler captains and plant personnel, records of the fishing of most ships are regularly received. Of 64 otter trawlers landing regularly in Newfoundland in 1971, complete reports were received from 92% of the trips.

The data are valuable in calculations of the status of the various stocks and in assessments of the effects of the fishery. They are also a part of the Canadian statistical submission to ICNAF.

8. Cod of the southern Newfoundland area

A. T. Pinhorn

Grand Bank (3N and 30). During 2 research vessel cruises to ICNAF Divisions 3N and 30 during the spring of 1971, 65-70% of the cod catches were composed of the 1968 year-class confirming previous estimates of the relative strength of this year-class. Average catch per haul in the February-March cruise was 740 lb while in June the average was 60 lb. Five sets during a fall cruise near 44°N in 25-100 fath produced only 45 cod. If the 1968 year-class has been fished as heavily in 1971 at 3 years of age as the very abundant 1964 year-class was in 1967, then its contribution to the catches will be limited to not more than 2 years. The landings from Divisions 3N and 30 by all countries in 1970 were about 104 thousand tons (230 million lb), only slightly less than the 110 thousand tons (220 million lb) of 1969.

Newfoundland south coast and St. Pierre Bank (3Ps). Routine sampling for lengths and ages and studies of catch and effort from the inshore commercial fishery were carried out as part of a continuing program to monitor the inshore portion of the 3Ps stock. Samples were obtained during May, June and July from Burin and Marystown and from Lawn, St. Lawrence and Red Harbour during June-July (see table in Groundfish Summary 1). No research vessel cruises were made to St. Pierre Bank during 1971.

The inshore fishery in 3Ps has been somewhat more productive in the past few years than in the middle 1960's and this is probably because of poorer recruitment of the 1956-60 year-classes and better recruitment of the 1961-67 year-classes as indicated by analysis of research vessel survey data. Catch per unit effort by codtrap decreased from a high level of 5000-6000 lb per haul in 1958-60 to a low level of less than 2000 lb in 1964-66 but then increased to 3000-4000 lb in 1967-70 except for 1969 when the catch per haul was 2000 lb. Similarly the catch per line for linetrawl decreased from 35 lb in 1957-60 to a level of 15-20 lb in 1962-66 and then increased to an average level of 40 lb per line in 1967-70. The multifilament and, more recently, the monofilament gillnet fishery since its inception in 1962 has maintained itself at a level of 110-130 lb per net except for 1964-65 when the catch was 80-90 lb per net.

9. Assessment studies on cod stocks in  
ICNAF Divisions 2J and 3Ps

A. T. Pinhorn

Yield per recruit calculations for Division 2J cod indicate that further increases in F (fishing mortality) will not give a long-term increase in yield-per-recruit and will further reduce the abundance of the stock. The fishing effort in recent years has been about 95% of that necessary to produce the maximum yield-per-recruit. The reduced number of older (mature) fish in the stock has resulted in a virtual extinction of the inshore Labrador fishery which traditionally has been dependent on older mature post-spawning cod.

Virtual population analyses on ICNAF Division 3Ps cod indicated that fishing mortality estimates (F) for ages 3-11 fluctuated only moderately between 0.3 and 0.4 during 1959-68 except for 1966 when the estimate of F was unusually high (0.55) especially for cod older than 6 years. There is some reason to doubt the validity of the estimates for this year however since neither catch nor effort increased proportionately. The cod in this area are fully recruited at age 7 with very few 3-year-olds being taken, the 50% recruitment age being approximately 4.5 years.

The total stock size of fish 3 years old and older decreased from about 200 million fish in 1959 to a low of 100 million fish in 1964 and then increased to 175 million in 1968. This resulted from poorer recruitment from the 1956-60 year-classes and better recruitment from the 1961-65 year-classes. The numbers of fish aged 6 years and older have declined fairly steadily from 34 million in 1959 to 14 million in 1967 and 17 million in 1968.

Yield per recruit calculations indicated the point of maximum sustained yield to be at an F-level of 0.3. The level of F for fully recruited age-groups prevailing in the 1960's was between 0.3 and 0.55 and thus was beyond this maximum level, being in the range of 90-100% of it. Further increases in fishing effort on this stock therefore will not result in long-term increases in yield and may result in long-term decreases in catch per unit effort and, depending on the stock-recruitment relationship, in stock size. In fact some reduction in fishing effort would probably not impair the yield and may result in improved catch per unit effort.

Calculations based on catch and effort data for 2J cod indicate the natural mortality (M) to be in the range of 0.15-0.20.

10. Continuing haddock scarcity on the Grand Bank

A. T. Pinhorn

Research vessel cruises to ICNAF Divisions 3N and 30 (Grand Bank) in the early spring of 1971 failed to produce any significant quantities of adult or pre-recruit haddock indicating once again that the adult stock is at an extremely low level and that year-classes up to 1970 have been poor.

During the 1971 inshore fishing season reports were again received of significant quantities of haddock being caught along the south and east coasts. Samples of these were obtained.

11. Pleuronectid research surveys

T. K. Pitt

Two groundfish surveys were carried out on the Grand Bank using the stratified random method of fishing station selection, one in June and the second in October 1971. The spring cruise, which was a 24-hour fishing operation, surveyed a major portion of the Grand Bank with a total of 86 successful 30-minute tows. Several relatively good catches of plaice were recorded in Division 3L, ranging from 700 to 1400 lb, mostly from the north and northwestern slopes of the banks. Plaice were generally scarce south of 45°N on the east and southeast slopes with catches all less than 500 lb. Records of yellowtail catches during this cruise indicated that this species has spread to most of the shallow (less than 50 fath) parts of the bank and catches of about 500 lb were obtained at several localities.

The fall cruise surveyed some of the deeper strata on the north and northeast parts of the bank that were omitted from the spring cruise and in addition repeated some strata sampled earlier in order to compare spring and fall distribution. Catches of plaice up to 2000 lb for a half-hour set were recorded, but average catches of plaice were in the 400-600 lb range.

12. Stock assessments of American plaice  
in ICNAF Divisions 3L and 3N

T. K. Pitt

An assessment of American plaice from the Grand Bank (3L and 3N) was completed using the virtual population method. This method permits the calculation of fishing mortality (F) for each age of the various year-classes independent of effort data. Data for 3L were available from 1955 to 1970 and for 3N the 1956 to 1970 period was used. Natural mortality (M) has been estimated at 0.25 for males and 0.20 for females. The average estimates of F are given in the following table.

A = average F for all age-groups; B = average for fully exploited age-groups

Year	Division 3L				Division 3N			
	Male		Female		Male		Female	
	A	B	A	B	A	B	A	B
1955	0.09	0.15	0.07	0.14				
1956	0.08	0.16	0.09	0.19	0.09	0.12	0.06	0.10
1957	0.05	0.10	0.11	0.25	0.13	0.19	0.10	0.14
1958	0.12	0.21	0.12	0.25	0.18	0.29	0.11	0.15
1959	0.14	0.29	0.13	0.27	0.20	0.33	0.11	0.17
1960	0.14	0.25	0.12	0.23	0.20	0.34	0.10	0.15
1961	0.15	0.25	0.14	0.26	0.14	0.22	0.10	0.17
1962	0.18	0.33	0.16	0.32	0.11	0.18	0.10	0.19
1963	0.22	0.45	0.15	0.30	0.17	0.27	0.14	0.25
1964	0.24	0.41	0.14	0.29	0.17	0.22	0.18	0.25
1965	0.23	0.41	0.21	0.44	0.27	0.32	0.28	0.37
1966	0.26	0.58	0.17	0.35	0.35	0.43	0.41	0.67
1967	0.34	0.60	0.26	0.48	0.33	0.47	0.37	0.71
1968	0.36	0.89*	0.31	0.58	0.36	0.58	0.30	0.60

\*calculated from 2 values only

Division 3L. Yield curves calculated for various values of F of fully recruited plaice indicated that in 1968 the stock in 3L was being exploited at a level equivalent to 82-86% of the apparent maximum sustainable yield. The effort (Newfoundland stern-trawler hours) in 1968 was 63.2 thousand hours producing 1250 lb per hour. In 1969 the effort was 92.7 thousand hours giving a projected value of F that would raise the yield level to about 90% of the maximum. The catch per hour was 1150 lb. In 1970 at about the same level of exploitation the catch per hour decreased to 990 lb. It is suggested for the type of yield curves produced, which apparently would reach a maximum beyond the 2.0 fishing level, that 80% of the maximum yield, i.e. F = 0.50, is perhaps an appropriate level of exploitation. This would apparently produce between 70 and 80 million lb.

Division 3N. For 3N the 1968 estimate of F was about 0.60 which is about 90% of the maximum yield. The effort in 1968 was 37.7 thousand hours

and the catch per hour 1250 lb. In 1969 and 1970 the effort was 33.6 and 59.0 thousand hours respectively producing catches per hour of 1010 and 750 lb per hour. Extrapolating the probable F for the 1970 fishing effort gives an F value between 0.65 and 0.80 or 92-95% of the maximum yield. If 30% of the maximum yield is an acceptable level of exploitation, then a fishing rate of 0.40, which was close to 1965 level, should be recommended. In 1965 about 50 million lb were landed from this division, however 3N is a relatively small area and apparently does not have a large reserve of pre-recruited fish as in 3L although they do grow faster. There is also the strong possibility that 3N is, in part at least, stocked by larval drift from the north and we have no knowledge of how a reduction in stock size in 3L will affect this. It was therefore suggested that landings in 3N probably should not exceed 40 million lb.

### 13. Yellowtail flounder investigations

T. K. Pitt

Landings. Landings of yellowtail from the Grand Bank increased rapidly from less than 2 million lb annually prior to 1965 to a total of about 60 million lb in 1970, with about 44 million lb of this being landed by Newfoundland trawlers.

Age composition. The age composition of commercial landings and research catches indicates a succession of year-classes of approximately equal strength. The fishery appears to be dependent primarily on just 3 age-groups, i.e., 6-, 7- and 8-year-olds; however, the 1970 landings from 3L were dominated by 6- and 7-year-olds only.

Estimates of total mortality. Total mortality estimates from ICNAF Division 3N from research vessel catch curves 1951-52 were 0.89 (59%) for males and 0.62 (46%) for females and 0.77 (54%) for males and females combined. These were for samples taken before the commercial fishery began. Catch curves (research) for 1970 gave mortality estimates as follows: males 1.82 (83%) and for females 1.27 (72%) or a combined estimate of 1.57 (79%). For commercial catch curves total mortality estimates increased from 0.83 (56%) in 1965 to 1.25 (71%) in 1969.

The high total mortality estimates for the pre-exploited period would seem to suggest a high natural mortality rate. However, during this period yellowtail were probably caught and discarded by the commercial fleet and in addition if the yellowtail stocks are increasing in abundance, which indeed appears to be a fact, then mortality estimated from catch curves probably gives too high estimates of total mortality.

With data available from 1971 it might be possible to get estimates of total mortality from catch curves of year-classes; this would eliminate the effects of combining a number of year-classes of unequal strength.

14. Greenland halibut tagging results

T. K. Pitt

A total of 410 Greenland halibut was tagged in Trinity Bay using  $\frac{1}{2}$ -inch Petersen discs, October 28-November 18, 1971. The fish were caught on longline gear using capelin as bait.

A further 7 tags were recovered from the 1969 White Bay tagging bringing the total recoveries to 27 from 249 tagged. Two of the 1971 recoveries were from USSR factory ships fishing on the edge of the continental shelf.

PELAGIC FISH

G. H. Winters

The guidelines for pelagic fish research in 1971 remained basically as they were in 1970 with practically all manpower and resources being devoted to herring research, with emphasis on the identification of stocks which frequent Newfoundland coastal waters, particularly the southwestern Newfoundland stock complex. Intensive sampling of herring from seiner landings was carried out at the field laboratory, Isle aux Morts, and sampling and collection of mobile fleet records at the Harbour Breton and Burgeo reduction plants were conducted during periodic visits of technical staff. The herring populations along the east and west coasts of Newfoundland and southern Labrador were surveyed and sampled during vessel cruises or overland field trips to these areas.

The herring tagging program in 1970 was expanded in 1971 to include use of external tags. Altogether 47,250 herring have been tagged, 43,300 of them with internal tags. Recoveries of tags have provided much useful information on stock sizes, exploitation rates and migrations. A special tag detection unit was installed in the reduction plant at Isle aux Morts which permitted accurate determination of the area of capture and also provided information on the local movements of herring along the southwest coast.

Utilizing funds provided by the Industrial Development Branch, the St. John's and St. Andrews Biological Stations chartered a stern-trawler, *J. B. Nickerson*, and carried out a joint echo-sounder and midwater-trawling survey of the offshore Nova Scotian banks in March 1971. Although no significant concentrations of herring were located, samples were obtained and their biological characteristics compared with southwest Newfoundland-southern Gulf of St. Lawrence herring from which it was concluded that the herring on the offshore Nova Scotian banks do not intermingle with those from the southern Gulf.

The M.V. *Pandalus*, a 46-ft research stern-trawler, carried out young herring explorations in the southern Gulf of St. Lawrence from St. Georges Bay to Chaleur Bay in August 1971. This was a pilot project conducted jointly by the St. John's and St. Andrews Stations. No significant concentrations of juvenile herring were located and plankton hauls yielded only insignificant catches of herring larvae.

Mackerel, sand lance and capelin were studied when material and information became available.

1. Status of the Newfoundland herring  
purse-seine fishery in 1970-71

G. H. Winters

In 1970-71, for the first time since the herring fishery began, the mobile fleet landings at Newfoundland ports showed a marked decline. Landings dropped from a record yield of 199,000 (short) tons in 1969-70 to just under 141,000 tons in 1970-71 representing a 30% decrease (Table 1). This decline is largely due to greatly decreased catches in the

Table 1. Mobile fleet herring landings (tons) by month and catch area 1970-71

Month	Area										Total
	GH	I	J1	J2	K	L	M	T	V	W	
July	...	...	...	...	...	...	...	526	...	...	526
Aug	...	...	...	...	...	...	...	366	...	...	366
Sept	...	...	...	...	...	...	...	34	...	...	34
Oct	...	...	...	...	...	...	...	242	...	...	242
Nov	...	...	...	639	...	...	927	498	...	...	2,064
Dec	...	...	11,915	3,768	...	...	843	241	...	...	16,767
Jan	...	5,798	15,762	22,781	...	...	...	...	1,130	923	46,394
Feb	...	3,791	1,679	26,193	...	...	...	...	...	1,486	33,149
March	...	5,559	2,580	18,446	...	...	...	...	...	7	26,592
April	...	889	...	3,702	3,698	80	...	3,759	...	...	12,128
May	...	...	...	...	19	2,383	...	193	...	...	2,595
June	...	...	...	...	...	...	...	...	...	...	...
Total	...	16,037	31,936	75,529	3,717	2,463	1,770	5,859	1,130	2,416	140,857

Note: Bar-seine catches not included.

November-December period of 1970 when the usual fishery at Magdalen Islands (Bird Rocks) (Area T) did not materialize because of a scarcity of herring in the area and the southwest Newfoundland fishery was 2-3 weeks later than usual in starting. Less than 20,000 tons were landed at the major reduction plants during November-December 1970 compared with about 50,000 tons in 1969.

As in previous years the bulk of the Newfoundland landings was from herring caught along the southwest coast (Area J) with the area west of Burgeo (Area J2) yielding the largest quantity of herring. Landings from the Fortune Bay stocks of herring (Area I) increased from 9000 tons in 1969-70 to a record of 16,000 tons in 1970-71 most of which was landed at the Harbour Breton reduction plant. The closure of the Magdalen Islands spring fishery in 1971 prevented the mobile fleet from following the spring-spawning concentrations of herring inshore in late April and early May. Consequently a portion of the seiner fleet operating out of Isle aux Morts diverted their fishing effort to the St. Georges Bay area (Area K) resulting in an increase in landings from that area from less than 50 tons in 1969-70 to 3700 tons in 1970-71. Area M (Bonne Bay-Hawke's Bay) landings were down 60% from the previous year whereas those from Areas V and W (Sidney Bight-Chedabucto Bay) remained at the 1969-70 level.

Prior to the 1970-71 season the herring landings of the mobile fleet were utilized almost entirely for reduction into meal and oil. However, during the 1970-71 season the high prices offered for food herring together with the relative scarcity of herring resulted in a significant proportion (20%) of the catch being diverted to the food processing plants. All the major reduction plants established herring food processing facilities on their premises. This trend is expected to intensify during the 1971-72 season.

## 2. Status of the southwest Newfoundland herring stocks

G. H. Winters

Investigations to elucidate the size, distribution and migrations of the herring stocks which support the winter purse-seine fishery along southwest Newfoundland were continued throughout the 1970-71 season. The field effort was mostly concentrated at the main landing port, Isle aux Morts, where a small field station has been set up. The reduction plants at Harbour Breton and Burgeo were visited periodically during the season and log-book records, plant turnouts and recovered tags were collected from plant personnel. Seiner landings were sampled on a regular and proportional basis at Isle aux Morts; over 5000 herring were examined in detail for length, sex, maturity, weight, nematode incidence, stomach content, meristic composition and otoliths. Also herring samples were selected monthly for fat analysis.

There has been a gradual increase in the average size of herring taken along southwestern Newfoundland since the purse-seine fishery began in 1965. The average length has increased by about 2 cm over the 6-year period with the 1970-71 average length being 0.6 cm larger than the previous season. The age composition data for the 1970-71 season (Table 2) reveals

Table 2. Per mille age composition of southwest Newfoundland herring by month and spawning type for 1969-70.

Year-class	Growth zones	Numbers per mille						
		Nov	Dec	Jan	Feb	Mar	Apr	Season
68	2				2			1
67	3		1	4	8	8	3	5
66	4		1	7	6	2	3	4
65	5		4	9	10	12	7	8
64	6	8	15	39	35	45	23	31
63	7	36	84	87	108	102	30	88
62	8	84	72	82	55	87	43	73
61	9	44	39	44	48	32	33	40
60	10	68	83	78	52	41	33	62
59-	11+	592	468	414	421	424	247	428
Total autumn spawners		832	767	764	745	753	423	740
69	2							
68	3			2	16	18	463	38
67	4		1	2	4	3	7	3
66	5		-	4	14	12		7
65	6		4	8	13	9		8
64	7	12	16	11	10	16	3	12
63	8	20	25	16	30	31	13	24
62	9	28	28	25	24	25	20	25
61	10	28	32	51	42	33	13	37
60-	11+	80	127	117	102	100	58	106
Total spring spawners		168	233	236	255	247	577	260
No. aged		250	1000	1000	1000	1000	300	4550

that the southwest Newfoundland fishery was still dependent on pre-1960 year-classes with over 50% of the herring sampled being 11 years old or older. Landings from the southwest Newfoundland winter fishery increased steadily from 15,000 tons in 1965-66 to a high of 154,000 tons in 1969-70 but dropped 26% to 113,000 tons in 1970-71. Part of this decline can be attributed to the rather severe weather conditions during the past winter but both the length and age frequencies indicate a substantial lack of recruitment to the adult stock. Population estimates from tag returns indicated that the size of the southwest Newfoundland herring population was only 60% of that present in the area during the 1969-70 season. Unless recruitment is more substantial than is indicated by our age and length composition data, a further decline in landings can be expected for the 1971-72 season.

