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FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

of the

Arctic Biological Station

Ste. Anne de Bellevue, P.Q.

for

1966-67

by

C. J. KERSWILL, Director

With Investigators' Summaries as Appendices

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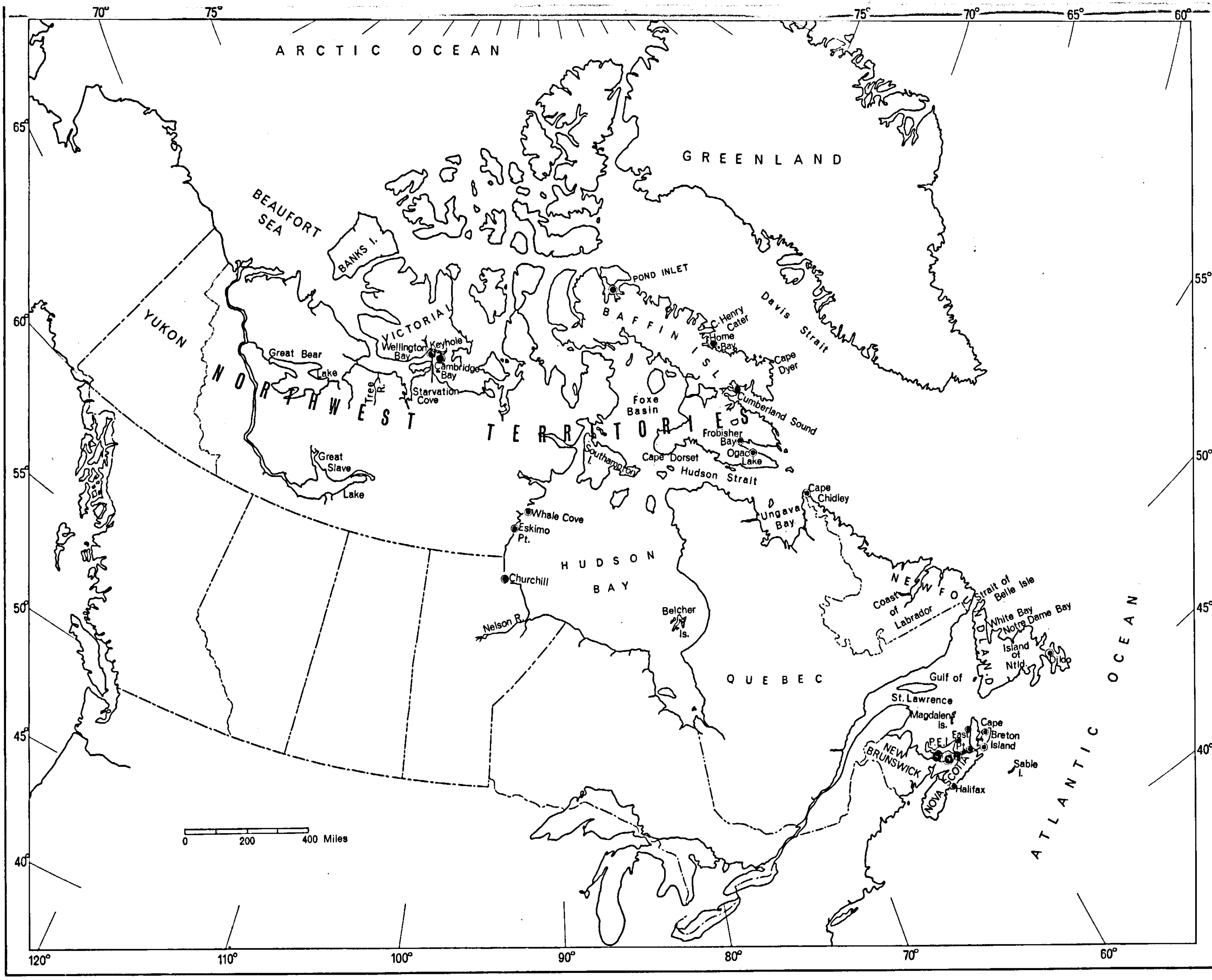

ARCTIC OCEAN
GREENLAND
BEAUFORT SEA
BANKS I.
VICTORIA I.
YUKON
NORTHWEST TERRITORIES
Great Bear Lake
Wellington Bay
Keyhole
Cambridge Bay
Starvation Cove
Tree R.
POND INLET
BAFFIN ISLAND
C. Henry Cater
Home Bay
Cape Dyer
Davis Strait
Cumberland Sound
Foxe Basin
Frobisher Bay
Ogac Lake
Cape Dorset
Southampton I.
Hudson Strait
Great Slave Lake
Cape Chidley
Ungava Bay
Whale Cove
Eskimo Pt.
HUDSON BAY
Churchill
Nelson R.
Belcher Is.
NEWFOUNDLAND
Coast of Labrador
Strait of Belle Isle
White Bay
Notre Dame Bay
Island of Ntld.
Dildo
QUEBEC
Gulf of St. Lawrence
Magdalen Is.
Cape Breton Island
East Pt.
P.E.I.
NEW BRUNSWICK
NOVA SCOTIA
Halifax
Sable I.
ATLANTIC OCEAN
0 200 400 Miles
70° 75° 75° 70° 65° 60°
65° 60° 55° 50° 45° 40°
55° 50° 45° 40°
120° 110° 100° 90° 80° 70° 60°

FISHERIES RESEARCH BOARD OF CANADA

Arctic Biological Station,

Ste. Anne de Bellevue, P.Q.