3. Herring tagging investigations

G. H. Winters

The extensive tagging program initiated in 1970 was continued and expanded in 1971. In addition to using internal tags, the increasing proportion of herring landings being diverted to food production and the extensive use of fixed gears in areas not served by reduction plants has necessitated the use of external tags in our migration studies. Two types of external tags have been used, an anchor tag and dart tag, both of which are made of #20 vinyl tubing and are approximately 2½" long. Both the dart and anchor tags are inserted through the dorsal region of the fish. Information posters have been sent to all of the processing plants and an incentive reward of \$1.00 is being paid for recovered tags. A list of the tagging experiments is given in Table 3. Altogether a total of 43,300 herring with internal tags and 3950 with external tags have been released.

A total of 708 tags (2.8%) has been recovered from the 25,000 tagged herring released in March 1970 on the southwest Newfoundland coast (Table 4). The majority of these tags were recovered from the Newfoundland winter fishery but a significant proportion was also recovered from the Magdalen Islands-St. Pauls area and the Chaleur Bay-Gaspé region of the southern Gulf of St. Lawrence. Complementary taggings in the southern Gulf area by the St. Andrews Station have confirmed the return migration to the Newfoundland coast.

The 1971 Bay de Loup releases also confirmed the migratory path of herring from the Newfoundland coast to their spawning grounds in the southern Gulf of St. Lawrence. A total of 425 tags (4.3%) has been recovered to date, 404 of which were recovered from the Newfoundland fishery.

The poor returns from the Hawke's Bay releases may be attributed to the high tagging mortality of the herring which were obtained from a purse seine and exhibited a high degree of scale loss. Nevertheless, the few tags recovered to date have been significant in that they demonstrate

Table 3. Details of herring tagging experiments carried out by the St. John's Biological Station in 1970-71 (D = Dart, A = Anchor).

Tagging locality	Date tagged	Number tags released			Total tags
		internal	external (D)	external (A)	
Newfoundland					
Lapointe Bay	March 3-13, 1970	25,000	-	-	25,000
Hawke's Bay	Dec 4, 1970	3,400	-	-	3,400
Bay de Loup	Jan 25-26, 1971	10,000	-	-	10,000
Noddy Bay	August 26, 1971	-	-	350	350
Hawke's Bay	Dec 3, 1971	200	-	2,000	2,200
Bay de Loup	Dec 12-13, 1971	4,700	800	800	6,300
Totals		43,300	800	3,150	47,250

Table 4. Areas of recapture of tagged herring released at various localities along southwestern and western Newfoundland.

Area of release	Date of release	No. of recaptures						Total recaptures
		Nfld.		Magdalen Is.		S. Gulf		
		1970	1971	1970	1971	1970	1971	
Lapoile Bay	March 1970	398	110	64	5	103	28	708
Hawke's Bay	Dec 1970	-	3	-	-	-	2	5
Bay de Loup	Jan 1971	-	405	-	6	-	14	425
Totals		398	518	64	11	103	44	1138

that local stocks of herring also overwinter along the southwest coast of Newfoundland and apparently some even move across Cabot Strait into the southern Gulf of St. Lawrence. The significance of such migrations is not yet evident.

Tag returns from the March 1970 and January 1971 releases have been adjusted for tagging mortality and recovery efficiencies and stock sizes have been estimated. The stock size of the southwest Newfoundland herring population was estimated at 400,000 metric tons at the start of the 1969-70 season and about 250,000 metric tons at the beginning of the 1970-71 season. Over the same period the landings decreased 26% which attests somewhat to the reliability of the population estimates. The monthly exploitation rate was estimated at 4-5% and if a similar rate applies for the summer fisheries in the southern Gulf of St. Lawrence, the annual rate for the stock as a whole would be about 40-50%. This is the level at which the Atlanto-Scandian stock began to collapse. Unless recruitment to the exploited stock is considerably more than is evident from present data, herring landings from the southwestern Newfoundland-south Gulf of St. Lawrence fisheries will continue to decline.

#### 4. Detection system for metal tags

G. H. Winters

In addition to elucidating the seasonal migrations of herring, the tagging experiments were also designed to provide information on the local movements of herring along southwestern Newfoundland. The tag recoveries from the reduction plants were not ideally suited for this purpose because of the time lag between landing and processing as well as the mixing of landings from many different catch localities in the storage tanks. With the kind permission of B.C. Packers Ltd. an electronic tag detection system, designed by Packtron Ltd. of Canada, was installed at Nelpack Fisheries Ltd., Isle aux Morts in late January 1971. The detection apparatus was installed in the scale room which is located on top of the herring storage tanks. The system consisted of a metal detector situated above the scale conveyor at the end of which was installed a powered conveyor 6 ft x 2 ft with a feed flap timed and driven by the metal detector.

Metallic objects passing underneath the metal detector triggered the feed flap open for a period sufficient to allow 50-70 herring to be separated from the scale conveyor onto the powered conveyor by which they were conveyed to the FRB sample room. Here they were fed individually through a smaller bench-mounted detection unit until the tagged fish was identified. Seeding experiments indicated that the detection system had a recovery efficiency of 90%.

A total of 73 tagged fish was recovered by the detection unit, 44 of which originated from the release of 10,000 tagged herring in Bay de Loup, January 25-26, 1971. Preliminary analyses of the returns indicate that there is a rapid westward movement of herring along the southwest coast. Five days after their release in Bay de Loup tagged herring were found as far west as Garia Bay (45 miles). There were no recoveries of tagged fish east of Burgeo but this may only reflect lack of fishing in the area. Also, a month after the Bay de Loup releases, tagged herring were still being recaptured in the area.

The tagged herring recovered by the detection system were examined for length, sex, maturity, tag position and tagging injury. Preliminary analyses of the results indicate that (a) there was no differential tagging mortality between spring and autumn spawners; (b) females predominated in the recoveries of tagged fish; (c) tagged herring released a year previously (March 1970) showed no scars from the tagging incision and internal damage caused by the tags was negligible; (d) the incision wounds of the majority of tagged herring released 6-7 months previously in Chaleur Bay were completely healed although there were some which had only healed externally and in one case the wound was still open; (e) infection at the insertion cut was not evident in any of the tagged fish examined.

5. Herring studies in St. Mary's Bay, Newfoundland

G. H. Winters

A study of the population dynamics of St. Mary's Bay herring was continued in 1971 to relate abundance of adult herring to amount of spawn deposited and subsequent abundance and survival of larvae. Efforts were directed towards obtaining information on the extent and intensity of spawning, environmental and substrate conditions required for spawning, egg predation and egg survival, distribution and survival of herring larvae and biological characteristics of adult and juvenile herring populations. Field operations were conducted from May to September from field headquarters located at North Harbour.

The *Marinus* conducted a gillnet survey of St. Mary's Bay, May 26-June 4, 1971 and herring catches were of the same magnitude and distribution as for the same period in 1970. Herring spawning occurred much later than in 1970 and was at a reduced level. The first herring larvae were caught on June 9, 1971 and catches increased until mid-July after which they declined. Hydrographic conditions in 1971 were similar to those observed in 1970.

6. Herring parasites - stock identification

L. S. Parsons

Studies to determine the usefulness of larval *Anisakis* as indicators of herring stock heterogeneity in the Northwest Atlantic continued in 1971. Emphasis was placed on the collection of specimens from the Scotian Shelf, Bay of Fundy and southern Gulf of St. Lawrence to further elucidate stock interrelationships in those areas. The St. Andrews Biological Station assisted in this investigation by providing approximately 1400 herring from Bay of Fundy, southwest Nova Scotia, Chedabucto Bay and the southern Gulf of St. Lawrence.

A comparison of Canso Bank, Banquereau, southwest Newfoundland and St. Paul Island samples revealed substantial differences between the levels of nematode infestation of herring from the northern Scotian Shelf and the southwest Newfoundland-southern Gulf stock complex. For Canso Bank herring the nematode incidence increases rapidly from about 15% for 27-cm fish to over 90% for herring larger than 33 cm total length. For Banquereau fish the incidence in 30-cm herring (the smallest examined) is about 60%, similar to that in Canso Bank herring, and increases to more than 90% for fish larger than 35 cm. The nematode intensity likewise increases with fish size (age) for both Canso Bank and Banquereau herring. In herring from southwest Newfoundland and St. Paul Island the increase in abundance with increase in fish size is much less pronounced; they have an average of less than one nematode per fish for all sizes up to 35 cm. For southwest Newfoundland herring the overall incidence increased from 33% during the 1970 winter fishery to 45% during the 1971 fishery. This is because the average size of the herring increased from 33.2 cm in the 1970 samples to 34.2 cm in the 1971 samples.

Total length measurements have been obtained from approximately 4000 larval nematodes and an attempt made to relate *Anisakis* length to host age. Preliminary analyses are inconclusive but suggest that the worms are permanent parasites in herring and continue to grow over an extended period in the herring.

7. Herring meristic studies

L. S. Parsons

Supplementary material, mainly from the northern Newfoundland-southern Labrador area, was collected during 1971 for studies of morphological differences between herring from various Newfoundland and adjacent areas.

To further evaluate the use of meristic characters as indices for racial separation, the technique of discriminant function analysis was applied to herring meristic data for spring and autumn spawners. From 79 to 91% of individual spring- and autumn-spawning herring were correctly classified to their respective spawning groups by the use of a linear discriminant function based on 3 meristic characters - pectoral and anal fin rays and gill rakers. The results of the discriminant function analyses confirm that the spring- and autumn-spawning components of the southwest Newfoundland-southern Gulf of St. Lawrence herring stock complex

are not members of a homogeneous group but constitute distinct breeding populations which develop at different times of the year under different environmental conditions. This clearly demonstrates that the vast majority of autumn spawners are the progeny of herring which spawned in the autumn and spring spawners of herring which spawned in the spring. The amount of interchange between the 2 spawning groups is probably slight.

In the Newfoundland area there are geographic trends in the mean numbers of gill rakers and anal fin rays which appear to be correlated with water temperature during early development. Spring-spawning herring from the generally cold waters of eastern Newfoundland have higher gill-raker averages than spring spawners from southeastern Newfoundland where water temperatures are somewhat intermediate. The lowest gill-raker averages occur along southwest Newfoundland and in the southern Gulf of St. Lawrence, generally warm areas which are relatively unaffected by the cold waters of the Labrador Current. The mean number of anal fin rays is also higher for eastern Newfoundland spring spawners than for spring spawners from southern Newfoundland and the Magdalen Islands. Hawke's Bay spring spawners are somewhat anomalous in that they are similar in mean number of gill rakers to southeastern Newfoundland spring spawners but are similar to eastern Newfoundland spring spawners in the mean number of anal fin rays. No such geographic trends are evident among autumn spawners. It is possible that temperature conditions on the spawning grounds and in the larval nursery areas are more uniform throughout the Newfoundland area during the autumn than during the spring or early summer.

S. Offshore herring survey of the  
Scotian Shelf March 1971

L. S. Parsons

In March 1971 the Fisheries Research Board, utilizing funds provided by the Industrial Development Branch, chartered the 156-ft steel stern-trawler *J. B. Nickerson* to conduct an echo-sounder and midwater-trawling survey from Banquereau to Emerald Bank during March 15-28, 1971. The primary purpose of the cruise, a joint venture of the St. John's and St. Andrews Biological Stations, was to assess the winter distribution and abundance of herring on the Scotian Shelf and to obtain herring samples for biological and biochemical studies.

Extensive coverage of the Scotian Shelf north of Sable Island during March 15-24 yielded little evidence of widespread distribution of herring. A 2-hr midwater-trawl haul on the western edge of Canso Bank March 19 yielded about 3 tons and a 5-hr trawl haul on the southeastern portion of Banquereau March 23 yielded 10 tons. During March 25-27 that part of the Scotian Shelf from off Halifax seaward to the eastern slopes of Sable Island and Emerald Bank was surveyed without detecting sufficient quantities of fish to warrant setting the midwater trawl. The presence of a fleet of 15-20 USSR purse seiners along the southeastern slope of Banquereau and a fleet of more than 30 USSR seiners along the northern edge of Western Bank suggested the presence of herring but no daytime activity was observed. However, during the night of March 25 these vessels were apparently operating drift nets near the surface.

In an attempt to clarify the relationship between southwest Newfoundland-southern Gulf of St. Lawrence herring and those which frequent the northern part of the Scotian Shelf, herring taken on Canso Bank and Banquereau on the *J. B. Nickerson* cruise were compared with herring from the purse-seine fishery along southwest Newfoundland during winter, in Chedabucto Bay during February and March and near St. Paul Island in April. Analyses of data on the incidence and intensity of the larval nematode *Anisakis* in herring from the various areas, supported by differences in pectoral, fin-ray and gill-raker numbers, indicate that herring from the southern Gulf of St. Lawrence-southwest Newfoundland region do not intermingle to any great extent with herring concentrations fished in winter by Canadian vessels in the Chedabucto Bay-Canso Bank area and by European vessels on Banquereau. It was also concluded that the herring samples taken on Canso Bank and Banquereau were derived from the same stock of which most of the adults overwinter offshore on Banquereau but the younger herring closer to shore in the Canso Bank-Chedabucto Bay area.

9. Herring investigations in eastern and northern Newfoundland and southern Labrador

L. S. Parsons

Studies aimed at elucidating the biology, distribution, relative abundance and seasonal movements of herring in eastern and northern Newfoundland and southern Labrador were intensified in 1971. Two research vessel surveys were conducted in those areas.

During a gillnet survey of Notre Dame, Bonavista and Trinity bays by the *Marinus* in May, herring were found to be most abundant in Notre Dame Bay with fairly large catches being made at Comfort Cove (1400 lb) and Phillip's Head (650 lb). In Bonavista and Trinity bays much smaller quantities of herring (approximately 40-60 herring per set) were caught. An echo-sounder survey did not detect any large concentrations of fish but numerous small markings were recorded in Notre Dame Bay; the best catches of herring were obtained in nets set at the surface. Most of the herring were maturing for spring spawning but there were a few recovering spents. According to local fishermen, spawning occurred earlier than usual in Notre Dame Bay in 1971; most of the observed spring spawnings took place between May 20 and June 1. Average length of the herring caught in the *Marinus* gillnet survey was 32.1 cm. The 1963 year-class was dominant as 8-year-old herring.

During the latter half of June a gillnet survey was conducted from Canada Bay to St. Margaret's Bay in northern Newfoundland and Anse Amour to St. Lewis Sound along the Labrador side of the Strait of Belle Isle. Catches were generally small. The largest catches (322 and 501 herring respectively) were obtained near Thistle Rock, Red Bay and off Dog Point, St. Margaret's Bay. The bulk of the herring were caught in nets set at a depth of 3 fath beneath the surface. Small markings of what appeared to be herring were detected along the Labrador side of Belle Isle Strait. It appeared that the herring were dispersed offshore feeding; the only markings that were recorded occurred offshore rather than in the bays and inlets.

Spring-spawning herring (recovering spents) predominated in the eastern part of Belle Isle Strait and late summer-autumn spawners (maturing) to the west. Only 38% of the herring taken at Quirpon, 22% of those taken in St. Lewis Sound and 36% of those taken in the Red Bay area were late summer-autumn spawners but 92% of the St. Margaret's Bay herring and 74% of those taken in the Forteau-L'Anse au Loup area belonged to that category.

Surface plankton tows yielded good catches of fish larvae in the Strait of Belle Isle area in late June. A substantial proportion of these were subsequently identified as herring larvae, which indicates a significant spring spawning of herring in the northern Newfoundland-southern Labrador area.

In addition to the 2 research vessel cruises, several field trips were made to east coast bays and the Strait of Belle Isle area to collect samples of herring from inshore fishermen for biological examination and to obtain information on the fishery for and seasonal movements of herring in these areas. Approximately 2900 herring from eastern Newfoundland bays, 1100 from northern Newfoundland (Quirpon to St. Margaret's Bay) and 700 from southern Labrador were examined for length, weight, sex, maturity, nematodes and meristics and otoliths taken for subsequent age determination. An additional 3000 herring from eastern and northern Newfoundland were examined for length, sex and maturity only.

Three-year-old pre-recruit herring (24-27 cm) were unusually abundant in the eastern portion of the Strait of Belle Isle during the summer of 1971. Herring of the same 1968 year-class were relatively abundant in east Newfoundland herring catches in the autumn of 1971. This indicates good survival of the 1968 year-class of spring spawners, which appears to be the first relatively strong year-class since that of 1963.

To further delineate stock interrelationships of eastern and northern Newfoundland herring and ascertain migration patterns, a limited number of herring for tagging were obtained from codtraps lined with small mesh or "herring backs" in northern Newfoundland during late August. On August 26, 355 herring were tagged at Straitsview with an external anchor tag consisting of yellow vinyl tubing attached to a nylon monofilament T-bar. One of the tagged herring was recaptured in the Straitsview area shortly after release and another was recaptured in Green Bay on November 8. Four shredded tags were reportedly observed in a herring filleting machine at Port au Choix on the Great Northern Peninsula during November 8-15. These must have been recaptures from the Straitsview tagging, which was the only external tagging performed up to that time.

ANADROMOUS FISH

A. W. May

Research continued in 1971 on ecology and population dynamics of salmon in the marine environment. Particular emphasis was directed toward tagging from commercial fisheries to investigate exploitation rates and stock origins, and on other techniques (morphometrics, meristics, parasitology and biochemical systematics) for identification of origins of mixed stocks. Additionally, substantial effort was directed toward collection of size and age data from Labrador and Newfoundland commercial fisheries as background for investigations of effects of distant fisheries on home waters fisheries and spawning escapements.

Research on the pink salmon transplant again continued at a minimal level, consisting only of maintenance of stream facilities and enumeration of runs of pink salmon and other species.

1. Atlantic salmon tagging, 1969-71

A. W. May, W. H. Lear

Data from tagging experiments during commercial fisheries and on the high seas in 1969, 1970 and 1971 are summarized below.

(DN = Drift net, LL = Longline)

Year	Area	Month	Gear	No. tagged	Returns			
					1969	1970	1971	Total
1969	Port aux Basques	May-June	DN	247	95	11	0	106
	West Greenland	Sept-Oct	DN	385	15	14	1	30
1970	Labrador Sea	April	DN	22	-	2	0	2
			LL	5	-	1	0	1
	Miramichi Bay	June-July	DN	302	-	112	22	134
	West Greenland	Sept-Oct	DN	147	-	3	0	3
1971	Labrador Sea	May	DN	24	-	-	2	2
			LL	35	-	-	6	6
	Labrador Coast	July	DN	145	-	-	36	36
	West Greenland	Sept	DN	121	-	-	1	1

About 75% of the returns from the Port aux Basques tagging in 1969 came from the Canadian mainland (almost entirely Quebec and New Brunswick), while the remainder were almost entirely from the Newfoundland west coast. The West Greenland tagging in 1969 produced 30 returns, of which 17 were from Greenland (2 in the year following tagging), 7 from Canadian waters and 6 from Europe. Tagging at Greenland in 1970 produced only 3 local returns.

Tagging in the Labrador Sea in spring has proved to be most successful when based on fishing by longlines rather than gillnets. Of 86 fish tagged in 1970 and 1971, 11 have returned; 6 from Newfoundland fisheries and 5 from the Canadian mainland.

Most returns from tagging during the period of the Miramichi drift net fishery in 1970 were from the Miramichi River and estuary, with a few returns from Chaleur Bay.

Tagging on the southern Labrador coast in 1971 was delayed due to mechanical problems with the research vessel *Marinus*, and most of the 145 fish tagged were grilse. Returns were almost entirely from the Labrador coast.

## 2. Scale studies

W. H. Lear

Analysis of scale patterns of Atlantic salmon smolts indicates that there are significant differences between the widths of annual growth zones and numbers of circuli on scales of smolts from rivers of widely different geographic areas. There were, however, large annual variations in the average widths of the annual zones and numbers of circuli in the second river zone of adult salmon taken in West Greenland during 1969 and 1970 and classified as of North American or European origin employing an electrophoretic technique on serum protein patterns. This may be due to annual variation in temperature, or in food and nutrients in the rivers from which the salmon originated, or possibly because the proportions of fish originating from both North America and Europe were derived from different river systems in 1969 than in 1970. The average widths of the first ocean zone for North American salmon taken at West Greenland during 1969 and 1970 were similar as also were those of European origin. However, there was a significant difference between the average widths of the first sea zone of scales of salmon originating in these 2 continents.

Analysis of the scale patterns of adult salmon and grilse recaptured in the Miramichi River System and in Labrador rivers from tagging experiments indicates that there are significant differences in the patterns of growth in the second river year between these 2 areas. However, the patterns of growth in the first annual sea zone show no significant difference and indicate the possibility that fish from both these geographic areas share similar feeding areas and live under similar hydrographic conditions during their first year of sea life.

The magnitude of variation in these growth patterns in the scale is such that it may be virtually impossible to take a sample of fish from the high seas or the commercial coastal fishery and determine the proportions originating in different areas on the basis of scale patterns alone. However, it may be possible to do so by using other characters in addition to scale patterns such as number of vertebrae or number of gill rakers.

## 3. Commercial sampling

W. H. Lear

The program of sampling Atlantic salmon from commercial catches was continued in 1971 to provide quantitative data on the sizes and ages of salmon taken in commercial fisheries. A total of 2962 salmon was

sampled for length, weight, scales and where possible for sex from the commercial fisheries at Port aux Basques, Bonavista, eastern portion of the Great Northern Peninsula including St. Anthony, various fishing communities along the southern Labrador coast and near St. John's. Samples of viscera and blood were also obtained from a representative sample of the fish. In addition 930 salmon were also sampled for viscera, length, sex and weight in connection with parasite investigations at Carleton, P.Q., Loggieville, N.B., and Saint John, N.B.

Analysis of the smolt ages of salmon and grilse sampled during 1969-70 shows that most of the fish caught along the Labrador coast have spent 4-5 years in the river and indicate that it is highly probable that they are of Labrador or northern Newfoundland origin. Fish sampled from St. Anthony and the eastern part of the Great Northern Peninsula have lower smolt ages than those of Labrador but, in many cases, significantly higher than those of Bonavista, Port aux Basques and Miramichi Bay (Table 1).

Table 1. Average smolt ages of Atlantic salmon sampled from various areas during 1969-70 (Res = Research, Comm = Commercial).

Area	Type of gear	Type of sample	Sea age					Total
			1	2	3	4	Previous spawners	
<u>1969</u>								
Port aux Basques	DN	Res	3.14	3.21	2.97	-	2.97	3.16
Bonavista	SN	Comm	3.00	2.83	2.37	-	3.00	2.80
St. Anthony	SN	Comm	3.33	3.79	3.00	-	4.00	3.56
Eastern Great Northern Peninsula (excluding St. Anthony)								
Labrador	SN	Comm	4.40	4.28	4.00	-	4.00	4.25
St. John's	SN	Comm	3.27	2.79	2.40	-	2.67	2.80
<u>1970</u>								
Rose Blanche	DN	Comm	2.75	3.18	3.02	3.00	3.19	3.16
Rose Blanche	SN	Comm	3.92	3.19	3.00	-	3.00	3.24
Bonavista	SN&T	Comm	3.19	2.78	2.95	-	3.20	2.99
St. Anthony	SN	Comm	3.99	4.01	5.00	-	4.00	4.01
Eastern Great Northern Peninsula (excluding St. Anthony)								
Labrador	SN	Comm	4.06	4.07	2.00	-	4.44	4.07
Conception Bay	SN	Comm	4.50	4.59	4.00	-	4.70	4.59
Miramichi Bay	SN	Comm	-	2.95	2.50	-	-	2.90
Miramichi Bay	DN	Res	2.99	2.79	3.25	-	2.67	2.88

DN = Drift net, SN = Set net, T = Trap

Analysis of the length data from fish sampled during June 1971 at Bonavista suggests that the ratio of grilse to older salmon changes significantly as the season progresses. The percentage of fish less than 62 cm (fork length) increased from 17.5% during June 8-11 to 46.4% during June 15-19 and to 54.9% during June 21-22.

#### 4. Biochemical systematics

R. H. Payne

Studies are being undertaken on the biochemical systematics of Atlantic salmon to establish the existence of major geographical races and to develop a program to determine the country of origin of Atlantic salmon caught on the high seas.

It has been demonstrated that European and North American salmon populations differ in specific serum proteins and that there are regional differences in the frequencies of the genes which determine these variant proteins. Studies are therefore being conducted to delimit local races of Atlantic salmon in North America.

Another aspect of the biology of Atlantic salmon which is being investigated is the existence of landlocked populations. It is believed that these populations are derived from typical anadromous fishes which were isolated from the sea by Postglacial crustal uplift and subsequently developed precocious sexuality. Genetically-determined variation common to local landlocked and anadromous populations would have been present prior to isolation of the landlocked population but genes which are not present in both populations would have arisen by mutation or immigration (anadromous populations) since the time of isolation. As it should be possible to calculate the date of isolation from geological considerations, a study of these landlocked populations and their anadromous neighbours would shed light on the rate of evolution in Atlantic salmon. Additionally, the concomitant existence of apparently non-interbreeding anadromous and nonanadromous populations of Atlantic salmon in several Newfoundland rivers is not only of some theoretical significance but an analysis of the genetics of this situation may be important to the commercial management of salmon.

It has become apparent that there is a need for biochemical systematics facilities in areas other than the Anadromous Division and requests for assistance have been received from other sections: Groundfish, studies on the biochemical systematics of population concentrations of American plaice in the Newfoundland area; Pelagic Fish, demonstration that spring- and autumn-spawning groups of herring off southwestern Newfoundland are genetically-distinct populations; Commercial Invertebrates, biochemical taxonomy of squids.

#### 5. Atlantic salmon parasites - stock identification

J.H.C. Pippy

Studies continued in 1971 to determine if parasites might be useful to separate stocks of Atlantic salmon caught on the high seas.

Emphasis was placed on continued sampling at 9 Canadian sampling stations and in West Greenland. Preliminary observations on the data compiled to date support earlier conclusions that in Greenland the parasitic nematode *Anisakis* sp. is more abundant in salmon of European origin. Also, that the tapeworm *Eubothrium crassum* is more abundant in salmon of Canadian origin.

Electrophoretic analyses of *Anisakis* larvae from Canadian salmon have continued and the work has been expanded to genetically controlled esterase and acid phosphatase polymorphisms in larvae from salmon taken in the British Isles. Results indicate genetic heterogeneity among samples of *Anisakis* larvae from different areas of the North Atlantic.

6. Pink salmon transplanted

W. H. Lear, A. W. May

Research on the pink salmon transplanted at North Harbour River continued at a minimal level in 1971. Current operations consist only of maintenance of stream facilities, enumeration of pink salmon and other species and collection of environmental data. A fry trap was operated at the mouth of the egg channel from April 6 to May 17. A counting fence with the trap set for the downstream migrating fish was installed in fishing order on May 3, approximately 100 ft above the head of tide. The trap was reversed for the upstream migration on June 10 and remained in good fishing order until October 12 when the nets were removed.

Fry survival. To determine the time of hatching and survival rate of pink salmon fry from the 1970 spawning, 12 perforated plastic boxes containing 25 eggs each were distributed in the spawning areas on September 15, 1970. One sample was examined weekly until hatching and monthly thereafter. The eggs had all eyed by October 15 and hatching occurred during the period November 13-19. This was 3 weeks earlier than for the previous year and the earliest record for North Harbour River.

To obtain an estimate of the total number of fry migrating to sea, small fyke traps were fished just above the head of tide from April 5 to May 17. The total number of fry was estimated by the mark and recapture method. The percentage survival of pink fry for 1969, 1970 and 1971 is as follows:

	<u>1969</u>	<u>1970</u>	<u>1971</u>
Egg samples (actual count)	80.4	77.0	78.5
Spawning channel (actual count)	77.8	75.2	76.4
River (mark-recapture estimate)	75.8	71.7	70.0

The estimated total fry run from the spawning channel was 126,795 fry from an estimated 161,600 eggs deposited by 101 females in 1970. To determine the extent of predation on fry during their migration to sea, a nylon gillnet was fished near the head of tide at various times during the run. Only 8 brook trout, 2 brown trout and 147 smelt were caught. None of these had any fry in their stomachs. The fry run was ended before the trout migration began.

Adult returns. The pink salmon run began July 17 and ended September 28. The total was 468 fish (235 males, 233 females), of which 296 were counted at the fence, 141 were seined below the fence and 31 spawned below the fence. All fish seined below the fence and some that passed through the fence were placed in the channel, both ends of which were screened to prevent escape. Total placed in the channel was 330 fish (162 males, 168 females).

Water temperature at the fence during the run ranged from 8.5 C to 24.5 C and water heights from 1 to 3 ft. Every tenth salmon of each sex passing through the fence was measured, weighed and a scale sample taken.

Except for a few late-running fish, spawning occurred between September 10 and 25 with the greatest concentration September 15-18. Although only 138 fish (73 males, 65 females) spawned in the main river, spawning was distributed over 3½ miles of river but unlike previous years none was seen in Cataract Brook. At the completion of spawning 231 redds were counted, 65 in the main river and 166 in the channel.

As in previous years, catch record forms were distributed to commercial salmon fishermen in St. Mary's Bay. A number of fishermen did not complete their forms because of the declining number of pink salmon and a poor Atlantic salmon fishery this year. However, when contacted they did supply their catch figures.

This year, pink salmon report forms were distributed to Fisheries Officers and wardens throughout the province.

The total number of pink salmon returns to date is 622 as follows: 468 in North Harbour River, 117 in the commercial fishery, 36 in 4 other rivers and 1 in the sport fishery in salt water. Of the total returns, 95.8% had entered St. Mary's Bay.

Other species. The downstream run of Atlantic salmon smolts began May 6 and ended June 2 with the peak on May 23; the total run was 671 fish. The run of adult Atlantic salmon began July 11 and ended September 12 for a total of 25 fish (11 salmon, 14 grilse).

The downstream run of brook trout began May 4 with the peak on May 18 and ended June 5 for a total of 2135 fish. The upstream run began June 18 and ended October 8 for a total of 1590 fish.

The downstream run of brown trout began May 5 with the peak May 19 and ended June 2 for a total of 1045 fish. The upstream run began June 24 and ended October 10 for a total of 1119 fish.

During the period of downstream migration of trout, 447 smelt and 178 eels were counted.

COMMERCIAL INVERTEBRATES

E. J. Sandeman

During 1971 research was carried out on lobsters, snow crabs, shrimps and squid. In addition a shore survey was conducted to assess the abundance of intertidal clams in northwestern Newfoundland and spat of the European oyster (*Ostrea edulis*) have been transferred to Newfoundland in preparation for an experiment to be started in the spring when an attempt will be made to assess the suitability of the species for introduction to Newfoundland on a commercial scale.

Main emphasis in the lobster investigation has continued to be placed on behaviour, productivity and ecology, with major effort being expended at Comfort Cove, Notre Dame Bay. The snow crab fishery continued to expand during 1971 with the majority of the 3 million lb landed being taken in and outside Conception Bay. Main priority for research on this species in 1971 was placed on obtaining good abundance estimates and effort was concentrated on evaluating several different methods of achieving this. Although most effort was devoted to photographic methods, beam trawling, catching by trap and direct observation from a submersible have also been examined. Shrimp landings at Port au Choix reached 1½ million lb during 1971, the first complete year of this fishery. With additional vessels entering the fishery the main research effort is being concentrated on prediction, on determining the limits of the stock, and on assessing the relative abundance of different year-classes and how these year-classes will affect the fishery in ensuing years. In spite of an encouraging start, total squid landings for the year were only 3½ million lb, considerably above the 166,000 lb landed in 1970 but still far below average. Investigations continued on many aspects of squid biology with emphasis on the identity of the stocks and the migration, mortality and growth involved in the migration of juveniles to our shores and adults to the spawning grounds.

1. Lobster (*Homarus americanus*)

G. P. Ennis

Efforts were continued in 1971 to monitor the commercial fishery in selected areas. These included biological sampling at Comfort Cove, Notre Dame Bay, in the spring, commercial catch measuring, collection of catch-effort statistics and obtaining trap density estimates at Arnold's Cove, Placentia Bay, St. Chad's-Burnside, Bonavista Bay and Comfort Cove, Notre Dame Bay.

Lobsters were tagged with the sphyron tag at Comfort Cove prior to the 1971 moulting season to obtain information on growth, movements, and survival. In the fall, after the moulting season, commercial-sized lobsters were tagged with the back strap tag to determine the rate of exploitation during the 1972 season. Recoveries of lobsters tagged at Arnold's Cove in 1970 were made throughout the 1971 fishing season.

Beginning in April, 7 species of decapod crustaceans that are lobster faunal associates in the St. Chad's area were sampled monthly to determine their maturity and reproductive cycles in order to assess the extent of interspecific competition between the larvae, and especially the effect of these larvae on the survival of lobster larvae. The species sampled

were the spider crabs, *Hyas araneus* and *H. coarctatus*; the rock crab, *Cancer irroratus*; the hermit crabs, *Pagurus arcuatus* and *P. acadianus*; and the shrimps, *Eualus pusiolus* and *Pandalus montagui*. Monthly sampling of these is continuing to complete the year-round picture.

A plankton collecting project using a newly designed diver-operated plankton collector was carried out at St. Chad's throughout the summer. The objectives were to determine decapod larval associations, etc., to study behaviour and distribution of decapod (especially lobster) larvae in the near-shore zone under various wind conditions and to collect different stages of all decapod species for identification and description.

An aquarium experiment to determine the effect of bottom type on the moulting rate of lobster larvae was carried out at St. Chad's during the summer. This was a repeat of the experiment conducted at Arnold's Cove in 1970.

## 2. Atlantic snow crab (*Chionoecetes opilio*)

R. J. Miller

The research projects of the snow crab program may be grouped under conservation and yield prediction of the resource. Progress on projects included in these areas vary from hypothesis formulation to preliminary results.

Conservation. Crab catch in the bottom gillnet fishery. An estimated 4 million lb of snow crabs are caught annually in the gillnet fishery in eastern Newfoundland. These are a nuisance to gillnetters since the crabs break the meshes of gillnets and are time consuming to remove. These crabs are a loss to the crab fishery (less than 1% are marketed) because it is not worth the fishermen's time to remove them in a healthy condition and the quantities caught by one boat are usually too small to make it worthwhile transporting them to a crab processing plant. Preliminary results indicate a high percentage of commercial crabs, carapace width 102 mm (4 inches) or greater, in this catch and a low survival of animals returned to the sea. Attempts to design a gillnet that will catch fish but not crabs have not been successful.

Catch of subcommercial crabs by the crab fishery. The percentage of subcommercial size animals in the commercial catch varies from about 50% in Conception Bay to 75% in Trinity Bay. These subcommercial animals are a nuisance to the fishermen because of time spent culling the catch and are also some loss to the fishery because of mortality due to deck exposure to subfreezing temperatures and warm summer temperatures. The magnitude of this loss has not yet been quantified. Preliminary experiments with net mesh size suggest that fewer crabs of all sizes are caught using a mesh large enough to allow the subcommercial animals to escape. The large meshes must deter the entry of large animals into the traps. Therefore, traps with small mesh and escapement rings or slits in the mesh appear to be the best solution.

Yield prediction. Areas yielding commercial catches of crabs. A large volume of catch/trap data was provided by Fisheries Research Board

observers accompanying exploratory fishing surveys conducted by the Industrial Development Branch. By defining the minimum commercial catch as 20 crabs of commercial size per trap, it appears that Placentia, St. Mary's, Conception, Bonavista, Notre Dame and White bays all have some commercial potential. The south coast of Newfoundland west of Placentia Bay, the west coast, the St. Anthony area, and most of Trinity Bay have not yielded commercial catches. Most of the offshore area around the Avalon Peninsula has also been unproductive. There is need for further exploratory work in the offshore areas on the east coast north of St. John's.

Crab population density. Trap catches alone indicate only relative crab densities and provide no information on absolute population density or sustainable yield. To use trap catches as indicators of absolute density we have attempted to determine the area "fished" per trap. The absolute crab density in areas was determined using bottom photography and this was followed by fishing the areas with traps. In Conception Bay the results for 1300 m<sup>2</sup> of bottom photographed were 220 m<sup>2</sup>/commercial crab and 7630 m<sup>2</sup> "fished"/trap. In Placentia Bay the results for 8280 m<sup>2</sup> of bottom photographed were 286 m<sup>2</sup>/commercial crab and 4860 m<sup>2</sup> fished/trap. These results must be considered preliminary since only 15 and 29 commercial crabs were photographed in Conception and Placentia bays respectively.

Sustainable yield: the sustainable yield of a population is defined as the annual recruitment to commercial size and is calculated as:

$$\text{sustainable yield (lb/yr)} = \frac{\text{catch of commercial crabs/trap (lb)}}{\text{fraction in recruit moult class}} \times \frac{\text{fraction of recruit moult class moulting/yr}}{\text{area fished/trap (m}^2\text{)}} \times \text{area occupied by population (m}^2\text{)}$$

The recruit moult class is defined as the range of animal sizes that became commercial size at their last moult. This size range is for the present taken from some unpublished data provided by Dr. J. Watson of the Fisheries Research Board's Biological Station, St. Andrews, N.B. The fraction of commercial animals in the recruit moult class is available from measurements of animal size in commercial catches or exploratory fishing records. The fraction moulting per year is assumed equal to the maximum fraction of animals in the recruit moult class with a soft shell at any one time of the year (most of the moulting appears to occur in June). A population is arbitrarily defined as all animals in water deeper than 90 fath within a bay or adjacent to a particular length of coastline.

Supplementary data from bottom photographs. Size frequency distribution of crabs in the photographs from Placentia Bay showed 5% smaller than 40 mm, 71% from 40 to 69 mm, 18% from 70 to 101 mm, and 6% larger than 101 mm. These data combined with beam trawl data showed that only 5% were sexually immature, only 6% were of commercial size, and the sex ratio was about 2:1 female to male. On a biomass basis the percentages are 0.7%, 39%, 35% and 25% for the 4 size classes respectively. Average biomass for commercial animals (> 101 mm) was 1.9 g/m<sup>2</sup> and for all sizes combined was 7.4 g/m<sup>2</sup>.

Other abundant epifaunal invertebrates in the crab habitat were whelks, shrimp, hermit crabs, basket stars and mudstars. Common fish were plaice, turbot, witch, eelpout and alligatorfish.

3. Shrimp (*Pandalus borealis*)

E. J. Sandeman

In 1971, the first full year of the new shrimp fishery at Port au Choix on the northwest coast of Newfoundland, 1½ million lb of shrimp were landed. The number of vessels engaged in the fishery increased during the year; at the end of 1970 only about 8 vessels were rigged for shrimp trawling but by December 1971 the number increased to about 18. Although grounds suitable for a viable shrimp fishery have been shown to extend some 40 miles or more southeast from Port au Choix in the deeper (> 100 fath) water of the Esquiman Channel, fishing during 1971, for the most part, was carried out only on the northern extremity of the known grounds with almost the entire catch being obtained from an area of about 50 square miles.