The Arctic Biological Station is responsible for scientific investigation of fishes in the Canadian arctic and subarctic and for marine mammal research in both arctic and northwest Atlantic waters. Biological oceanography and limnology complement the program, to define and explain the interaction of factors limiting production. The general objective is to develop a sound biological basis for optimum use of the available fishery resources. In the past, northern fish and marine mammals mainly provided subsistence for the native population; now outside interests show growing enthusiasm for developing new commercial and sport fisheries in the Northwest Territories. Such developments would provide northern residents with valuable employment opportunities. At the same time interesting new fishery products as well as recreational fishing and hunting would become available to people living south of 60°N.

The Montreal area developed as the administrative centre of arctic research soon after the 1947 Annual Meeting of the Fisheries Research Board, when Dr. M. J. Dunbar of McGill University presented a plan of research for the eastern arctic. The following year a sub-committee on arctic research recommended that the Board develop a long-term program of research in the western and eastern arctic and in Hudson Bay. The program was to be integrated with those of other departments of the Canadian Government and other organizations engaged in arctic research, including the Arctic Institute of North America which has Canadian headquarters in Montreal. It was emphasized that FRB would have responsibility for investigating the fisheries and hydrography of the Canadian arctic.

The Eastern Arctic Investigations were established under direction of Dr. Dunbar with the following terms of reference: (1) to discover, if possible, marine resources which could be developed by the Eskimo populations; (2) to make a fundamental study of the physical and biological oceanography of eastern arctic waters. In August 1948 a specially designed and equipped 49-ft vessel, the M.V. Calanus, was launched and sailed to Ungava Bay. These activities were supplemented by physical and chemical oceanography carried out by the Canadian Hydrographic Service, the Royal Canadian Navy and various U.S. task forces, culminating in a joint United States-Canada cooperative study of the western arctic by the new H.M.C.S. Labrador and two other ships in 1954.

In 1953 Parliament recognized the growing importance of the North by passing a bill outlining the responsibilities of the Minister of the new Department of Northern Affairs and National Resources. They included measures for economic and political development in the Northwest Territories and the Yukon, and associated scientific investigations and technological research. A new program of arctic investigations was considered by the FRB Executive Committee in June, 1954. As a result the "Arctic Unit" was established in 1955 on the campus of McGill University, staffed by six full-time scientists with Dr. H. D. Fisher in charge, and several support and part-time employees. In July, 1963 Dr. Fisher resigned and Mr. J. G. Hunter was acting director until January 1965. During the 10-year period 1955 to 1964 the scientific staff totalled from six to eight, supporting personnel increased to six technicians and four administrative and clerical staff, and from 10 to 24 student assistants were engaged annually for summer field work.

In 1964 the name of the laboratory was changed to "Arctic Biological Station" and in February, 1965 the Station moved from rented quarters on the McGill campus to a new building near the TransCanada Highway on the outskirts of Ste. Anne de Bellevue, 20 miles from downtown Montreal. The building was officially opened by the Minister of Fisheries on April 28, 1965. It is attractively designed, on a well-landscaped lot in rural surroundings, with convenient travel connections by car, air and train.

Since its inception 19 years ago the FRB arctic program has passed through an exploratory survey stage. The results are now being used by several agencies concerned with management of northern fisheries. Effort is shifting gradually to long-term basic studies which are needed to understand the factors limiting fish and mammal production and to give improved estimates of stock size and potential yield. Increased attention is now being given to year-round observations on the aquatic environment, flora and fauna of the arctic; most of the past work of the Station has been limited to the summer season.

The Station continues to provide scientific information, and opinions on management procedures, to the Department of Fisheries and several other departments of the Federal Government that are concerned with the development of northern fisheries, particularly the Department of Indian Affairs and Northern Development (formerly Department of Northern Affairs and National Resources). Many specialists in invertebrates and fishes at universities and museums have assisted us in identifying collections and in working up the data for publication. Qualified university students are encouraged to undertake post-graduate studies using specimens, data and Station facilities. In 1966 such accommodation was provided for two graduate students of McGill University who were supported by FRB grants. Station staff are acting as outside examiners for three other Master's theses at McGill University and one at the University of Montreal; material for two of them is being obtained through FRB summer employment and ship time in the arctic.

On March 31, 1967 the full-time staff of the Station comprised 9 scientists, 8 technicians, a librarian and 8 other support staff, totalling 26. During 1966-67 the following new appointments were made: Scientific--Mr. K. M. Muth, from June 15, to assist with the fisheries investigations; Dr. J. W. Wacasey, from January 16, to assist with biological oceanography; Technical--Mr. D. B. Fleet, Technician 3 from October 1 and Miss Marsha I. Joynt, Technician 1, from January 3, to assist with fisheries investigations; Mr. W. Hoek, Technician 2, from June 6 and Mr. M. W. Cawthorn, Technician 3, from June 13, to assist with marine mammal investigations; Administrative--Mrs. M. C. Claremont, Stenographer 4, from July 13; Buildings and Grounds--Mr. G. A. Sleno, Maintenance Craftsman 2, from August 8. On July 31 Dr. L. Johnson, Scientist 3 in fisheries investigations transferred to the Freshwater Institute, Winnipeg, and the vacancy has not yet been filled.

The 39-ft M.V. Salvelinus operated mainly in Starvation Cove about 40 miles west of Cambridge Bay where she wintered in 1965-66, and returned there for wintering in 1966-67. The 49-ft M.V. Calanus wintered again at Frobisher Bay in 1966-67 after summer operations in connection with the marine mammal investigations on eastern Baffin Island. For the new tagging program on large North Atlantic whales a 165-ft steel refrigerated cargo ship, the William S. was chartered for the period July 17 to October 17, operating out of Halifax to waters off Newfoundland, Labrador, West Greenland, then southward to Jamaica, Venezuela and Puerto Rico. As usual, transportation of staff and equipment for several fisheries and marine mammal projects was provided by chartered aircraft. A new semi-permanent small laboratory building was erected at Starvation Cove, Victoria Island for a new year-round marine fisheries productivity study.

Review of 1966-67 investigations

Staff participation in various conferences and meetings included the following: May 17-19--L. Johnson presented a paper on the freshwater environment at a symposium on arctic biology, Queen's University; June 3--D. E. Sergeant lectured to Department of Transport Ice Observers on identification of marine mammals; September 30-October 5--J. G. Hunter and D. E. Sergeant attended ICES symposium on ecology of pelagic fish in arctic waters and other meetings, Copenhagen; October 13-15--D. E. Sergeant attended ICNAF sealing meeting as Canadian adviser, Copenhagen; November 14-18--E. D. Mitchell attended meeting of Geological Society of America, San Francisco and Society of Vertebrate Paleontology, Berkeley, California; January 9--J. G. Hunter, C. J. Kerswill, K. M. Muth, and D. E. Sergeant attended CCFFR meeting, Ottawa; January 10--C. J. Kerswill gave seminar on Station program at Macdonald College; January 27--C. J. Kerswill guest at opening Eskimo art exhibit, T. Eaton Co. Ltd., Montreal; January 31-February 2--J. G. Hunter and C. J. Kerswill attended meeting on Northwest Territories fisheries with Department of Fisheries and DIAND staff, Winnipeg; February 7--E. D. Mitchell interviewed on CBC program, "7 on 6"; February 8--C. J. Kerswill guest at annual dinner meeting Atlantic Salmon Association, Montreal; February 13-15--J. G. Hunter, A. W. Mansfield, K. M. Muth,

D. E. Sergeant, and C. J. Kerswill attended Northeast Fish and Wildlife Conference, Quebec City, the first four presenting papers; March 2-3--C. J. Kerswill and K. M. Muth attended FRB meeting on bioenergetics and growth of fish, Winnipeg Station; March 28--C. J. Kerswill addressed Centennial meeting of 300 Cubs, Scouts and leaders, Montreal West, on arctic fisheries research.

Highlights of the 1966-67 research projects are mentioned here and details are appended in the Investigators' Summaries as indicated. The main areas and most of the places where work was in progress are shown in the accompanying map (Frontispiece).

FISHERIES INVESTIGATIONS. Effort is directed mainly to active continuing field programs where the work can be done entirely by Station staff. In some projects, however, biological samples and data are collected under our direction by staffs of the Department of Fisheries and the Department of Indian Affairs and Northern Development (DIAND).

Great Bear Lake. A three-year limnological and fisheries survey of Great Bear Lake ended in 1965 and the analysis and publication of data are continuing. Phytoplankton collections gave 250 species, all scarce, as expected from the extremely low level of nitrates, phosphates and other nutrients shown by water analyses. Freshwater algae predominated but some marine diatoms and silicoflagellates have suggested an earlier occurrence of saline pro-glacial waters. Production of all fish species is low. Only the lake trout has widespread distribution but it grows slowly and does not reach sexual maturity until 14 years of age, when it weighs about 5 lb. Other fish species including whitefish, lake herring, grayling and yellow pickerel have restricted distribution and low productive capacity.

Keyhole Lake. The standing crop of landlocked arctic char in 120-acre Keyhole Lake, Victoria Island, was estimated to be 50 lb per acre, through a tag and recovery program started in 1963 and concluded in 1965. Comprehensive analysis of the data neared completion in 1966. Total mortality (natural only) varied with age from 29% at age 10 to 94% at age 15. (Appendix No. 1)

Zooplankton and phytoplankton were scarce at the period of spring runoff but soon afterward the populations increased rapidly. The phytoplankton standing crop was dominated by a succession of Dinophyta, the most abundant being *Glenodinium oculatum*. Zooplankton consisted of a few forms dominated numerically by rotifers, but the major weight contribution was by larger forms such as the cladoceran, *Daphnia*. (Appendix No. 2)

Starvation Cove. In 1966 a new long-term investigation of marine productivity was started in Starvation Cove 40 miles west of Cambridge Bay, using the M.V. *Salvelinus*. It includes the systematic collection of plankton, benthos and fish at regular intervals over a