The severity of the winter weather and the attendant ice conditions prevented any fishery during January, February and March. In April, when the fishery started, excellent catches were obtained with the fleet attaining an average catch of more than 200 lb/hour's trawling. Characteristically, these good catches which proved to be the best of the year were of ovigerous females just prior to the hatching of their eggs. Catches of shrimp decreased to about 90 lb/hour's trawling during the late July-August period after which they increased as a new, rather strong year-class (1969) entered the fishery in increasing numbers.

The effect of the 1969 year-class on the fishery was considerable, for in the months of September, October and November over half the shrimp landed were of this year-class. The rather dramatic decrease in count/lb from 55 in April to 90 in late July illustrates the joint influence of increased availability of the new abundant year-class to the otter trawl at the same time that mortality, both from natural causes and from fishing, caused a reduction in the stocks of larger and older shrimp.

A preliminary estimate of the growth rate and examination of the relative success of the year-classes of which the present stock is composed indicates that, although the 1969 year-class is likely to exert a considerable influence on the fishery, those of 1968 and 1967 were not impressive. Thus, we might anticipate that the fishery will rely rather heavily on small shrimps during 1972 and 1973. This conclusion is based on the limited data available only from the area of the 1971 commercial fishery. If the fleet ranges farther afield and in particular to deeper water, it is likely that greater numbers of larger shrimps (1966 and 1967 year-classes) will be available.

4. Bait squid (*Illex illecebrosus*)

M. C. Mercer

Offshore surveys. In a groundfish survey completed by the *Academician Knipovitch* about June 25, catches of 20-40 kg/hr of *Illex*

were made on the St. Pierre Bank while no squid were encountered on the Grand Bank (Dr. Y. Benko, in conversation).

The *E. E. Prince* conducted a squid survey on the shelf off southern Newfoundland and Nova Scotia, July 12-22, 1971. Fifty-eight otter-trawl sets were made at locations fished in the 1970 surveys. Squid were taken in all areas except the southern tip of the Grand Bank. Largest catches were made in the Eastern Gully east of Green Bank (860 and 133 specimens in 75 and 150 fath respectively), on Banquereau (186 specimens in 100 fath) and south of Sable Island (268 specimens in 100 fath). Total catch for the cruise was 2100 specimens, up considerably from the 1970 surveys. Standard biological sampling was conducted and specimens collected for electrophoretic study.

The fishery. Squid were first reported inshore at North Harbour, Placentia Bay on June 17, the earliest inshore appearance on record. First east coast records were strandings on June 24 at Ferryland and first commercial landings were made there on about June 28. In spite of the encouraging start, total landings for the year were only 3,513,145 lb, up considerably from 166,000 lb in 1970 but still far below average. The jigging ground at Holyrood produced at the same level as in 1967 but this accounted for 20% of the Newfoundland landings; catches at Holyrood were greatest in July and August, no squid were landed September 12-October 11 after which low landings continued to November 10.

The surface temperature at Holyrood was 7.0 to 7.4 C on July 5 at the time of first landings. The time of absence of squid from the grounds coincided with the warmest temperature conditions, ca 10-12 C. On October 12, when the squid returned, surface temperatures were 7.6-9.5 C; their departure coincided with the first drop of temperature below 5 C.

Population sampling and tagging. Size distributions, growth, maturity and parasites were monitored throughout the season at Holyrood and several population samples were obtained from other areas for comparison.

Tagging was accomplished with a small metal clip tag fastened to the fin, the technique being similar to that employed in Japanese research on a closely related species. A return of 18.7% was obtained for a tagging of 402 squid at Holyrood. Although the experiment was publicized by radio and through distribution of posters, all returns were from Holyrood. Nearly all recaptures were made within 2 days of tagging but a few were reported captured up to 86 days after release.

##### 5. Soft-shell clam (*Mya arenaria*)

M. C. Mercer

During July and August a survey was conducted to assess the abundance of intertidal clams in northwestern Newfoundland; most beaches between St. Pauls Bay and Pistolet Bay were visited.

Samples were collected hydraulically from 1/5 m<sup>2</sup> stations set at fixed intervals on transects from the low to the high water lines: *Mya arenaria* and *Macoma balthica* were the only species encountered and standing stocks were small in all surveyed areas except Hawke Bay where a first assessment indicated a density of seven 2" *Mya*/m<sup>2</sup> over a flat estimated at 700,000 m<sup>2</sup>.

Circumstantial evidence was obtained for raven predation on *Mya* by active digging. Hundreds of excavations 3-6 inches deep were observed in exposed substrate at Hawke Bay; each pit was surrounded by bird tracks and had a large broken *Mya* shell nearby. The tracks were anisodactyl with narrowly splayed toes as in corvids; corvids were sighted near the beach, the only species reported in the area being the Northern Common Raven (*Corvus corax principalis*).

#### 6. European oyster (*Ostrea edulis*)

M. C. Mercer

On November 15, 1971 approximately 3000 spat were transferred by air from the Ellerslie Substation, Prince Edward Island, to holding facilities provided by the Marine Sciences Research Laboratory (Memorial University), St. John's. These spat represented the second generation bred under quarantine at Ellerslie from oysters imported from Maine, the stock there being of Dutch origin.

It is intended to set the spat in suspended tray culture in the spring of 1972. Growth, meat condition and gametogenesis and environmental conditions in the planting area will be monitored in order to assess the suitability of the species for introduction on a commercial scale. The species has lower thermal requirements for growth and maturation than does the American oyster (*Crassostrea virginica*) and it is larviparous, a further advantage for cultivation under high-exchange situations.

HYDROGRAPHY

W. Templeman

In July-August 1971, the 6 standard monitoring sections taken across the Labrador Current east of Newfoundland at approximately the same time each year were occupied by the *Cape Freeels*. Station 27, off Cape Spear, was occupied monthly or more often during the year. The 1971 section temperatures are compared with the lowest, average, and highest temperatures at each station and depth in 1951-65 at approximately the same dates and also with temperatures in 1969 and 1970.

In the sections, the surface temperatures and salinities are by necessity placed above and occasionally somewhat displaced from the stations which indicate the correct location, otherwise the position of the decimal point indicates the level and position of the temperature or salinity.

1. Sections across the Labrador Current in July-August

W. Templeman

Temperatures. In the Labrador Section from off Seal Islands across Hamilton Inlet Bank (Fig. 1), apart from surface temperatures at the shoreward Stations No. 51-54 which were above average, the temperatures of the western, colder water part of the Labrador Current were below, and the volumes of water below -1 C and below 0 C greater than the 1951-65 average and conditions were closer to those of the years with the lowest observed temperatures than to the average of this period. Temperatures of the cold water section at or below 0 C were not as low as in 1969, but were not greatly different from those of 1970, except that the small coastward volume of water below -1.5 C present in 1970 was not present in 1971. In the offshore, warmer part of the Labrador Current of West Greenland origin, temperatures of the deeper water at the most seaward stations east of the continental slope were close to the 1951-65 average, but were considerably below those of 1970 which were similar to the highest and in some cases higher than any previously encountered, and for the deeper parts of all the deeper stations east of the continental slope were slightly lower than in 1969. Offshore surface temperatures were close to the average for 1951-65.

In the section off Cape Bonavista (Fig. 2), surface temperatures, except at Station No. 47, were higher than any previously recorded. Temperatures in the western, colder mid-water portion of the Labrador Current were below the 1951-65 average and close to the lowest previously encountered but the volumes of water below -1.5 and -1 C were less than the maximum. Coastward in the deepest water and over the Northeast Newfoundland Shelf, temperatures were slightly higher than any of the 1951-65 and 1969 periods, and on the average were similar to those of 1970. In the offshore deeper water adjacent to the continental slope, temperatures were above the average of the 1951-65 period and higher than in 1969 but lower than in 1970.

In the section from St. John's to Flemish Cap (Fig. 3), surface temperatures were above the average but below the highest recorded for the

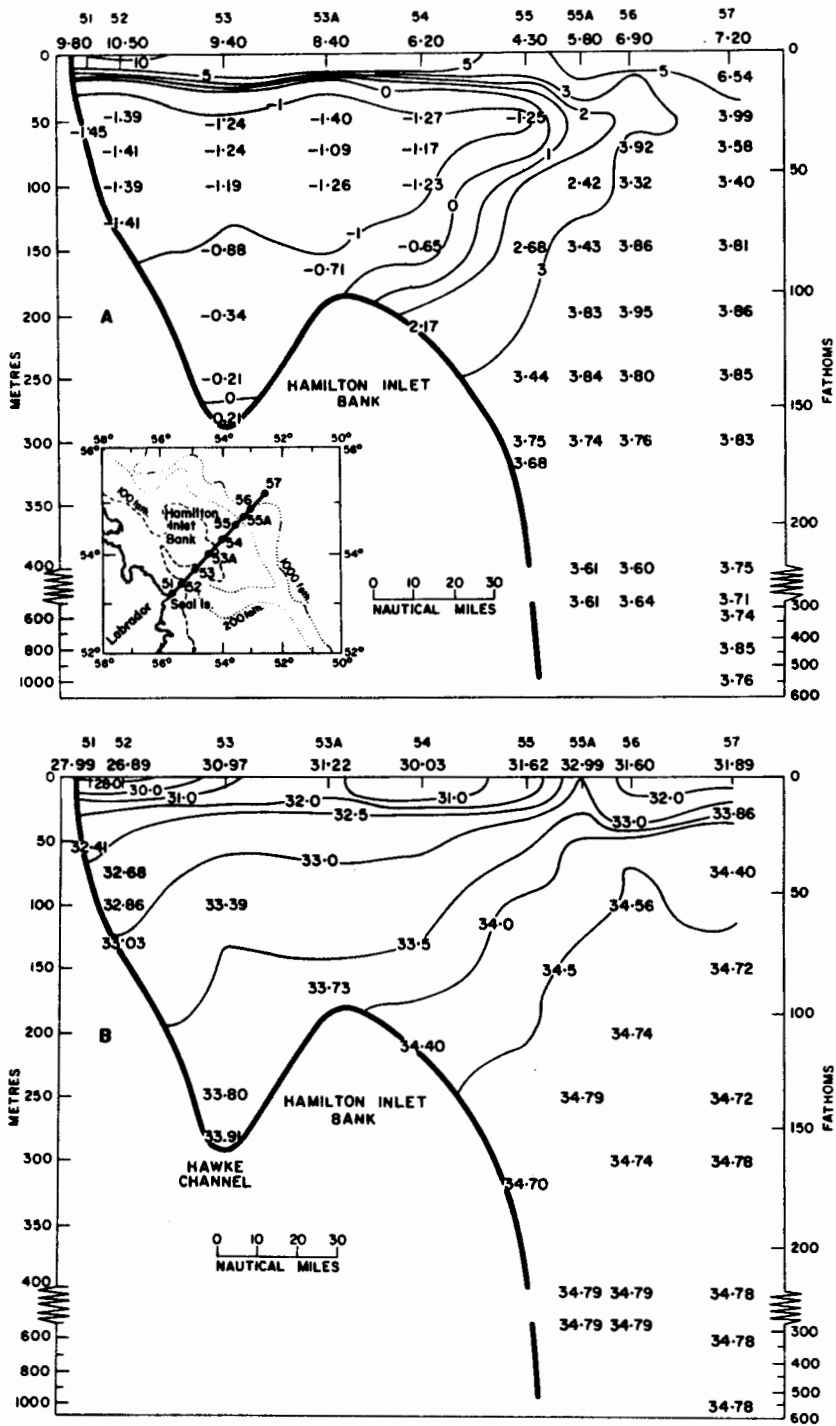


Fig. 1. Temperature (C) above and salinity (‰) below, Seal Island-Hamilton Inlet Bank, 3-4 August 1971.

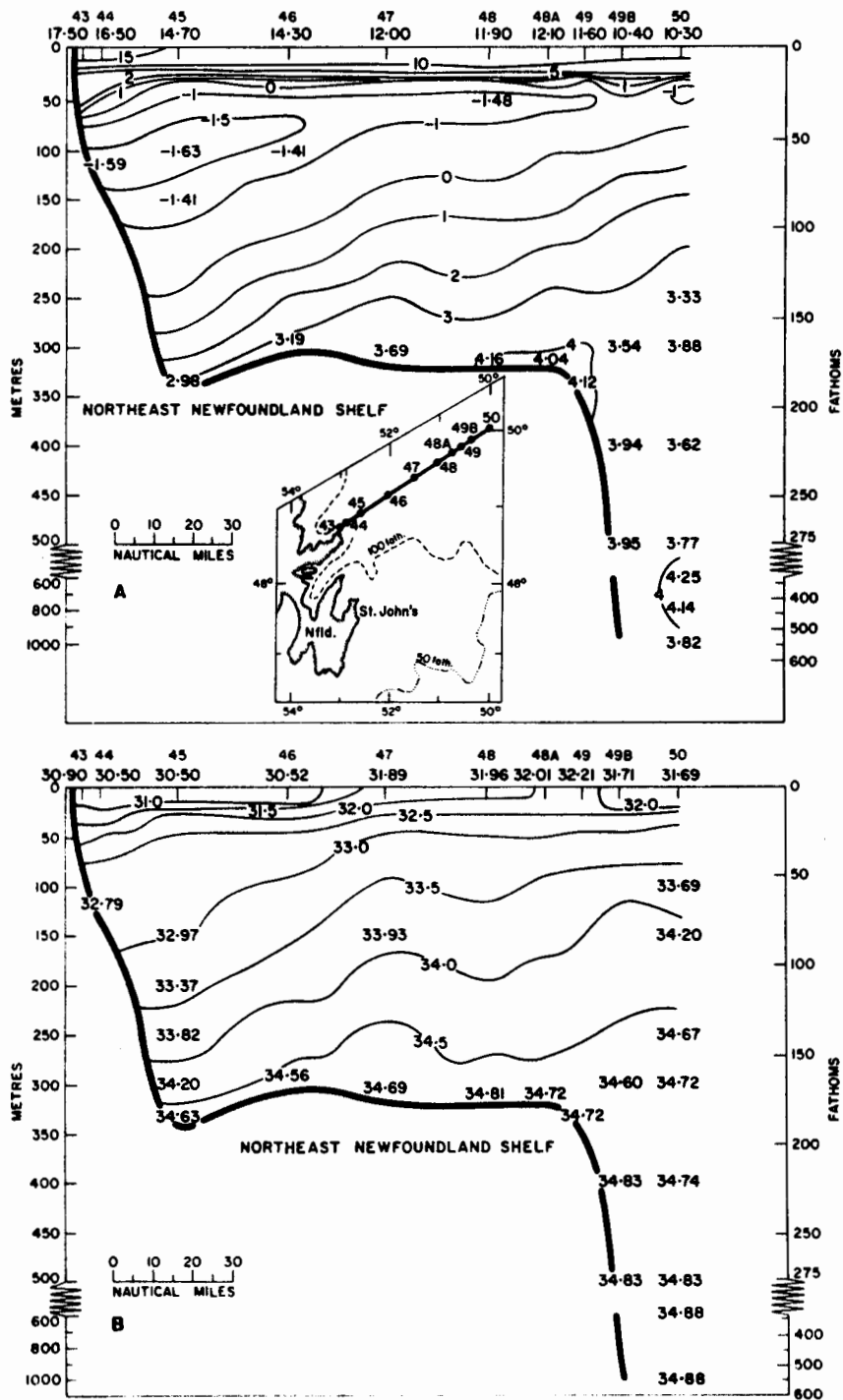


Fig. 2. Temperature (C) above and salinity (‰) below, off Cape Bonavista, 1-2 August 1971.

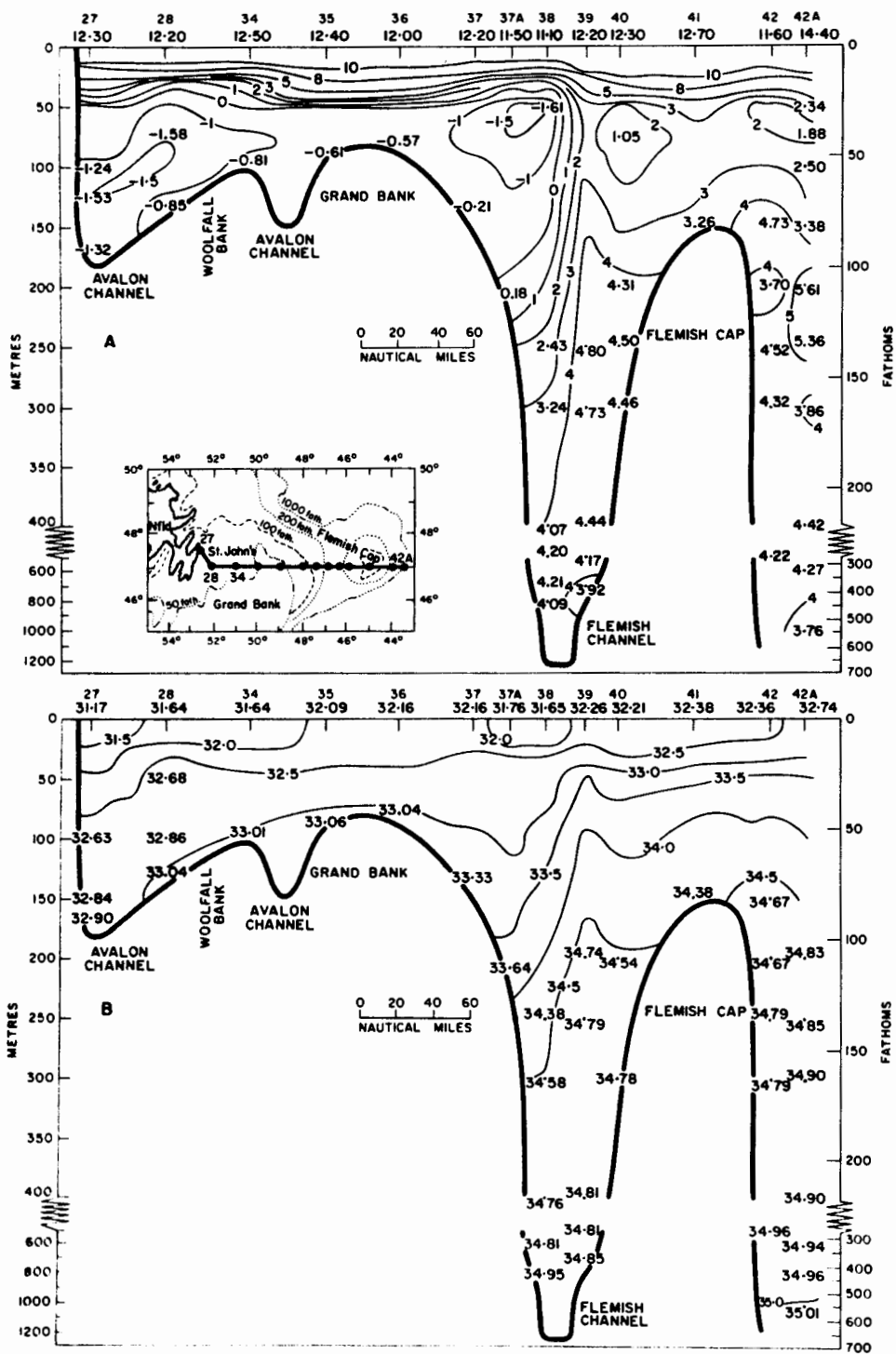


Fig. 3. Temperature (C) above and salinity (‰) below, St. John's-Flemish Cap, 29-31 July 1971.