10-square-mile area. Facilities include a new semi-permanent laboratory on the shore of the Cove. Year-round observations will be made. (Appendix No. 3)

Seismic explosions. In August a series of 16 one- and two-ton seismic explosions in lakes of the Northwest Territories was observed to assess the effects on fish. In some cases many lake herring and whitefish as well as some lake trout were killed within a radius of about 300 yards from the explosion. The project provided an excellent opportunity to obtain fish samples for data on length, weight, sex, parasites, etc., from several lakes not previously examined. (Appendix No. 4)

Miscellaneous studies of arctic char. Continuing investigations involve mainly (1) monitoring population changes in a commercial char fishery at Frobisher Bay, Baffin Island, started in 1959, by measuring annually the size and age of fish caught, catch per unit of effort, time of runs, and maturity of fish; (2) similar monitoring of catches of char (and lake trout in Ferguson Lake, Victoria Island); (3) assessing productivity of a small arctic lake (Keyhole Lake, Victoria Island) for landlocked char, by following through 1968 the recovery of the fish population after drastic reduction by gill-netting in 1965, supplemented by quantitative determinations of zooplankton and phytoplankton; (4) analysis of data on a number of arctic char sports fisheries, obtained under our direction by staffs of the Department of Fisheries and DIAND; in progress for several years this has provided valuable biological data and given information on which to base widespread recommendations for management.

MARINE MAMMAL STUDIES. For over ten years investigation has been directed to harp, hood, and grey seals on the Atlantic coast, to ringed seals and walrus in the eastern arctic, and to beluga populations in Hudson Bay. An intensive three-year study of the narwhal was completed in 1965 in the vicinity of Pond Inlet, northern Baffin Island. For many years data on occurrence of North Atlantic whales, mostly obtained by other agencies, have been analyzed by our staff. Intensive investigation of large east coast whales was initiated in 1966 to provide population data for management of a new Atlantic coast whaling industry which started in 1964. In the winter of 1966-67 it was decided to transfer the Pacific marine mammal investigations from the Nanaimo Station to Ste. Anne de Bellevue and the move was effected on April 1, 1967. The Arctic Biological Station is now responsible for all FRB marine mammal investigations.

Harp seal. Investigations for 15 years on Canadian harp seals to provide a sound basis for managing the fishery have included (1) aerial surveys to give the number of whelping adults and their young; (2) tagging newborn seals and analyzing recaptures made during the ensuing brief fishery; (3) following in different areas the range of ages of females at which sexual maturity is reached to indicate separateness of stocks, since a heavily-exploited stock reproduces at a higher rate than a lightly-exploited stock.

Harp seals are divided into two stocks or herds, one whelping and moulting in the Gulf of St. Lawrence, the other east of Newfoundland and Labrador. These herds mix in summer in arctic waters.

The Gulf herd produces about 350,000 pups per year and the total population before pupping is about 1½ million. It has never been overfished and the original population probably never exceeded 2 million. Now 85,000 young and 15,000 older animals are taken annually by Canadian ships, aircraft, and landsmen. The Department of Fisheries imposed a quota of 50,000 young seals for ships and aircraft in the southern Gulf in 1965. The maximum sustainable yield is about 95,000 young and 18,000 older animals per year.

The east coast of Labrador or "Front" herd once numbered about 2 million animals and produced about 430,000 pups per year. In recent years production of pups has been reduced to about 200,000 annually. Apparently some animals enter it from the Gulf herd. Recent annual "Front" catches of 180,000 young and 30,000 older animals are considered to be excessive. (Appendix Nos. 5, 6, and 7)

Hood seal. Hood seals occurring in Canadian North Atlantic waters are an offshoot from animals occurring farther north, probably in Davis Strait. Numbers reaching southern Labrador fluctuate greatly from year to year and over longer periods, apparently under the influence of the climatic cycle. The species is even scarcer in the Gulf which may be too warm. There is evidence that they are not hunted excessively; however, the catch includes more adult females than adult males. (Appendix No. 8)

Beluga or white whale. The total population of white whales on the west coast of Hudson Bay was estimated at 5000 to 10,000 by an aerial survey in July 1965, made to provide information on which to base quota recommendations for a local fishery. (Appendix No. 9)

Large North Atlantic whales. To provide information on which to manage an Atlantic coast fishery started in 1964 for large whales (mainly fin whales), an extensive survey and tagging program was initiated in 1966 using a 165-ft chartered vessel. For a three-month period starting July 17, the vessel operated first off Nova Scotia, Newfoundland, Labrador, and West Greenland, then cruised southward to Venezuela, Puerto Rico and Bermuda. Tags were applied to 76 fin whales (of 283 sighted), 62 sperm whales, and 30 whales of seven other species. Fin whales were seen only within the continental shelf, from Cape Cod northward to 57°N on the Labrador coast. Two independent estimates of the stock size of fin whales were: (a) by tagging and recapture, based on 4 recoveries at Nova Scotia and Newfoundland whaling stations--6790; (b) by strip census, based on sightings adjusted for area carefully searched, visibility, etc.--6620. Assuming a 12% exploitation rate for sustained yield (as used in Antarctic fin whaling) the allowable annual catch from the above populations would be about 800. This first approximation to a quota will be used to control the 1967 fin whale fishery, when it is expected that four shore stations will operate in Newfoundland and Nova Scotia. (Appendix No. 10)