1951-65 period and were all, except at Station 27 in 1970, above those of 1969 and 1970. In the western, cold water part of the Labrador Current in the Avalon Channel and over the surface of the Grand Bank, temperatures were lower and low temperatures ran deeper than the average of 1951-65 and lower than in 1969 and 1970. Core temperatures in the eastern branch of the colder water of the Labrador Current were lower than the lowest of the 1951-65, 1969-70 period. Lower temperatures also extended farther seaward than in any year of the above period. Temperatures in the offshore, deeper water of the Flemish Channel and on the seaward slope of Flemish Cap were generally higher than the highest of the 1951-65, 1969-70 period but were most similar to those of 1970 when temperatures near the bottom of the western side of Flemish Channel were a little higher, but for most of the remainder, lower than in 1971.

In the section from St. John's to the southeast slope of the Grand Bank (Fig. 4), surface temperatures at the 3 shoreward stations and Station 33D were close to the highest, at the intermediate stations No. 30 and 31 about halfway between the average and the highest, and at the remaining seaward stations close to the average of the 1951-65 period. Surface temperatures were considerably higher than in 1969, and slightly higher for the shoreward Stations No. 27 to 29, and lower for the remaining seaward stations (except 33D) than in 1970. Temperatures in the deeper water of the Avalon Channel were close to the average of the 1951-65 period but at intermediate levels higher than in 1970. Water below 0 C extended a little farther eastward on the Grand Bank than the average of 1951-65 or in 1969-70. The core temperatures in the eastern branch of the Labrador Current to the east of the Grand Bank were lower than the 1951-65 average and lower than in 1969 and 1970. Deep water temperatures below 200 m at the most easterly Station 33F were above the average of the 1951-65 period and, at 600-800 m, were above or equal to the highest of this period, but for the whole station, were lower than 1969 when very high temperatures were recorded and at 200-300 m were lower than in 1970.

In the section extending along the southwestern edge of the Grand Bank at about 75 m (Fig. 5), surface temperatures were usually above the 1951-65 average, much higher than in 1969 and higher than in 1970 at the western Stations No. 20A-24 but generally lower at the eastern stations. Temperatures in the Haddock Channel were below the average of the 1951-65 period and below those of 1969 and 1970. Bottom temperatures over the surface of the Grand Bank were below the 1951-65 average on the central part of the bank and slightly above the 1951-65 level on the eastern part of the bank and were not greatly different from those of 1969 and 1970. The eastern branch of the Labrador Current had a greater than average volume of water below 0 C, temperatures below -1 C extended farther eastward and the lowest temperature of -1.42 C was lower than was previously recorded. Deep water temperatures below 400 m were well above average and close to the highest recorded.

In the section at about 275 m along the southwestern slope of the Grand Bank to St. Pierre Bank (Fig. 6), surface temperatures were above the average but lower than the highest surface temperatures of the 1951-65 period. Most surface temperatures were considerably higher than those of 1969, and at most of the western stations they were higher, and at most of the eastern stations lower than in 1970. Temperatures in the colder part of the western branch of the Labrador Current at Stations 10 and 13 were

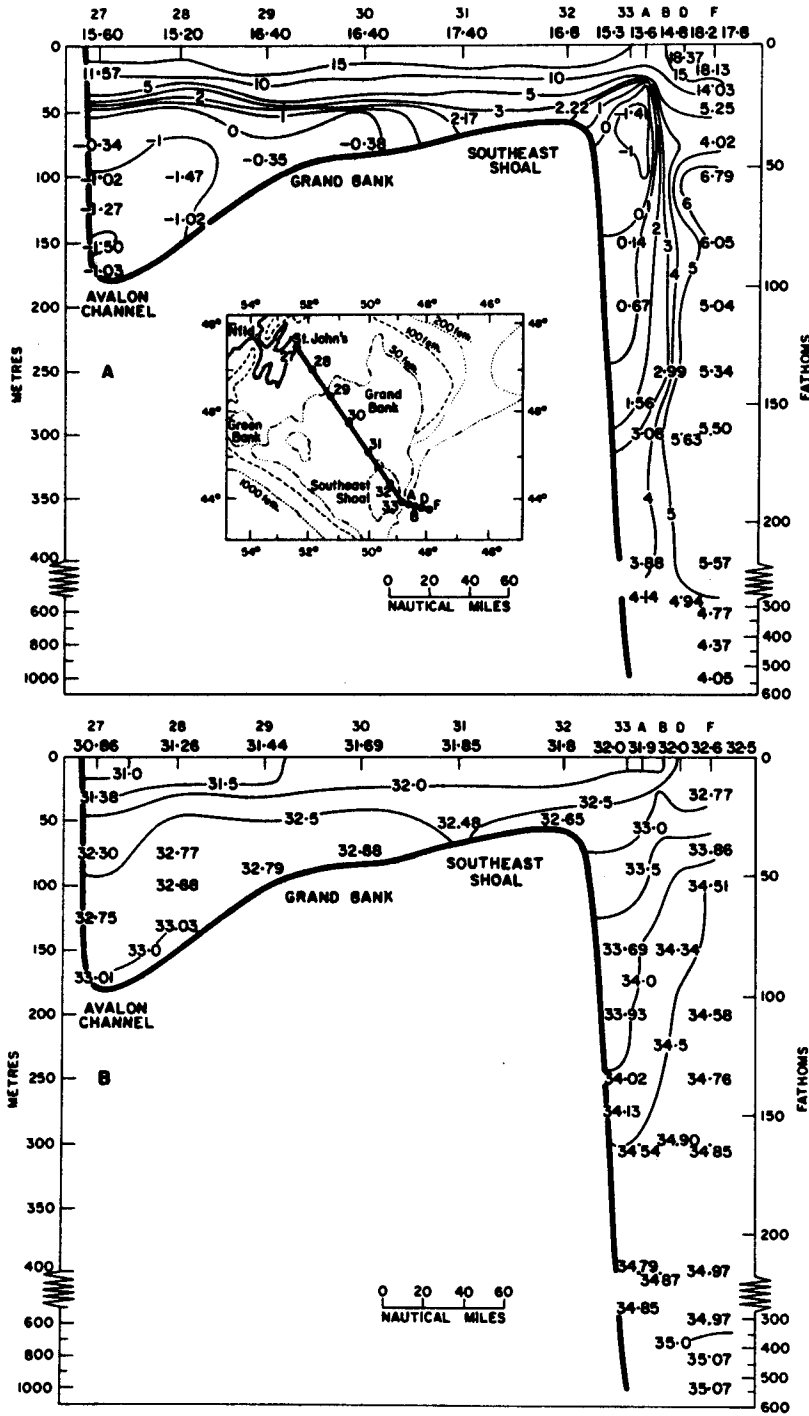


Fig. 4. Temperature (C) above and salinity (‰) below, St. John's-SE slope Grand Bank, 18-19 August 1971.

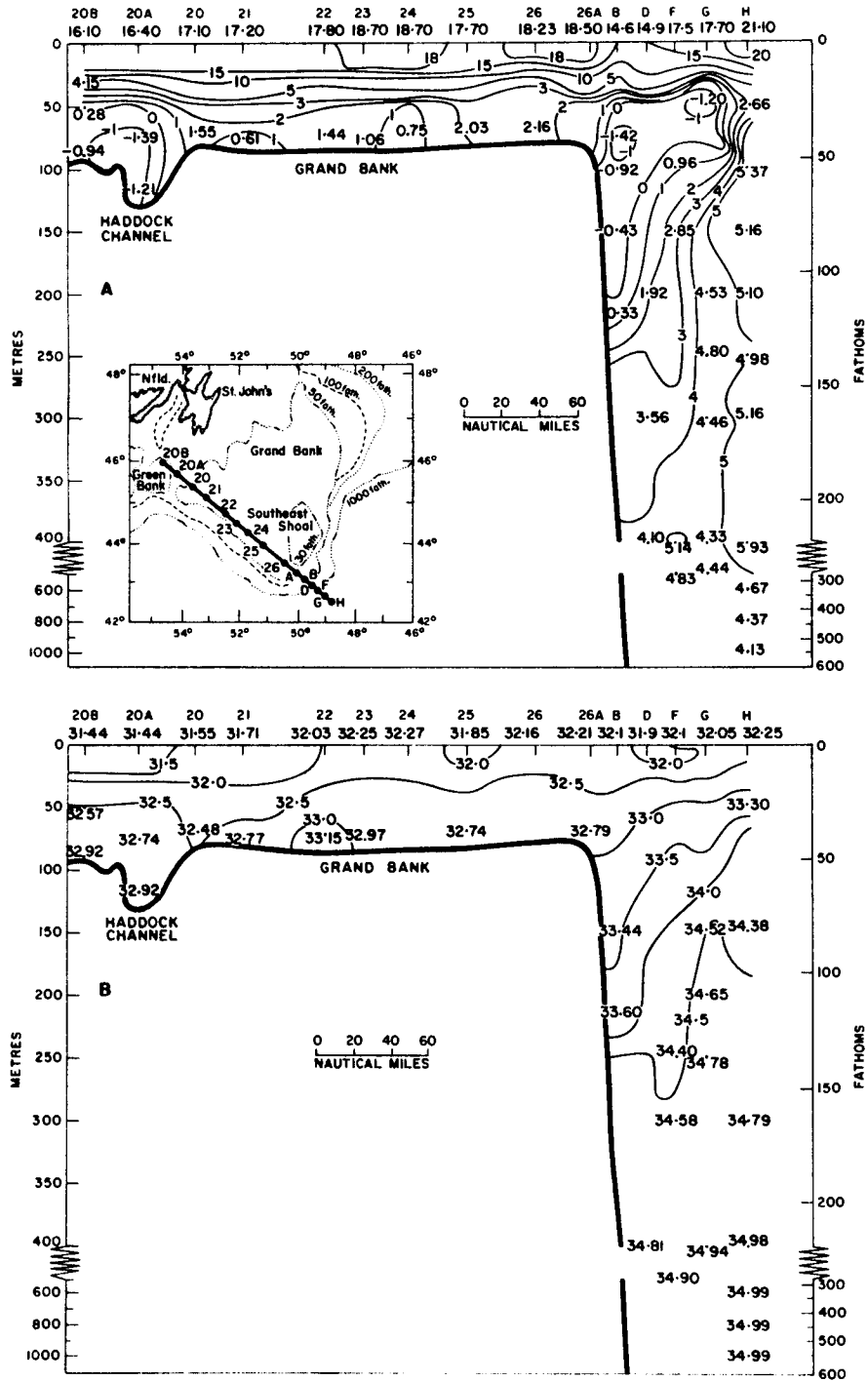


Fig. 5. Temperature (C) above and salinity (‰) below, Green Bank-SE Grand Bank, 20-23 August 1971.

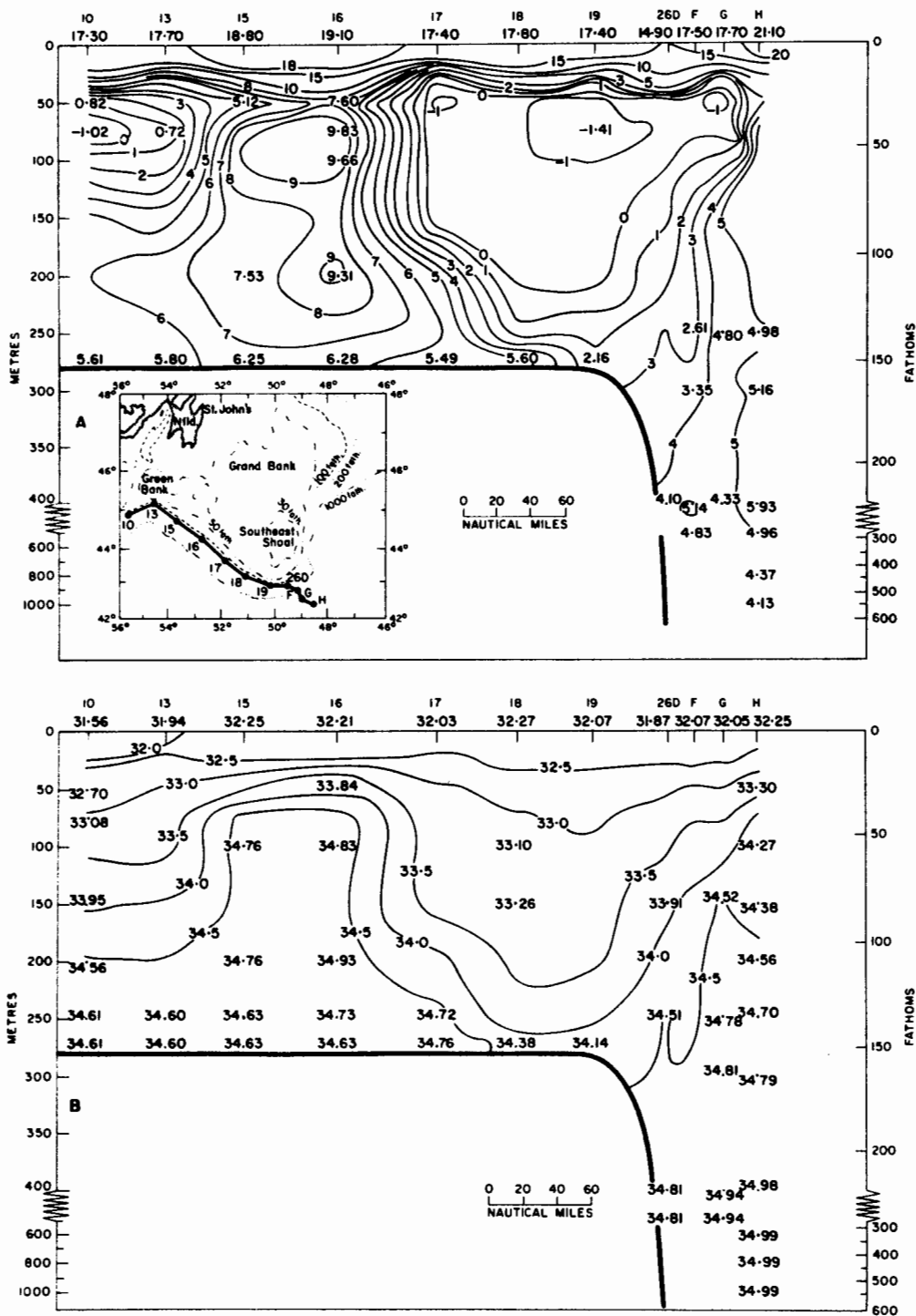


Fig. 6. Temperature (C) above and salinity (‰) below, SW slope Grand Bank-St. Pierre Bank, 20-23 August 1971.

lower than the average of the 1951-65 period and lower than in 1969 and 1970. The volume of cold water in the eastern branch of the Labrador Current passing westward around the tail of the Grand Bank was greater than the 1951-65 average and the lowest temperature of this branch,  $-1.41$  C, was the lowest yet recorded in our observations. Temperatures in the warmer slope water impinging on the bank at Stations 15 and 16 between the west and east cold water masses were similar to the highest recorded in the August sections since 1951. Bottom temperatures along the southwest edge were above average but, except at Station 18 (where it was higher), not as high as the highest recorded in 1951-65, and were higher than in 1969 and higher at some and lower at other stations than in 1970. The eastern slope stations shown (26D-H) were the same as those in Section E (Fig. 5).

Salinities. In the Seal Island section (Fig. 1), salinities near the bottom in Hawke Channel and at the crest of Hamilton Inlet Bank were lower than in 1970, resembling those of 1969. The deep water salinities seaward of Hamilton Inlet Bank were lower than in 1969 and still lower than in 1970.

Off Cape Bonavista (Fig. 2), salinities of the deep water east of the continental slope were lower than in 1970 and fairly similar to those of 1969.

From St. John's to Flemish Cap (Fig. 3), near-bottom salinities in the Avalon Channel and over the Grand Bank were lower than those of 1969 and 1970. Salinities in the deeper parts of Flemish Channel and seaward of Flemish Cap were lower than in 1970 and not greatly different from those of 1969.

From St. John's to the southeast slope of the Grand Bank (Fig. 4), near-bottom salinities in the Avalon Channel were fairly similar to those of 1970 and lower than in 1969. In the deep water east of the Grand Bank, salinities at the deepest levels ranged from slightly lower to slightly higher than in 1970 and 1969.

At about 75 m extending along the southwestern slope of the Grand Bank (Fig. 5), salinities in the Haddock Channel were lower than in 1969 and 1970, and near-bottom salinities over the surface of the Grand Bank were low, as in 1970, and lower than in 1969. Salinities of the water on the eastern slope of the Grand Bank and continental slope were lower than in 1969 and 1970.

At 275 m along the southwestern slope of the Grand Bank to St. Pierre Bank (Fig. 6), near-bottom salinities were lower than in 1970 but usually little different from those of 1969.

## 2. Station 27, 1971

W. Templeman

At Station 27 off Cape Spear (Fig. 7), surface temperatures from May to September were above the 1950-62 average; in other months they were lower than this average. Winter-spring surface temperatures were generally

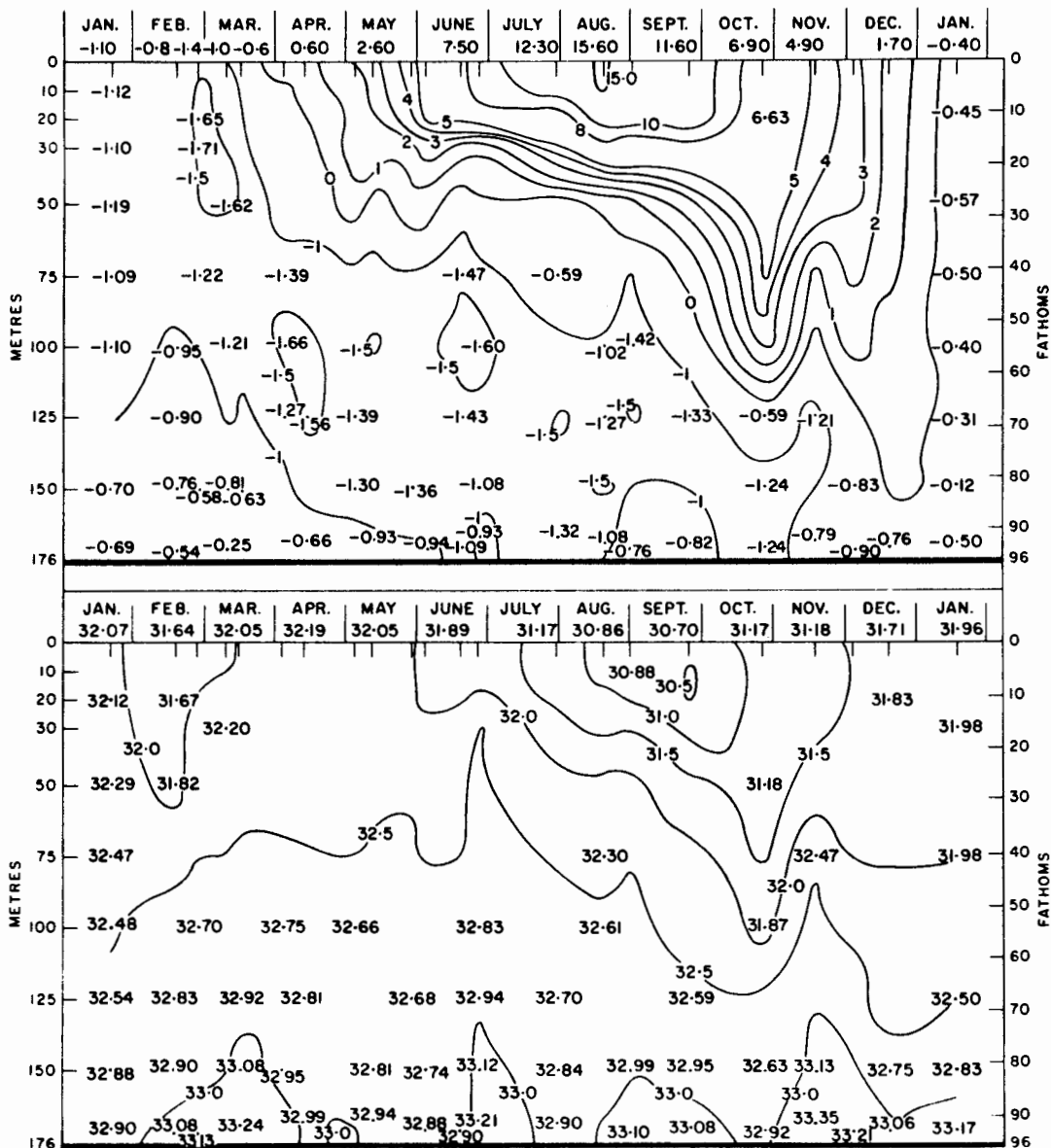


Fig. 7. Temperature (C) above and salinity (‰) below, January 1971 to January 1972, from surface to bottom at Station 27 (see Fig. 3, 4 inset), 2 nautical miles off Cape Spear near St. John's.

lower, June-August temperatures approximately similar and October-November temperatures lower than in 1970. At intermediate levels, in the coldest water of the Labrador Current, temperatures were below the 1950-62 average, below those of 1970 and well below that of 1969. Bottom temperatures were close to the 1950-62 average and generally lower than those of 1969 and 1970.