Ringed seal. Previous intensive research of the ringed seal off Baffin Island ended in 1958 and there is now a need for new biological studies over a wide area of the arctic. In 1966 ringed seals came under intensive population study in Cumberland Sound where there is relatively heavy exploitation. Later the work will extend northward to Home Bay where the species appears to be under-utilized, to assess the significance of hunting pressure as a factor limiting stock size. Many birth lairs were found about 15 miles from nearest land, whereas the earlier work indicated they were restricted to land-fast ice much closer to shore. Records of catch statistics and related information were improved by providing Eskimo hunters with illustrated booklets containing labels, maps and containers for jaw samples which are used to age the seals. This produced 2000 jaws, which will give a distributional record of different age classes and their mortality rates. (Appendix No. 11)

Grey seal. Population and behaviour studies of grey seals have been carried on for several years in the Gulf of St. Lawrence and off eastern Nova Scotia to assist management authorities reach a decision on the need for and method of stock reduction. The species is an important vector of parasitic nematodes in codfish and damages salmon nets. Observations in 1965-66 indicated that controlled killing of several hundred animals would be desirable and feasible during the breeding season in January. This information was used by the Department of Fisheries in allowing a limited kill on the Basque Islands, N.S., in January, 1967, after such action had been requested by local salmon fishermen. (Appendix Nos. 12, 13, and 14)

Narwhal. Specimens of narwhal obtained in 1965 during netting operations off northern Baffin Island gave new information on physiology of reproduction which will be useful for population estimates. Conception occurs in mid May and the length of the gestation period is about 14 months, determined from measurements of well-developed foetuses from two pregnant females compared with foetal measurements recorded in the literature.

BIOLOGICAL OCEANOGRAPHY. In 1966 with the scientist in charge of this project on sabbatical leave in Europe (Appendix No. 20), no field program aimed specifically at biological oceanography was attempted. The M.V. Calanus, usually occupied mainly with biological oceanography, was used for marine mammal work around Baffin Island (Appendix No. 15). Laboratory analysis continued on pelagic phytoplankton collected previously in the Arctic Ocean (Appendix No. 16), and plankton collections from Keyhole Lake (Appendix No. 17). Progress has been made with the taxonomy of the family Gymnoasteraceae of the Dinophyta (Appendix No. 18) and in speculating on the importance to human nutrition, of the lipids of arctic diatoms and dinoflagellates (Appendix No. 19).

PERSONNEL

(April 1, 1966 to March 31, 1967)

Administration

C. J. Kerswill, M.A., Ph.D.	Scientist 5, Director
G. F. Hart	Administrative Officer 4
H. W. McNeill, B.A.	CR5
Lois G. McMullon	ST6
Margaret C. Claremont	ST4 (Secretary) (from July 13, 1966)
Michelle Besner	ST3 (Term)
Joyce F. Fellows	ST3 (Sept 21, 1966 to March 3, 1967)
Patricia Nichols	ST3 (Secretary) (to June 17, 1966)
May E. Sloan	ST2 (June 1, 1966 to June 3, 1966)
Nancy A. Trottier	ST2 (to April 29, 1966)

Buildings and Grounds

C. Chartré	Maintenance Supervisor 6
G. A. Sleno	Maintenance Craftsman 2 (from August 8, 1966)
P. Lacasse	Carpenter (Casual) (from February 23, 1966)

Library

Joan E. Campbell, B.A., B.L.S.	Librarian 2

Fisheries Investigations

J. G. Hunter, M.A.	Scientist 3
L. Johnson, M.Sc., Ph.D.	Scientist 3 (to July 31, 1966)
K. M. Muth, M.Sc.	Scientist 1 (from June 15, 1966)
I. G. Gidney	Technician 4 (half time)
D. B. Fleet	Technician 3 (from October 1, 1966)
M. Louise LeBrun	Technician 2 (to July 15, 1966)
Marsha I. Joynt	Technician 1 (from January 3, 1967)
Shirley T. Leach	Assistant Technician 3

<u>Fisheries</u> (Continued)

J. Boulva	Student Assistant (June 15, 1966 to Sept 13, 1966)
D. R. Curtis, B.Sc.	Student Assistant (June 15, 1966 to Sept 5, 1966)
R. J. Rowland	Student Assistant (May 16, 1966 to Sept 13, 1966)
Zandra A. Scott	Student Assistant (May 2, 1966 to August 31, 1966)

<u>Marine Mammal Investigations</u>

A. W. Mansfield, M.A., Ph.D.	Scientist 3
D. E. Sergeant, M.A., Ph.D.	Scientist 3
E. D. Mitchell, M.A.	Scientist 2
M. W. Cawthorn	Technician 3 (from June 13, 1966)
C. W. Nicol	Technician 3
W. Hoek	Technician 2 (from June 6, 1966)
P. F. Brodie, B.Sc.	Student Assistant (May 2, 1966 to Sept 16, 1966)
D. M. Casson	Student Assistant (May 2, 1966 to Sept 2, 1966)
G. S. Jamieson	Student Assistant (June 1, 1966 to Sept 6, 1966)
F. M. Keith	Student Assistant (May 3, 1966 to Sept 9, 1966)
W. D. Robb, B.Sc.	Student Assistant (June 15, 1966 to Sept 7, 1966)
A. F. Spence	Draftsman 5 (Casual) (March 23, 1967 to March 31, 1967)

<u>Biological Oceanography</u>

E. H. Grainger, M.Sc., Ph.D.	Scientist 4
A. S. Bursa, M.Sc., Doctor of Biological Sciences	Scientist 3
J. W. Wacasey, M.Sc., Ph.D.	Scientist 3 (from January 16, 1967)
W. F. Shields	Technician 4 (half time) (to May 31, 1966)
A. A. Mohammed, B. Sc.	Technician 2

M.V. *Calanus*

W. F. Shields	Technician 4 (half time) (to May 31, 1966)
D. B. Fleet	Student Assistant (May 27, 1966 to Sept 30, 1966)

M.V. *Salvelinus*

I. G. Gidney	Technician 4 (half time)

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(January 1 to December 31, 1966)

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Beck, Brian. Seal net fisheries along the north shore of the St. Lawrence River. Trade News 18(2-3): 18-19.

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Sergeant, D. E. Reproductive rates of harp seals, Pagophilus groenlandicus (Erxleben). J. Fish. Res. Bd. Canada 23: 757-766.

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INDEX TO SUMMARY REPORTS

No. 1

Arctic char studies, Keyhole Lake, Victoria Island.

Keyhole Lake, situated in the south central lowlands of Victoria Island, covers an area of 48.6 ha and has a mean depth of 2.99 m and maximum depth of 6.50 m. In 1962, 1963, and 1965 land-locked arctic char in the lake were sampled for age, size, growth, and mortality.

The population of char 16 to 36 cm in length was estimated at 5292 (range 4684 to 6045) fish, averaging 109 fish/ha. Mortality (entirely natural mortality) varied with age as follows.

Age	Total mortality (%)
10 years	28.64
11	44.62
12	51.74
13	68.71
14	65.04
15	94.00

From a total sample of over 6900 fish, only 13 were longer than 40 cm and the largest specimen measured only 45 cm.

No significant difference in growth rate was noticeable between the small samples obtained in 1962 and 1963 but a difference was evident in 1965 following intensive fishing in 1963. Re-examination of 1965 otolith samples is presently in progress to confirm the latter.

J. G. Hunter

No. 2

Keyhole Lake limnological studies.

Keyhole Lake showed depauperated zooplankton and phytoplankton fauna at the period of spring runoff but there was soon a rapid increase. The phytoplankton, examined by Dr. A. S. Bursa, showed that the standing crop composition was dominated by a succession of species, the most abundant of which was *Glenodinium oculatum*. This species, concentrated in surface waters, reached peak numbers of 173,120 cells/l during early breakup and average counts of 57,036 cells/l throughout the summer. Calculated weight contribution of this species to the lake at its peak abundance on July 3 was 0.236 g/m^3. Total weight contribution of the 135 species of phytoplankters identified from the lake cannot be calculated. Direct weighing of filtered phytoplankton was not possible because of the presence of large quantities of detrital phytoplankton throughout the water mass, which in all cases was more plentiful than the living cells.

Zooplankton sampled in 1965 consisted principally of a few forms dominated numerically by the rotifers. Major weight contribution was by larger forms such as cladocerans, Daphnia sp. Biomass estimates of the major groups and total zooplankton standing crop are shown in Figure 1. Similar estimates of standing crop were found in both 1963 and 1965 with only slightly greater values in the latter year.

Sixteen benthic samples taken with a 0.1 m^2 Peterson grab dredge during the period June to September had a mean weight of 226.6 g of organic material/m^2 of which 218.7 g consisted of plant material. The remaining 7.9 g consisted principally of chironomids, oligochaetes and monoecious pelecypods.

J. G. Hunter

No. 3

Marine fish studies from M.V. Salvelinus, 1966.

Field work on marine fish started with arrival of personnel at Cambridge Bay on June 18. The M.V. Salvelinus was readied for summer work and launched in the first open water on July 6. Ice cleared from the harbour entrance for the vessel to leave on July 23. Fishing activities commenced the following day in Wellington Bay but suitable trawling area near Starvation Cove was not found until August 3. A discrete area was buoyed off and successive trawling with a 19.6-ft balloon trawl was carried out in this area until September 9 when the vessel returned to Cambridge Bay. Continuation of cod studies, planned for the period September 10-18 in Cambridge Bay, was prevented by gale force winds. The M.V. Salvelinus was "hauled out" on September 13 and personnel left Cambridge Bay for Ste. Anne de Bellevue on September 18.

During the season 84 trawls were made over the selected bottom; 15 hydrographic stations including salinity and temperature measurements and 3 other stations measuring oxygen, light intensity, radioactive carbon uptake, and phytoplankton abundance were occupied. At Starvation Cove a field station building (10 ft X 24 ft) was erected in the period September 1-8, and a gasoline-driven power plant (4000 watts) was installed.