The salinity picture in the deeper water and near bottom was generally similar to that of 1970.

TECHNOLOGY

1. Quality, storage life and processing of marine fish

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D. H. Shaw, J. T. Lauder,  
M. J. Hayward

As in the previous year, the major continuing program of the Technological Division in the area of quality, storage life and processing of marine fish was concerned with handling and processing American plaice (*Hippoglossoides platessoides*) and yellowtail flounder (*Limanda ferruginea*). Studies were also started on another species of flatfish, the greysole (*Glyptocephalus cynoglossus*). Chemical and physical markers which might provide an indication of the storage quality of the latter species when stored in ice were studied and taste panel tests were conducted on single- and double-frozen greysole stored at low temperature for nearly 6 months. The effect of ante- and post-mortem handling on the extent of blood discoloration in fillets of American plaice was studied. The continuing problem of off-odors in comparatively freshly-caught American plaice (5 and 7 days in ice) was given further attention. The present conclusion is that feed, or bottom, or both, are the cause of off-odors; to establish the validity of this thesis, plaice will have to be examined at time of boating during the May-June period of 1972 and possibly in succeeding years, with additional examination and analyses being carried out after icing for specific periods. There is need too for information on bottom type and the effect of types of feed found on these grounds under particular conditions (water temperature, amount of sunlight, etc.). The transfer of pigments (yellow and gold pigments in American plaice and green pigments in yellowtail flounder) to subcutaneous (American plaice and yellowtail flounder) and cut (American plaice) surfaces which results from freezing and thawing or from handling in the vessel and plant was studied from the standpoint of mechanics of transfer: freezing and thawing with skin *in situ*, contact of skins-on surfaces with cut surfaces during storage at room and ice temperature or upon freezing aboard ship or ashore. The chemical characterization of the discoloration in both plaice and yellowtail flounder was studied. At the end of the year samples of chalky plaice were received for study.

The influence of trawling times and bleeding operations on bruising in fillets of American plaice. Earlier work (Templeman and Pitt, FRB Atlantic Prog. Rept. 59, 1954) showed a noticeable proportion of flounder landed in ice from the Grand Bank to be in a bruised condition with red blotches predominant on the white, "blind" side. Later observations (Etchegary, Crewe and MacCallum, Bull. Inst. Int. Froid Supp. VIII, Annexe 1969-5, 1969) lead to the conclusion that a significant proportion of the bruising noted under the white skin of otter-trawled plaice may result from injury in the trawl. An experiment was carried out to obtain further information on the extent of bruising in the trawl net, to determine the influence of the duration of the drag on such bruising, and finally to obtain information on the incidence of bruising (in relation to the various bleeding cuts) in addition to that reported by Etchegary, Crewe and MacCallum. These investigators had found that fish completely headed (consequent high degree of bleeding), gutted (also consequently well bled) or slash-cut (with poor

removal of the viscera) produced fillets uniformly free of bloody areas, whereas the fillets processed from whole unbled iced fish were bruised significantly. In the present work the heading operation was omitted; however, the effects of the other 2 treatments previously studied are reported and, as well, 2 additional operations, viz. cutting the throat (without removing the viscera) and bobtailing (severing the tail from the fish).

The size of the catches made by the *A. T. Cameron* ranged from 258 lb for one of three ½-hr hauls to 2366 lb for a single 3-hour haul. Other trawling times were of 1- and 2-hr duration.

After the whole fish were examined for bruising (immediately after boating) they were immediately bled and iced, or iced without being bled. After 4 days the fish were re-examined for bruises. They were then filleted and skinned either aboard ship or at the laboratory, frozen in polyethylene bags, cold stored at -29 C for 4 months and finally re-examined.

Examination of the white "blind" side of the fish boated after trawling periods of ½, 1, 2 and 3 hr showed there was little or no apparent difference in the amount of bruising. The percentage (average) bruised whole fish after 4 days in ice amounted to 31% for all methods of handling, up from the 18% figure at boating. Among the flounder bled by the 4 methods, viz. slash-cut, throat cut, complete gutting and bobtailing, there was 28% bruised fish; the 4 methods of bleeding were of equal merit. In numbers, the whole unbled fish yielded a 41% incidence of bruising, compared to the 28% figure for the bled plaice.

After filleting and skinning, fillets from the 4 differently-bled fish were judged to carry about equal numbers of bruises, confirming the data obtained on the whole fish. The fillets of the whole unbled fish showed a significantly greater percentage of bruising than did those produced from the bled fish.

Assessment of fillets frozen and cold stored was similar to the above. These data appear to hold for "eyed" as well as "blind" side fillets examined after freezing and cold storage.

Off-odors in iced landings of American plaice. In keeping with earlier experience, a noticeable proportion of some commercial catches of iced American plaice made in 1971 was rejected because of off-odors in fillets of fish iced for normally accepted periods. It appears from an examination of samples of these landings that there may be a relation between the development of the odors and the area and season of catch, i.e. the problem is probably associated with feed. Areas reported to have yielded a large percentage of off-odor flounders (5 and 7 days in ice at landing) in May and June produced fish of normal appearance, odor and keeping quality when fished by the *A. T. Cameron* in October.

In the off-odor plaice examined in 1971 feed appeared to be normal for this species. A great variety of bottom-procured food was found in the gut and the intestine, e.g. echinoderms, molluscs, crustaceans and polychaetes. Capelin were found in each of 2 fish along with the bottom feed. Pteropods *per se* were not identified. The odor from the gut was particularly strong

(bilge-like) in several instances and sweet, dimethyl sulphide (comparison made with bottled dimethyl sulphide) and bilge-like odors appeared to have permeated the fillets. Fillets of all whole fish examined and other fillets produced from the same catch in the processing plant and frozen in cartons were examined after freezing, cold storage and thawing. The fillets appeared to carry dimethyl sulphide odors from low to high intensity; some fillets were also sour or were bilgy. Some of the fish viscera and fillets were examined chemically for volatile sulphur compounds, particularly hydrogen sulphide and other sulphides, sulphur (thiols) and carbonyl compounds, including dimethyl sulphide. At present there is no explanation for the odoriferous viscera and fillets being found negative for the sulphur compounds, but the negative result raises the question of the accuracy of identification of these compounds using the sense of smell. Should future organoleptic and chemical tests be in agreement on the presence of sulphur compounds on relatively freshly-caught plaice, the possible causes could be: contact with other odoriferous fish, with sulphur-odor producing sponges (occasionally observed in the trawl net), or with contaminated nets, or food (e.g. pteropods) metabolized by the time the fish are captured, at which time the gut could be clear of such food.

Yellowing in American plaice as the result of freezing and thawing and plant handling. Until the present, the production and marketing of shore processed, refrozen fillets of sea-frozen, eviscerated American plaice, or of skins-on, untrimmed fillets of plaice and, to a lesser degree, the production of once-frozen fillets of iced plaice has been affected adversely. In the first instance, yellow, lemon-yellow or gold pigmentation has been observed in the subcutaneous layer upon skinning the dark, eyed side of the fish. This pigmentation is thought to be sufficiently different from the natural brown color customarily observed in skinned fillets of iced plaice to create marketing problems. In the second instance, yellow and lemon-yellow pigmentation has been observed on the cut surfaces of fillets remaining in contact with the skins of other dark-skinned fillets for more than short periods during processing, prior to freezing. These observations led to continuing studies of the effect of handling on carotenoid transfer from the skin to the subcutaneous layer (whole fish and fillets) or to the cut surfaces of fillets. This was determined by color panel evaluation and chemical determination of relative amounts of carotenoid in the skinned fillets. From a study of the results, optimum conditions were suggested for processing (e.g. method of skinning; presentation to the consumer of fully skinned, or breaded-and-battered and skinned, or skins-on fillets) and for freezing (e.g. single or double freezing).

First series of tests. Several catches were examined, one or more of these providing raw material for a number of tests (treatments): (1) freezing (without subsequent cold storage) and thawing whole eviscerated fish or fillets skins-on versus storing similarly prepared control samples in ice, with subsequent examination of the subcutaneous layer in the 2 instances; (2) freezing whole fish or fillets skins-on with or without the application of external pressure, thawing skins-on, then filleting, versus storing unfrozen control samples, also unskinned, in ice; (3) freezing and thawing (without subsequent cold storage) whole fish and fillets with or without removing the skin, then thawing and examining the subcutaneous layers of the fillet; (4) after thawing and processing either whole fish

or fillets frozen, or frozen and cold stored with or without the skin *in situ*, comparing the skinned fillets for differences in color arising from (a) freezing and thawing or (b) freezing, cold storage and thawing; (5) performing different depths of cut in the skinning operation, prior to freezing; (6) storing skins-on fillets in contact with the cut surfaces of other fillets packed in cartons and frozen.

In samples from one catch the subcutaneous layer of the dark-skinned fillets of fish was natural (slightly brown) in color with only a minor amount of yellowing, after the whole fish had been stored for 4 and 10 days in ice; thus, yellowing was not shown to develop to a marked degree with extended storage time in ice prior to processing. When these whole fish with the dark skin *in situ* were frozen either with or without the application of external pressure, then thawed, filleted and skinned, the subcutaneous layers were significantly deeper yellow in color than fillets prepared from iced, unfrozen fish. There was no difference in panel rating attributable to freezing and thawing the whole fish with or without the application of pressure. Moreover, the carotenoid-discolored test samples when refrozen and held for 14 days, then rescored after thawing, had not worsened in color during this interval. After the fish were thawed and processed, the yellow color in the subcutaneous layer under the dark skin of plaice frozen and cold stored for 2½ months was shown not to be in worse condition than observed immediately after freezing.

In fact, there was evidence with this and with a later catch that yellowing encountered in the subcutaneous layer of plaice, frozen and cold stored with the dark skin *in situ*, primarily is the result of freezing and thawing *per se* and may be little affected by storage of the fish at temperatures normally encountered in well designed and maintained cold storages, or by storage for periods (1-3 months) which might normally relate to commercial operations. Earlier work on plaice reported by others suggests that upon cold storing fish frozen with the dark skin *in situ*, a significant amount of yellow pigmentation is encountered in the subcutaneous layer. These workers made no mention of yellowing attributable to freezing and thawing *per se*. The deterioration they described was attributed to the use of raw material held too long in iced storage or held too long at too high temperature after freezing. Although discoloration resulting from the transfer of carotenoids to the flesh of other species following freezing, immediate thawing, and filleting has been reported for a few other species, this is the first instance where carotenoid has been shown to diffuse from the skin to the subcutaneous layer of fillets of American plaice used in the production of "finished" products (freshly frozen raw material was used). As such, this knowledge is basic to the development of the technology of freezing whole or "rough-cut" fillets at sea or ashore.

In a second catch, filleted, frozen and thawed with the dark skin *in situ*, or kept unfrozen in ice as control, test samples frozen with the application of external pressure showed greater intensity of the yellow, lemon-yellow and gold colors in the subcutaneous layers than samples frozen without this pressure. Results supported the previous finding that appreciably greater yellowing develops in the subcutaneous layer of frozen and thawed, unskinned plaice than in similar samples stored unfrozen in ice.

The cut surface of all fillets in contact with the dark-pigmented skin of other fillets during freezing and thawing was stained yellow, showing that flesh having both little or no fat (cut surface of fillets) or maximum fat (subcutaneous layers) appear to absorb quantities of carotenoid measurable by the eye. Results showed too that these pigments move both inward and outward from the dark skin of plaice upon freezing and thawing with the skin *in situ*.

Seven fillets from the above test fillets chosen without regard to method of freezing and all observed to be lemon-yellow or gold in the subcutaneous layer were judged, upon cooking and visual examination, to be virtually devoid of color other than the light brown associated with cooked fillets of iced fish. Color induced in fillets as the result of transfer of carotenoids from the skin might be expected to disappear upon heating.

In samples from a third catch, frozen after filleting with or without the dark skin *in situ*, then thawed, filleted and examined immediately or after 2 months frozen storage, yellow discoloration was significantly less in the fillets frozen and thawed with skins-on. The difference in the amount of yellowing was not pronounced after 7 months cold storage and thawing, both skinned and unskinned fillets having yellowed. The major portion of the discoloration after 7 months cold storage is attributed to air oxidation.

Evidence of difference in yellowing in fillets of iced, unfrozen controls obtained from different catches than those providing the frozen test samples, and in the test samples themselves, was somewhat contradictory, but generally the test samples were given inferior scores by the color panel.

Unfrozen control fillets, examined after fine hand skinning, were slightly yellow or brownish yellow in the subcutaneous layer; with deep skinning obtained after adjusting the skinning machine for a coarse cut, most of this color remained with the skin. This leads to the conclusion that fillets of sea-frozen skins-on plaice, if found to be objectionably yellow upon thawing and processing, might have to be deep skinned for the production of unbreaded, individually quick-frozen fillets, with consequent loss in yield.

Second series of tests. The experiment was planned and executed to show, by visual examination and by measurement of relative amounts of carotenoid in the skinned fillet or in a layer of fillet immediately adjacent to the cut surface, the amount of yellow color transferred from the skin to the fillets processed from a catch of American plaice given various post-filleting treatments. It was found that when skins-on fillets were stored together, either in ice or at room temperature, as in the fish cutting room, there was a transfer of yellow-colored carotenoid from the outside of the skin to the cut surfaces of the fillets in contact with the skin. Freezing and thawing a similar lot of fillets also showed transfer of yellow color to the cut surfaces, showing that it is not advisable to freeze fillets with skin and cut surfaces in contact. Similarly, skins-on and skins-off fillets, either stored together at room or ice temperature, or frozen together, showed yellow color transfer to the fat layer of skins-off fillets. These results confirmed that carotenoid may be transferred either

inward or outward from the dark skin of American plaice stored at room or ice temperature or during the process of freezing and thawing. The amount of carotenoid transferred, measured chemically, or as indicated by color evaluation of subcutaneous layers or cut surfaces of fillets, is considerably greater after freezing and thawing than after storage at ice (see also first series of tests) or at room temperature. Indeed, iced storage of whole fish up to 9 days showed little or no effect on yellow color transfer, in agreement with results experienced in the first series of tests.

Tests on cooking fish showed some yellow-color transfer from skin to muscle of cooked, skins-on fillets, but in general the degree of discoloration was not great, giving credence to the theory that the pigment transferred is a carotenoid, most of which is destroyed upon heating.

Third series of tests. It was shown by chemical analysis that the yellow color developed post-freezing in the subdermal layer of American plaice is due to a carotenoid with a visible spectrum indicating it to be tunaxanthin. The same compound was also extractable from the skin, and it is postulated that the skin cells containing carotenoid are ruptured during the freezing process, allowing the material to pass into the subdermal fat layer where it is dissolved. A colorless extract of the fat layer was shown to give yellow compounds when subject to thin layer chromatography and atmospheric oxidation. It is thought, however, that this does not contribute to yellowing on short term frozen storage, but may during periods greater than 3 months.

Green discoloration in yellowtail flounder. For the past 2½ years we have been aware of the occurrence of "green" fillets of yellowtail flounder (*Limanda ferruginea*), processed and individually quick frozen from iced catches taken in late summer and autumn in a large but well defined area of the Grand Bank, an area often left unfished by most skippers engaged in the offshore fall fishery. Fish segregated by the purchaser were examined and, in the opinion of our scientific staff, 2 types of "green" fillets were encountered; these are "blue-green" and "green". The amount of material available for studying the "blue-green" yellowtail was not sufficient to permit drawing any concrete conclusion as to the nature of the color. Additional samples of this type have not been obtained, leading to the conclusion that "blue-green" fillets are a rarity. The "blue-green" color, which appeared as distinct spots on otherwise light-colored fillets, showed high iron content. A similar "blue-green" discoloration, but apparently with less blue in it and much less saturated, could be induced in normal white fillets by soaking in ferric sulphate solutions. On the other hand, "green" fillets were fairly numerous. They often carried major blotches of darker green color superimposed upon a more or less slightly green base but judged to be different from the "blue-green" markings discussed above. The "green" samples are discussed in the following summaries. Quantities of "green" fish from an August landing were brought to St. John's and the whole fish, particularly the white "blind" side, the gut and the skinned fillets of fish of 3 post mortem ages in ice were examined. Despite the less than alarming conclusions reached after organoleptic examination of these fish and chemical examination of the distinctly "green", IQF-frozen samples selected by industry personnel, it is still felt that "greening" can be a major cause for concern to industry and can affect the profitability of processing to a significant degree.

Results of organoleptic examination of iced yellowtail flounder. Fish were selected from the same commercial landings which produced "green" individually quick frozen fillets. The undersides of slash-cut whole fish, 2 days in ice at landing, or 5 days in ice (counting 3 days iced storage at the laboratory) from time of capture in the suspect area, were pinkish-red near the head and along the frills; this discoloration was attributed to bruising in the trawl, on deck, or in icing. None of the white sides was discolored green. However, after a total of 10 days iced storage (8 days storage at the laboratory), 6 of 10 whole fish were slightly green near the gut cavity and the gill area; only one fillet had green areas while 5 fillets were slightly green or yellow-green in the subcutaneous layer ("blind"-side fillet) in areas located near the head and gut. In summary, the appearance of the above iced samples, both before and after processing, was not suggestive of a color condition other than that which might be expected in normal spoiling (products of bacterial decomposition) of fish in ice for 10 days from time of capture.