Delivery failures for chemicals and glassware equipment and malfunction of a spectrophotometer in the initial year of this study restricted the planned observations.

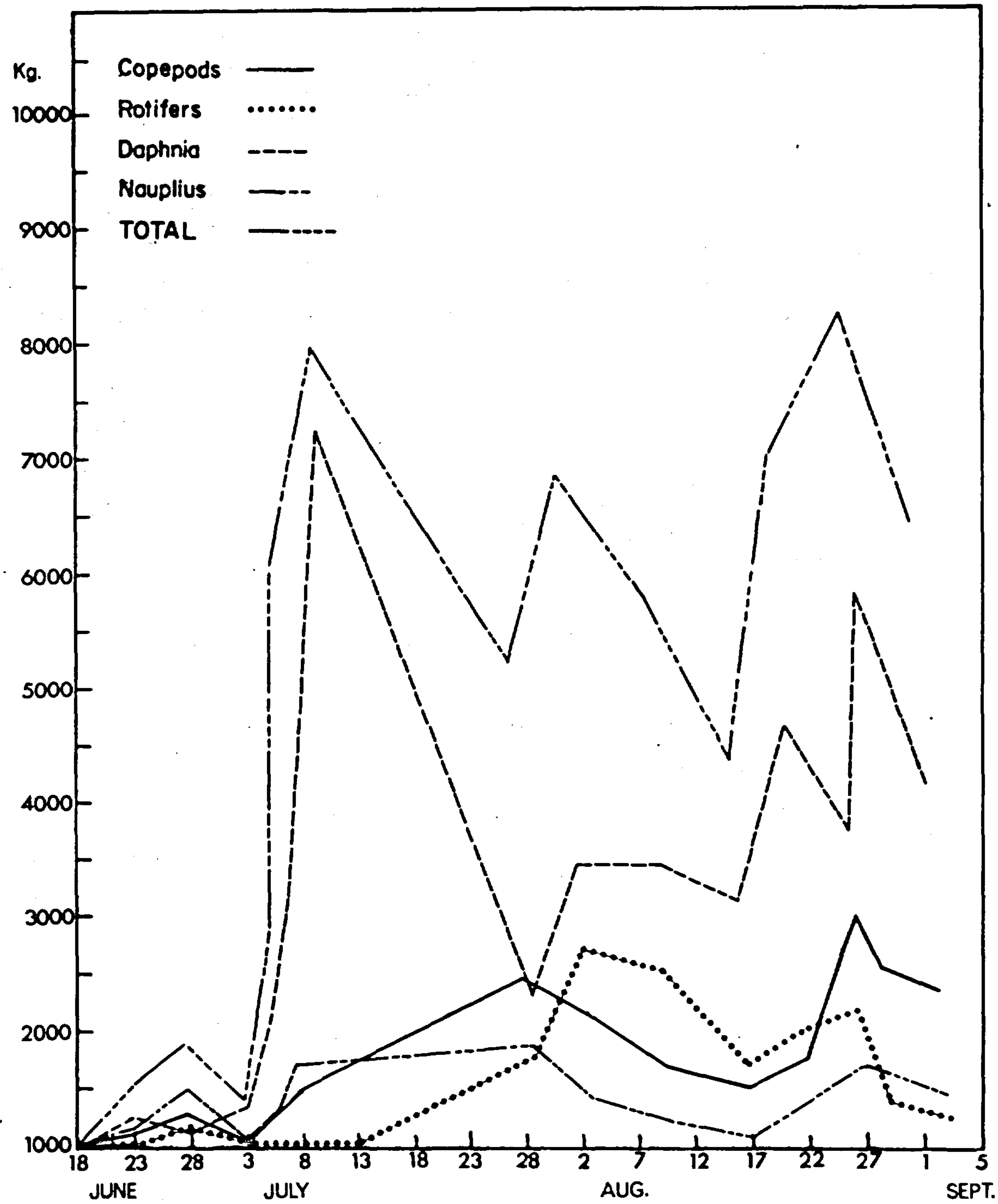


Figure 1. Standing crop estimates of zooplankton in Keyhole Lake during the summer of 1965.

The buoyed section about one mile from shore in Starvation Cove covered an area of 130,000 m^2 in water 60 m deep. Complete theoretical coverage of the bottom by trawling was possible with 40 trawls. These were effected in a four-day period from August 3-7 and showed a decline in catch/unit of effort with increased fishing. Extrapolation of this declining rate of catch/unit of effort for invertebrate fauna indicates a total invertebrate standing crop of 1000 kg or 77 kg/ha available to the trawl. The remaining 44 trawl hauls over the same area in the period August 12-25 showed a continuing decline of catch/unit of effort, with a similar standing crop estimate. Standing crop estimates by species have yet to be calculated. Benthic fish catches were as follows:

Boreogadus saida (Arctic cod)	8876
Icelus spatula (Spatulate sculpin)	1990
Aspidophoroides olriki (Arctic alligatorfish)	717
Gymnocanthus tricuspis (Arctic staghorn sculpin)	282
Lumpenus medius (Stout eelblenny)	281
Icelus bicornis (Twohorn sculpin)	262
Liparis keofoedi (Gelatinous seasnail)) Liparis sp.)	241
Triglops pingeli (Ribbed sculpin)	83
Lumpenus fabricii (Slender eelblenny)	17
Gymnelis viridis (Fish doctor)	3
Eumesogrammus praeciscus (Fourline snakeblenny)	3
Leptagonus decagonus (Atlantic sea poacher)	1
Eumicrotremus derjugini (Leatherfin lumpsucker)	1
Lycodes sp. (Eelpout)	?