However, another lot of fish reported to be from the same catch as the above was examined 6 days after capture, without further iced storage, and substantial "green" areas were encountered. Areas near the head and gut cavity of 5 of 10 fish were discolored while in the same areas very slight green (2 instances), slightly green (3 instances) and more markedly green areas (2 instances) were observed on the skin side of skinned, blind-side fillets. Generally, the fish upon removal from the ice emitted an unpleasant odor not associated with well handled fish 6 days after capture. Areas of green discoloration, separate from the head and gut cavity, were also observed in both male and female fish. Obviously, the occurrence of these particular green areas should not be associated with stain-producing products from the gut or particular organs of the fish so discolored, but might have been affected by contact with juices or organs (a large percentage of slash-cut fish were poorly gutted) of other fish. The color apparently did not arise from bile pigments as the Gmelin test was negative. Among the green areas located apart from the head and gut sections of the fillet only 2 occurred at corresponding places on the outside of the white skin and on the underlying fillet. Among 8 fish there were many instances of discoloration of the main body of the fillet without accompanying marks on the outside of the white skin. The green in the main body of the fillet or near the head and gut end of the fillet appeared to be similar to the eye. The 10 fillets were re-examined after IQF freezing and cold storage for one week. Freezing appeared to intensify the green color. In some instances, areas which appeared to be white when the unfrozen fillets were examined had a slight green or green tinge after freezing. In our opinion, the green was intense, making the fillets unacceptable in appearance. Fillets from the same 6-day iced lot prepared by the processor were iced and soon after examined at the laboratory. The skinned surfaces of the blind fillets had large green areas which disappeared upon cooking. It is believed that this discoloration results from natural causes - possibly food (see below) - but staining from organs of other stowed fish should not be ruled out in some instances. However, in opposition to the latter thesis, there were many instances of discoloration in the main body of the fillet without accompanying marks on the outside of the white skin. Further study in our laboratory would be productive only with advice from, and active participation of, a protein chemist.

Chemical cause of "greening" in yellowtail flounder fillets. The cause of the greening in these fillets making them unacceptable for commercial sale, was shown not to be due to blood, or blood pigments. Current evidence indicates that the color is probably due to a chromo-protein, extremely labile to heat, in which the prosthetic group is possibly a carotenoid. The substance is probably taken in through the food chain. The green compound has characteristic absorption at 620 nm, behaves chemically as a protein, but to date has proved to be degraded during most techniques of protein purification. Possible solutions of interest to industry might include selling as pre-cooked portions, or holding in frozen storage for 3-6 months. Both methods seem to remove color.

Taste panel and chemical assessment of inshore-caught greysole.

Studies were continued on the suitability of greysole for consumption when caught in gillnets about 20 miles offshore from Twillingate, bob-tailed to permit bleeding and to eliminate the majority of bruise marks, iced aboard a longliner, frozen (single and double freezing) and held in cold storage. Success in holding the once- and twice-frozen fish for several months at low temperature would help to assure that the filleting plant could be operated for a period beyond the time the fish can be captured by longliners and would help to stabilize production during the season.

The investigations required taste-testing samples to be packed and frozen under controlled conditions. Chemical and physical markers were examined also, including pH, moisture, protein, etc., associated with the fish as received on the boat and after several days storage in ice. After experience gained from careful examination of the first catch, it was decided to examine the chemistry of jellied (a high incidence of jellied greysole was observed) and non-jellied fish.

Taste panel assessment. Male and female fish, 55-60 cm in length, were obtained under the conditions outlined above. Upon freezing whole, thawing (after 3½ months), filleting and skinning, the fillets were separated into normal, intermediate and jellied categories (fillets of female fish only were frozen) and were individually quick frozen (refrozen) for taste panel assessment 5½ months after capture. At time of landing from the longliner, female fish only were processed and frozen (single freezing) in 2 categories, normal and jellied fillets. The latter samples too were examined 5½ months later. The control and blind control fillets were processed from fish iced aboard a trawler for 2-3 days. From the size of the fillet, the control fish were estimated to have been 38-42 cm in length, much smaller than the test samples and presumably (based on Templeman and Andrews, J. Fish. Res. Bd. Canada, Vol. 13, 1956) would be less likely to be jellied than would the large female test fish. The fish used for the 2 controls were obtained from the Grand Bank and were 5 months fresher than all test samples. The controls were once-frozen.

The results of panel assessment, after statistical treatment, showed no significant difference between control and blind controls for which scores were in the 75-100% suitability range, and also between the once-frozen and twice-frozen test samples which were evaluated in the 15-35% suitability range. (The once- and twice-frozen samples were accidentally thawed, or partially thawed, then refrozen shortly before taste-testing. Therefore, the test samples at time of taste-testing had actually been subjected to

double and triple freezing. However, the effect of the accidental thawing or partial thawing must have been minimal since on average the triple-frozen fish were given a grade of about 15% and the double-frozen fish about 28%, there being no significant difference in these scores.) The quality of the controls and that of the once- and twice-frozen test samples was significantly different. The latter were tough or very tough and rubbery. The above scores for the test samples are averages for normal, intermediate and jelly-textured samples. They were not reduced when down-grading for the jellied category was eliminated. The amount of jellied fish, found by the taste panelists among samples judged to be normal or intermediate at time of freezing, was disturbing. Thus the results are not encouraging from the standpoint of holding single- and double-frozen inshore-caught greysole for extended periods at low temperatures (-34 and -40 C) prior to marketing, nor is the possibility of detection and separation of jellied and non-jellied fish at time of filleting considered to be promising.

Changes in chemical indices. Using the greysole sampled in June from landings in the inshore fishery off Twillingate, the markers ATP, lactate, pH, moisture, glycogen, TMA/DMA and hypoxanthine were measured during iced storage of fillets from fish previously bled immediately after capture. This species appeared to stay fresh longer than other flatfish species, although ATP, lactate, and pH showed normal post mortem breakdown patterns. Hypoxanthine for this species showed a steady rise over 10 days, atypical for flatfish, where this compound has been regarded as an unsatisfactory marker, due to its early build-up to a maximum amount. TMA on the other hand showed an abnormal drop during the first 3 days of iced storage. Moisture was higher in both normal and jellied greysole than reported by Templeman and Andrews (1956) for normal and jellied American plaice. Large changes in moisture content between the greysole appear to be more a function of the jelliness than of iced storage.

In the second experiment, in which July-caught fish were used, chemical indices on jellied and non-jellied greysole were studied. On a dry weight basis, there was no significant difference in protein and fat contents between normal and jellied fish. But there was a significant difference in water content of jellied and non-jellied fish.

Comparative chemistry of jellied and non-jellied greysole. Comparison of the electrolyte balance in the July-caught greysole showed that jellied fish, assessed on a dry weight basis, had a gross increase in the percentage of sodium ion, a significant drop in potassium ion, and higher concentrations of both Ca<sup>++</sup> and Mg<sup>++</sup> when compared with normal textured fish. Expression of these parameters on the basis of percentage electrolytes in the fluid accentuates this trend. Chloride ion, determined as sodium chloride, increases in direct proportion to the amount of moisture in the flesh, though at all times, increase of chloride ion appears to lead the increase in water.

## 2. Process, products and engineering

W. A. MacCallum

Preservatives and other dip treatments. Discussions were held and advice offered members of the Newfoundland fishing industry concerning

acceptability from the standpoint of regulations, effectiveness, cost and preferred method of treating or storing fish and fish fillets. The following topics were explored: (1) dipping fillets in sodium tripolyphosphate and sodium chloride or sodium hexametaphosphate and sodium chloride solutions. Discussions were held with Dr. W. J. Dyer of the FRB Halifax Laboratory on the effectiveness of these dips; (2) dipping fillets in solutions of sodium chloride to which "Acronize" (commercial chlortetracycline) is added; (3) preserving fish using butylene glycol, propylene glycol or pyroligneous acid (plus sodium chloride and lemon essence). Discussions were held with Dr. Lloyd Regier of the FRB Halifax Laboratory on the potential of these preservatives; (4) pre-freezing storage of whole fish (demersal and pelagic catches) in refrigerated sea water.

Cooling, freezing, thawing. Cooling curves were developed by K. M. Kane for fresh fillets packed in plastic pans buried in ice. Results were forwarded to industry.

Advice was provided other FRB establishments and industry on thawing methods and equipment. Industry was advised also on loss in yield of fish thawed in water. Suggestions were advanced on methods of packing herring fillets for subsequent freezing, thawing and canning. The preferred method of thawing frozen blocks of herring fillets was discussed.

Industry was provided with data on the rates of plate-freezing surface and centre-packed fillets in cartons. It was shown that fillets in the centre of commercially frozen cartons may not be lowered to the temperature of the cold storage room after remaining between the freezer plates for the times customarily followed by industry. Commonly, 2 sources of heat (in addition to normal loads resulting from heat passing through the walls and infiltrating into the cold storage rooms in other ways) are added to the refrigeration plant servicing these rooms: (1) the heat remaining in the centre of the "frozen" cartons of fish, and (2) the heat in the master cartons. The tons of refrigerating capacity required for the removal of this extra heat was determined.

Assistance was provided a professor of engineering at Memorial University permitting him to formulate a proposal for a research project for an engineer(s) in training to study and report on the adequacy or otherwise of low temperature holding rooms in Newfoundland fish processing plants for the storage of frozen seafoods.

### 3. Carbohydrates in the marine environment

D. H. Shaw, R. J. Striha

Progress in the field of exploratory research into marine carbohydrates has centred mainly on the glycosaminoglycans present in the skin of American plaice, and the relationship of these to the massive post mortem exudation of mucopolysaccharides through the skin during iced storage. We have also explored the feasibility of producing commercial quantities of mucopolysaccharides from fish skins. Further to this, work has been concentrated on the milk carbohydrates of marine mammals, the differences from land mammals, and whether these differences could be correlated with the different living

environment of the young. In view of the suggested development of the seaweed industry in Newfoundland, we have done some minor work on the chemistry of local seaweeds.

The structure of the glycosaminoglycans of American plaice. The non-sulfated glycosaminoglycans of flounder skin were separated and shown to be a mixture of approximately 90% hyaluronic acid and 10% chondroitin (probably). Hyaluronidase digestion of the fraction left a small residue, which we feel could be the protein-carbohydrate linkage region in hyaluronic acid. This has not heretofore been shown to exist, although current work indicates that there is a linkage. This would help explain how the hyaluronic acid is synthesized on a protein core in the endoplasmic reticulum. The residue was shown to be composed of glucosamine, galactosamine, mannose, galactose, and uronic acid in a ratio of 2:1:1:4:2 together with 32% protein. These identifications and quantities remain tentative subject to further experimental work.

The sulfated glycosaminoglycans from the same source have been isolated and freed from most of the contaminating protein and found to contain, on an average, one sulfate group per disaccharide unit. This, together with electrophoresis, indicates a classical chondroitin sulfate. However, digestion with CHase AC or Hase leaves the material untouched, whilst CHase ABC digestion cleaves only one-third of the mixture, giving the oligosaccharide to be expected from Dermatan sulfate. The neutral sugars galactose and xylose in a ratio of 2.0 to 1.04 (by moles) have been identified. This is in agreement with recent work on the carbohydrate-peptide linkage region by other workers. The undigested material appears to have the characteristics of a chondroitin sulfate. In line with the removal of Dermatan sulfate with CHase ABC, there is no iduronic acid in the residue.

Because commercial quantities of glycosaminoglycans are available in flounder skin, a shortened, cheaper method of extraction from the skin has been developed.

Ocean sunfish. The subdermal layer in ocean sunfish (*Mola mola*) has been examined and found to be 94.6% water; the remaining material was shown to be proteinaceous. Amino acid analysis indicated that the major portion of the protein was mainly collagen. Carbohydrate was shown to be insignificant.

Carbohydrates in the milk of marine mammals. The carbohydrates in dolphin (*Tursiops truncatus*) milk have been isolated, purified and identified as lactose (89.5%), glucose (3.7%), *myo*-inositol (4.8%) and *scyllo*-inositol (2.0%). This milk is unusual in the high content of *myo*-inositol (often regarded as a high growth factor) and free glucose. *Scyllo*-inositol is reported for the first time in milk, and the suggestion that it is of food-chain origin is strengthened by recent reports that phytoplankton contain large amounts of this inositol.

Preliminary studies on fin whale milk indicate major differences from the milk of the dolphin. Notably, *scyllo*-inositol and free glucose appear to be absent, *myo*-inositol appears in even larger quantities, and oligosaccharides are present as a significant portion of the milk carbohydrate.

Chemistry of seaweeds. Work has been recently initiated on 2 morphologically different sets of *Rhodymenia palmata* (dulse) plants gathered from different points on the Newfoundland coast. The polysaccharides are being isolated and their structure determined; initial results indicate that one plant contains approximately 4% galactose in the polysaccharide. Work previously undertaken on dulse polysaccharides does not report the presence of galactose.

#### 4. Exploratory research

The esterases of salmonid fish. The polymorphic esterases from Arctic char were separated and shown to have differing molecular weights. The smaller of the alleles had similar molecular weight to the single allele from 3 other species of salmonid fish, whilst the alternate allele had a molecular weight about 1.7 times higher. It appears that the distribution of the 2 alleles depends to some extent on the environmental temperature.

APPENDICES

1. Summary of research vessel operations
2. Staff and organization list
3. Publication list
4. List of principal meetings and visits



1. Summary of research vessel operations

A. T. Cameron

Trip No.	Date sailed	Date returned	Area	Investigation	Personnel
181	Jan. 22 (St.J.)	Feb. 6 (P. aux Basques)	E Gulf of St. Lawrence	Cod: distribution, abundance during winter migration	<u>Wells</u> , Kean, R. Tucker, Mullett, E. LeGrow, Pike, (Brown: PIROP)
182	Feb. 8 (P. aux Basques)	Feb. 18 (St.J.)	SW Newfoundland	Herring: tagging and hydrographic survey	<u>Winters</u> , Barbour, Dawson, Murphy, E. Squires
183	Feb. 26 (St.J.)	Mar. 9 (St.J.)	E and SW Grand Bank	Cod and haddock: distribution, abundance	<u>Pinhorn</u> , Cluett, R. Ennis, Kelland, Pike, Woodford
*184	Mar. 19 (Hfx.)	Mar. 31 (St.A.)	Western, Emerald and Browns banks	Groundfish: fecundity, tagging, parasites	<u>Scott</u> , Lyon, McFarlane, Robicheau, Sampson, Smith, E. Squires, Thurber, (Theauvette: CODC)
185	Apr. 13 (St.J.)	May 3 (St.J.)	NE Nfld. Shelf, Hamilton Inlet Bank	Cod: distribution, abundance with depth and temperature	<u>Wells</u> , Kean, E. LeGrow, Manuel, Pike, R. Tucker
186	May 10 (St.J.)	May 27 (St.J.)	Labrador Sea	Salmon: tagging, efficiency of drift nets, longlines	<u>Lear</u> , Bishop, Burfitt, Mansfield, E. Squires, (Tull: PIROP)
187	June 2 (St.J.)	June 18 (St.J.)	Grand Bank	Groundfish: stock inventory	<u>Pitt</u> , Butt, Collier, Dyke, R. Ennis, Pike, Rose, Stevenson, (Rucabado: Inst. de Invest. Pesqueras; Galinat: PIROP)
*188	June 29 (St.A.)	July 9 (Hfx.)	Bay of Fundy, Browns and La Have banks	Groundfish: stock inventory	<u>Kohler</u> , Fraser, Leech, MacPherson, McFarlane, Robicheau, E. Squires, Thurber, (Hamon: ISTPM; Galinat: PIROP; Theauvette: CODC)

*A. T. Cameron*

Trip No.	Date sailed	Date returned	Area	Investigation	Personnel
*189	July 12 (Hfx.)	July 22 (Syd.)	Sable Island- Banquereau banks Sydney Bight, S Gulf of St. Lawrence	Groundfish: stock inventory	<u>Halliday</u> , Fitzgerald, Lyon, Sampson, Smith E. Squires, (Lyczkowski, Pushee, Wenner: VIMS; Scott: ROM)
*189A	July 25 (Syd.)	July 30 (Syd.)	Gulf of St. Lawrence	Engineering data on underwater gear	<u>Carrothers</u> , Baker, Foulkes, Polar, Walker
190	Aug. 30 (St.J.)	Sept. 25 (St.J.)	West Greenland and Labrador Sea	Atlantic salmon: tagging, relative catching efficiency of gears	<u>Payne</u> , Batten, Burfitt, Mansfield, Pike, Tizzard, (Minet: ISTPM; Swain: Freshw. Fish. Lab., London; Wykes: RDB; Leahy: PIROP)
191	Oct. 4 (St.J.)	Oct. 15 (St.J.)	Grand Bank	Groundfish: stock inventory	Pitt, Butt, Mullett, Rose, E. Squires, R. Tucker
192	Oct. 25 (St.J.)	Nov. 9 (St.J.)	Labrador and northern Newfoundland	Cod: distribution and abundance	<u>Wells</u> , Kean, Kelland, Legge, Manuel, Pike, (Brown: PIROP)
193	Nov. 16 (St.J.)	Dec. 3 (St.J.)	Placentia and Conception bays	Snow crab: calibration of Japanese crab traps	<u>Miller</u> , Collins, Dawe, Hart, E. Squires, W. Squires, G. Tucker

\*St. Andrews operations

*E. E. Prince*

82	Jan. 19 (P. aux Basques)	Jan. 26 (P. aux Basques)	SW coast Newfoundland	Herring: tagging, hydrographic survey	<u>Barbour</u> , Dawson, Barrett
87	July 11 (St.J.)	July 22 (Hfx.)	SW Grand Bank, St. Pierre Bank and Nova Scotia Shelf	Squid: distri- bution, abundance and biology	<u>Mercer</u> , Collins, C. LeGrow, Ring, W. Squires

*Cape Freels*

Trip No.	Date sailed	Date returned	Area	Investigation	Personnel
1	July 29 (St.J.)	Aug. 5 (St.J.)	Labrador to Grand Bank	Hydrography: northern cruise	<u>Cluett</u> , E. LeGrow, Manuel, Mullett
2	Aug. 18 (St.J.)	Aug. 25 (St.J.)	Grand Bank and St. Pierre Bank	Hydrography: southern cruise	<u>Kelland</u> , Cluett, Manuel, Mullett

*Marinus*

1	Feb. 26 (St.J.)	Mar. 1 (St.J.)	St. John's to Torbay	Snow crab: distribution and abundance	<u>Sandeman</u> , Collins, Hart
2	Mar. 3 (St.J.)	Mar. 31 (St.J.)	South coast of Newfoundland	Herring survey	<u>Dawson</u>
3	Apr. 19 (St.J.)	May 1 (St.J.)	SW coast of Newfoundland	Shrimp survey	<u>Sandeman</u> , Collins, G. Tucker
4	May 6 (St.J.)	May 19 (St.J.)	Notre Dame, Bonavista and Trinity bays	Herring survey	<u>Sullivan</u> , Ryan
5	May 26 (St.J.)	June 4 (St.J.)	St. Mary's Bay	Herring survey	<u>Winters</u> , Dawson, Maloney
6	June 4 (St.J.)	June 30 (St. Anthony)	Labrador and Strait of Belle Isle	Herring survey	<u>Parsons</u> , Chaulk, Forward, Murphy
7	July 3 (St. Anthony)	Aug. 5 (St.J.)	Labrador and NE coast of Newfoundland	Cod: monitoring cod stocks; salmon: tagging	<u>Batten</u> , Andrews, Bowering
8	Aug. 18 (St.J.)	Sept. 10 (St.J.)	Labrador coast	Cod: monitoring cod stocks	<u>Kean</u> , Legge
9	Oct. 28 (St.J.)	Nov. 15 (St.J.)	Trinity Bay	Greenland halibut: tagging	<u>Rose</u> , Butt
10	Nov. 24 (St.J.)	Dec. 16 (St.J.)	SW coast of Newfoundland	Herring: tagging	<u>Barbour</u> , Chaulk Murphy

2. Staff and organization list

Scientific staff

Wilfred Templeman, O.B.E., Ph.D.(Toronto), F.R.S.C., Director.  
A. M. Fleming, M.A.(Toronto), Assistant Director.

Fish Distribution and Systematics

Wilfred Templeman. (See above.)

Cod, Northern and Gulf

R. Wells, M.Sc.(Memorial).

Cod, Eastern; Monitoring Commercial Groundfisheries

A. M. Fleming. (See above.)

Haddock and Cod, Southern

A. T. Pinhorn, M.Sc.(Memorial).

Pleuronectids

T. K. Pitt, M.A.(Toronto).

Pelagic Fish

V. M. Hodder, M.Sc.(Memorial). To Sept. 14, 1971.  
G. H. Winters, M.Sc.(Memorial).  
L. S. Parsons, M.Sc.(Memorial).

Anadromous Fish

A. W. May, Ph.D.(McGill).  
J.H.C. Pippy, M.Sc.(Memorial).  
W. H. Lear, M.Sc.(Memorial).  
R. H. Payne, B.Sc. Hons.(Belfast). From Aug. 26, 1971.

Commercial Invertebrates

E. J. Sandeman, M.Sc.(Memorial).  
M. C. Mercer, M.Sc.(Memorial).  
G. P. Ennis, M.Sc.(Memorial).  
R. J. Miller, Ph.D.(North Carolina State). From Apr. 28, 1971.

Technological Division

W. A. MacCallum, M.Sc.(Dalhousie).  
D. H. Shaw, Ph.D.(Univ. of Capetown, S.A.).  
J. L. Lauder, B.Sc. Hons.(Dalhousie).  
K. M. Kane, B.Sc.(Memorial).  
R. J. Striha, M.Sc.(Victoria).

Organization of staff (January 1 - December 31, 1971)

Administration

SE-REM-3 (Director)	W. Templeman, Ph.D.
SE-REM-2 (Assistant Director)	A. M. Fleming, M.A.
A.S. 5	O. E. Wheeler
P.G. 2	F. G. Porter
S.T. 6 (Director's Secretary)	Sheila T.M. Keough
C.R. 5	D. E. Phelan (from May 10)
S.T. 5	Jean M. Maidment
S.T. 4	Shirley Peckford (to March 9)
S.T. 4	Edith Manuel
S.T. 4	M. Teresa Morris (Mar. 1 to Oct. 18)
S.T. 4	Della Squires (from Dec. 6)

Library

C.R. 4	Catherine E. Philpott
C.R. 1 (Term)	Elizabeth E. Bishop (May 10-Aug. 27)

Photography and Drafting

D.D. 5	H. R. Mullett
P.Y. 5	E. L. Rowe

Computational and Statistical Services

EG-ESS-4	R. J. Tucker
D.A. 3	M. Lorene Tuck

Buildings and Grounds

GL-ELE-6	B. G. Yetman
GS-PRC-2	W. Courage
GS-PRC-2	E. B. Martin
GS-PRC-2	T. J. Delurey
GS-PRC-3	G. Pottle

Fish Distribution and Systematics

SE-REM-3 (in charge)	W. Templeman, Ph.D.
EG-ESS-7	L. N. Cluett
EG-ESS-7	E. M. LeGrow
EG-ESS-5	M. H. Manuel

Cod, Northern and Gulf

Scientist 2 (in charge)	R. Wells, M.Sc.
EG-ESS-6	G. H. Kean, B.Sc.
EG-ESS-4	W. E. Legge
Student Assistant	H. R. Andrews (May 1-Aug. 19)
Student Assistant	J. R. Hoyles (May 3-Aug. 20)
Student Assistant	R. B. Stead (May 3-Aug. 20)

Cod, Eastern; Monitoring Commercial Groundfishes

SE-REM-2 (in charge)	A. M. Fleming, M.A.
EG-ESS-6	T. Collier
EG-ESS-4	D. G. Badcock
EG-ESS-3	P. C. Beck
C.R. 3	Joan L. Tuff
Student Assistant	R. F. Butler (May 3-Aug. 20)
Student Assistant	Brenda J. Humby (May 3-Aug. 27)

Haddock and Cod, Southern

SE-RES-2 (in charge)	A. T. Pinhorn, M.Sc.
EG-ESS-6	C. J. Woodford
EG-ESS-3	R. J. Ennis
Student Assistant	Marion G. Parsons (May 3-Aug. 24)
Student Assistant	G. M. Boland (May 3-Aug. 20)

Pleuronectids

SE-RES-2 (in charge)	T. K. Pitt, M.A.
EG-ESS-7	C. A. Rose
EG-ESS-4	C. Butt
Student Assistant	G.W.A. Dyke (May 3-Aug. 27)
Student Assistant	S. C. Stevenson (May 3-Aug. 20)

Pelagic Fish

SE-RES-2 (in charge)	V. M. Hodder, M.Sc. (to Sept. 14)
Scientist 2	G. H. Winters, M.Sc.
Scientist 1	L. S. Parsons, M.Sc.
EG-ESS-7	C. I. Barbour
EG-ESS-6	R. Chaulk
EG-ESS-5	M. F. Dawson
EG-ESS-3	R. Sullivan

Pelagic Fish (Cont'd.)

EG-ESS-2 (Term)	A. D. Murphy
EG-ESS-2 (Term)	W.E.G. Barrett
Student Assistant	W. J. Maloney (May 3-Aug. 20)
Student Assistant	W. E. Chafe (May 3-Aug. 27)
Student Assistant	L. A. Ryan (May 3-Aug. 20)
Student Assistant	Gloria R. Dyke (May 3-May 28)
Student Assistant	D. M. Matthews (May 31-Aug. 20)
Student Assistant	K. R. Forward (May 3-Aug. 27)

Anadromous Fish

SE-RES-2 (in charge)	A. W. May, Ph.D.
SE-RES-1	J.H.C. Pippy, M.Sc.
SE-RES-1	R. H. Payne, B.Sc.(Hons.) (from Aug. 26)
Scientist 1	W. H. Lear, M.Sc.
EG-ESS-7	F. A. Day
EG-ESS-6	R. F. Burfitt
EG-ESS-5	W. N. Batten
EG-ESS-4	R. J. Tizzard
EG-ESS-3	L. E. Mansfield
GL-ELE-5 (Continuing Seasonal)	R. J. Whalen (Mar. 15-Nov. 5)
GL-ELE-5 (Term)	A. J. Ryan (Mar. 15-Nov. 5)
Student Assistant	Linda G. Bowers (May 3-Aug. 27)
Student Assistant	Paula C. Clarke (Apr. 26-Sept. 10)
Student Assistant	Lois M. Carew (May 3-Aug. 27)
Student Assistant	J. A. Moores (May 3-Aug. 20)
Student Assistant	W. A. Ring (May 3-Aug. 27)
Student Assistant	W. R. Bowering (May 3-Aug. 27)
Student Assistant	R. G. Bishop (May 3-Aug. 20)

Commercial Invertebrates

SE-RES-2 (in charge)	E. J. Sandeman, M.Sc.
SE-RES-1	R. J. Miller, Ph.D. (from April 28)
Scientist 2	M. C. Mercer, M.Sc.
Scientist 1	G. P. Ennis, M.Sc.
EG-ESS-7	G. E. Tucker
EG-ESS-4	G. Dawe
EG-ESS-4	W. R. Squires
EG-ESS-3	R. H. Hart
EG-ESS-3 (Term)	P. W. Collins
Student Assistant	R. Mercer (May 3-Aug. 27)
Student Assistant	G. B. Russell (May 3-Aug. 27)
Student Assistant	C. F. LeGrow (May 3-Aug. 27)
Student Assistant	C. R. Rowsell (May 3-Aug. 24)
Student Assistant	D. G. Parsons (May 3-Aug. 27)
Student Assistant	F. P. Bursey (May 3-Aug. 27)
Student Assistant	E. P. Ring (May 3-Aug. 25)

Hydrography

EG-ESS-7	A. G. Kelland
Student Assistant	F. M. Cahill (May 3-Aug. 20)

Groundfish Clerical Services

C.R. 6 (in charge)	Jacqueline R. Burt, B.Sc.
C.R. 4	Cheryl H. Riche
Student Assistant	Karen E. Coombs (May 3-Aug. 13)
Student Assistant	Jennifer M. Jeans (May 3-Aug. 27)

Electronic Technicians

EL-5	E. E. Squires
EL-4	L. G. Pike

Technological Division

SE-RES-2 (in charge)	W. A. MacCallum, M.Sc.
SE-RES-2	D. H. Shaw, Ph.D.
Chemist 1	K. M. Kane, B.Sc.
Chemist 1	J. T. Lauder, B.Sc.(Hons.)
Chemist 1	R. J. Striha, M.Sc.
GL-MAM-11	J. W. Vallis
ST-5	Bertha L. Hodder
EG-ESS-5 (Term)	M. J. Hayward
Student Assistant	C. R. Hudson (May 3-Aug. 27)

C.G.S. A. T. Cameron

SE-RES-2 (Liaison Officer)	E. J. Sandeman, M.Sc.
Master	E. G. Walters
Chief Engineer	C. R. Barbour
First Officer	C. Pardy
Second Engineer	E. C. Blackwood
Second Officer	C. Kean
Third Engineer	R. E. Inkpen
Chief Cook	N. C. Stoodley
Boatswain	E. B. Abbott
Oiler	L. D. Bennett
Oiler	N. Wilkins
Oiler	E. P. Leonard (to Nov. 14)
Assistant Cook	T. W. Stockley

C.G.S. A. T. Cameron (Cont'd.)

Twinehand	C. G. Janes
Twinehand	E. G. Lockyer
Twinehand	W. J. Pardy
Twinehand	C. W. Hodder
Twinehand	G. C. Sturge
Twinehand	C. Roberts
Twinehand	J. Anderson
Twinehand	P. Pittman
Twinehand	D. J. Farrell
Twinehand	L. Milley
Steward	L. F. Dillon (to May 31)
Steward	M. J. Wade (from Nov. 8)
Steward	W. F. Johnson
Steward	F. C. Blackwood
Oiler (Term)	L. M. Winsor (from April 13)

C.G.S. Marinus

Master	F. A. Winsor
Engineer	S. G. Maidment (to Nov. 15)
Engineer	E. P. Leonard (from Nov. 15)
Cook	H. Freeborn
Boatswain	M. Walbourne
Twinehand	P. G. Baker
Twinehand	R. Hackett

Research vessels *A. T. Cameron* and *Marinus* are attached to the Office of the Atlantic Regional Director (Research) in Halifax, N.S., but they are based in St. John's.

3. Publication list

(January 1 - December 31, 1971)

Primary publications (published in recognized scientific journals, based on hitherto unpublished data).

- Hodder, V. M. and L. S. Parsons. Comparison of certain biological characteristics of herring from Magdalen Islands and southwestern Newfoundland. Intern. Comm. Northwest Atlantic Fish. Res. Bull. No. 8: 59-65.
- Hodder, V. M. and L. S. Parsons. Some biological features of Southwest Newfoundland and northern Scotian Shelf herring stocks. Intern. Comm. Northwest Atlantic Fish. Res. Bull. No. 8: 67-74.
- Lear, W. H. and J.H.C. Pippy. A record of the Atlantic menhaden (*Brevoortia tyrannus*) from Northumberland Strait. J. Fish. Res. Bd. Canada 28: 461-462.
- Lear, W. H. and A. W. May. *Paralepis coregonoides borealis* (Osteichthytes: Paralepididae) from the Davis Strait and Labrador Sea. J. Fish. Res. Bd. Canada 28: 1199-1203.
- Mercer, M. C. 1970. Sur la limite septentrionale du calmar *Loligo pealei* LeSueur. Naturaliste Can. 97: 823-824.
- Miller, R. J., K. H. Mann and D. J. Scarratt. Production potential of a seaweed-lobster community in eastern Canada. J. Fish. Res. Bd. Canada 28: 1733-1738.
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- Pitt, T. K. and A. T. Pinhorn. General localities of unsuitable fishing bottom in some areas adjacent to eastern Canada. Intern. Comm. Northwest Atlantic Fish. Ser. No. 2597, Res. Doc. 71/112, 3 p.
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- Pitt, T. K. Report on the tagging of Greenland halibut (*Reinhardtius hippoglossoides*) on the NE coast of Nfld. Intern. Comm. Northwest Atlantic Fish. Ser. No. 2613, Res. Doc. 71/119, 3 p.
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- Squires, H. J., G. E. Tucker and G. P. Ennis. Lobsters (*Homarus americanus*) in Bay of Islands, Nfld., 1963-65. Fish. Res. Bd. Canada Manuscript Rept. (Biol.) No. 1151: 1-58.

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4. List of principal meetings and visits

Jan. 21-23	Meeting of ICNAF Working Group on Co-ordinated Groundfish Surveys, Copenhagen, Denmark.	A. T. Pinhorn
Jan. 22	Accompanied Atlantic Regional Director (Research) to Meeting with Sea Pool Fisheries Staff, Clam Bay, N.S.	A. W. May
Jan. 25-30	ICNAF Midterm Meeting, Copenhagen, Denmark.	V. M. Hodder
Jan. 25-30	Midterm Meeting of ICNAF Assessments Subcommittee, Copenhagen, Denmark.	A. T. Pinhorn
Feb. 1	Meeting of the Frozen Fish Trades Association held in the Board Room of the Association, St. John's, Nfld.	W. A. MacCallum
Feb. 1-3	Visit to Fisheries Laboratory, Lowestoft, England.	V. M. Hodder
Feb. 18	Annual Meeting of Atlantic Salmon Association, Montreal, P.Q.	A. W. May
Feb. 24	Meeting to plan co-operative research activities, Halifax, N.S.	V. M. Hodder
Mar. 2-5	Meeting of Directors with Chairman, Ottawa, Ont.	W. Templeman
Mar. 9-11	Annual Meeting of the Program Working Party on Atlantic Anadromous Fish, Halifax, N.S.	A. W. May J.H.C. Pippy W. H. Lear
Mar. 13	Meeting with FRB biologists re cruise plans of M.V. <i>J. B. Nickerson</i> , Halifax, N.S.	V. M. Hodder L. S. Parsons
Mar. 24-25	Workshop meeting of the International Atlantic Salmon Foundation, Manchester, New Hampshire, U.S.A.	W. H. Lear
Mar. 26-Apr. 1	Planning Group, 1972 International Salmon Tagging Experiment in West Greenland; ICES/ICNAF Joint Working Party on North Atlantic Salmon, Pitlochry, Scotland; Discussions with scientists working in salmon serum protein studies, Drottningholm, Sweden and Weymouth, England.	A. W. May

Mar. 29-Apr. 2	Course conducted by the Dept. of Environment on Classification for Senior Management, St. John's, Nfld.	O. E. Wheeler
Apr. 1 and 27	Meeting Atlantic Directors with ARDR, Halifax, N.S.	W. Templeman
Apr. 17-May 9	Visit to University of Miami for research on cephalopods, Florida, U.S.A.	M. C. Mercer
Apr. 27-28	Visited Fisheries Laboratory and participated in cruise of R.V. <i>Corrella</i> , Lowestoft, England.	G. H. Winters
May 12-14	Discussion on research programs FRB, Halifax, N.S.	D. H. Shaw
May 17-June 4	ICNAF and associated meetings, Halifax, N.S.	W. Templeman A. W. May
May 18-26	ICNAF Environmental Symposium also Statistics Committee Meetings, Dartmouth, N.S.	V. M. Hodder A. T. Pinhorn
May 23-26	NE Fish and Wildlife Meeting of American Fisheries Society, Maine, U.S.A.	T. K. Pitt
May 24-26	Discussion on queen crab research problems, St. Andrews, N.B.	E. J. Sandeman R. J. Miller
June 7-11	Discussion on Board programs on marine plants and fish muscle pigments, FRB, Vancouver, B.C.	D. H. Shaw
June 14-16	Canadian Society Zoologists Meeting, St. John's, Nfld.	A. W. May
June 21	Discussions on clam and oyster research, MEL, Dartmouth, N.S.	M. C. Mercer
June 28-29	Meeting on Management of Continental Shelf Resources, Ottawa, Ont.	A. M. Fleming A. W. May
Aug. 2	Visit to Halifax Laboratory, Halifax, N.S.	D. H. Shaw
Aug. 25-27	Conference of FRB Atlantic Directors with the Chairman and Atlantic Regional Director (Research), Halifax, N.S.	W. Templeman

Aug. 27-Sept. 3	International Congress of Refrigeration, Washington, D.C., U.S.A.	W. A. MacCallum
Sept. 3	Resource Management Committee Meeting with Nfld. Fish Trades Association, St. John's, Nfld.	A. M. Fleming
Sept. 7-11	Fourth European Malacological Congress, Geneva, Switzerland.	M. C. Mercer
Sept. 13-30	Visits for research on cephalopods to: Musée Océanographique, Monaco; Zoologisches Museum, Berlin, Germany; British Museum (Natural History), London, England; National Institute of Oceanography, Wormley, Surrey, England.	M. C. Mercer
Sept. 14-17	Meeting of Board Directors with FRB Chairman and Deputy Minister, Dept. of the Environment, Ottawa, Ont.	W. Templeman
Sept. 27-29	Sixteenth Atlantic Fisheries Technological Conference, Dartmouth, N.S.	D. H. Shaw K. M. Kane
Sept. 28-Oct. 1	37th Statutory Meeting of ICES, Helsinki, Finland.	A. M. Fleming
Oct. 3-4	Federal-Provincial Deputy Ministers' Fishery Conference, Charlottetown, P.E.I.	W. Templeman
Oct. 4-6	Conference on Canadian Atlantic Seaweed Industry, Charlottetown, P.E.I.	D. H. Shaw E. J. Sandeman
Oct. 7	Departmental-industry meeting on herring conservation measures at Bedford Institute, Dartmouth, N.S.	L. S. Parsons G. H. Winters
Oct. 7-9	Meeting Minister of Fisheries with the "Save Our Fisheries Association", Ottawa, Ont.	W. Templeman
Oct. 25-Nov. 15	Course on Material Management General Level, Ottawa, Ont.	F. G. Porter
Nov. 15	Visit to FRB Oyster Unit concerning transplantation of European oysters, Ellerslie, P.E.I.	M. C. Mercer

Nov. 18-20	Meeting concerning Law of the Sea Conference, St. Andrews, N.B.	A. M. Fleming
Nov. 24	Meeting with the Peruvian Fisheries Delegation held at the Dept. of the Environment, St. John's, Nfld.	W. A. MacCallum A. M. Fleming
Nov. 25-26	Meeting on 1972-73 Budget Proposals, Ottawa, Ont.	W. Templeman O. E. Wheeler
Dec. 1-2	Interim meeting of the Program Working Party on Atlantic Anadromous Fish, Corner Brook, Nfld.	W. H. Lear R. H. Payne
Dec. 7	Meeting of herring biologists at ARDR Office, Halifax, N.S.	L. S. Parsons G. H. Winters
Dec. 13-17	Directors' Conference with the Deputy Minister, Dept. of the Environment, Ottawa, Ont.	W. Templeman