J. G. Hunter
I. G. Gidney

No. 4

Fish mortality caused by seismic explosions in the Northwest Territories, 1966.

During the summer of 1966, the Department of Energy, Mines and Resources conducted a seismographic project in the Northwest Territories and adjacent areas of Alberta and Saskatchewan. Dr. C. J. Kerswill and K. M. Muth were invited to attend the series of explosions as observers and to obtain data on fish mortality.

A number of widely dispersed lakes and one river were selected for detonation locations (Figure 2). In an effort to minimize fish kills and damage to any fishery, detonation locations were chosen in consultation with personnel of the Department of Fisheries.

Explosives used for the seismic project consisted of one- and

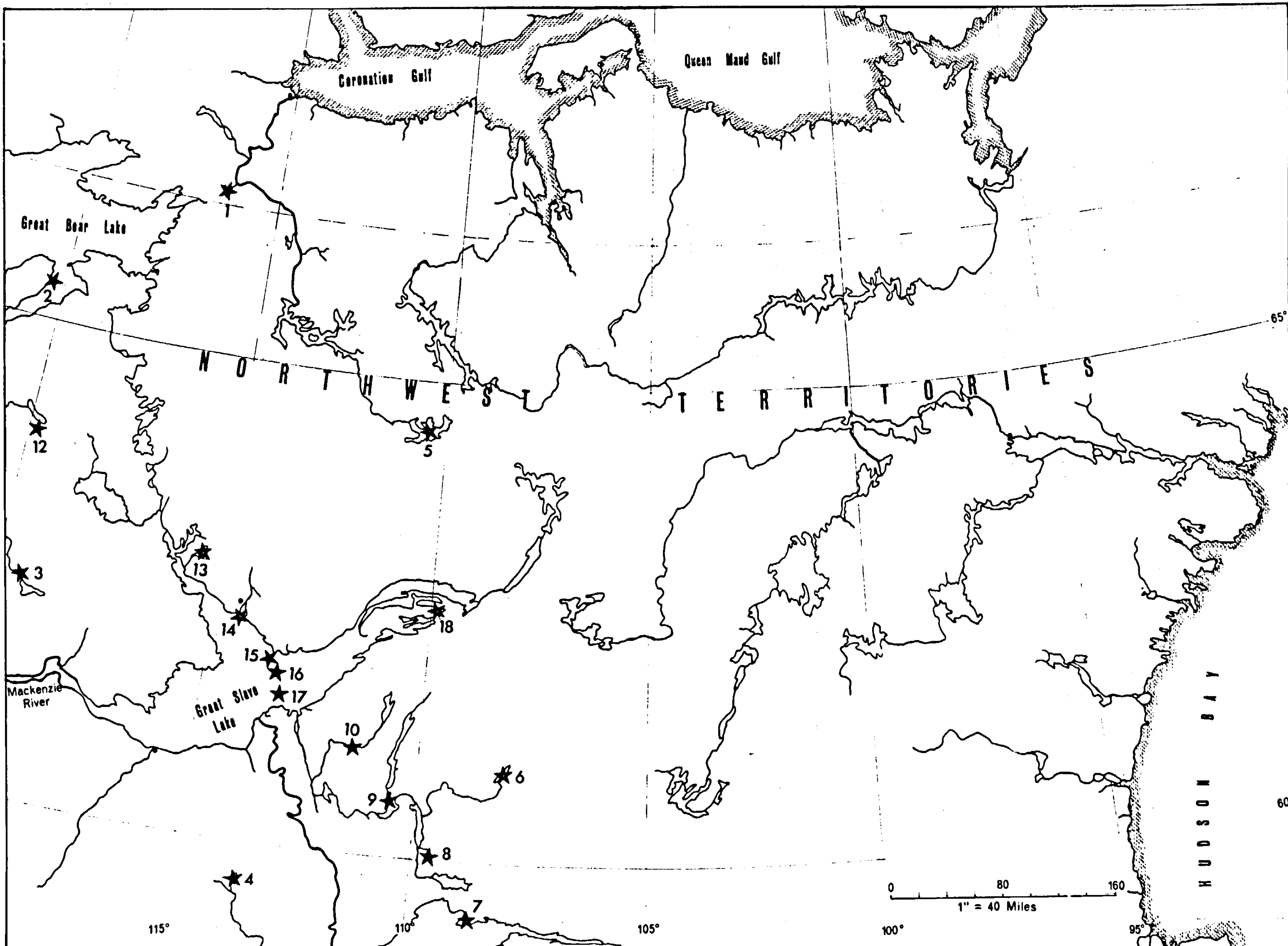


Figure 2. Detonation locations numbered in the order in which they were fired. Lake names appear in Table I.

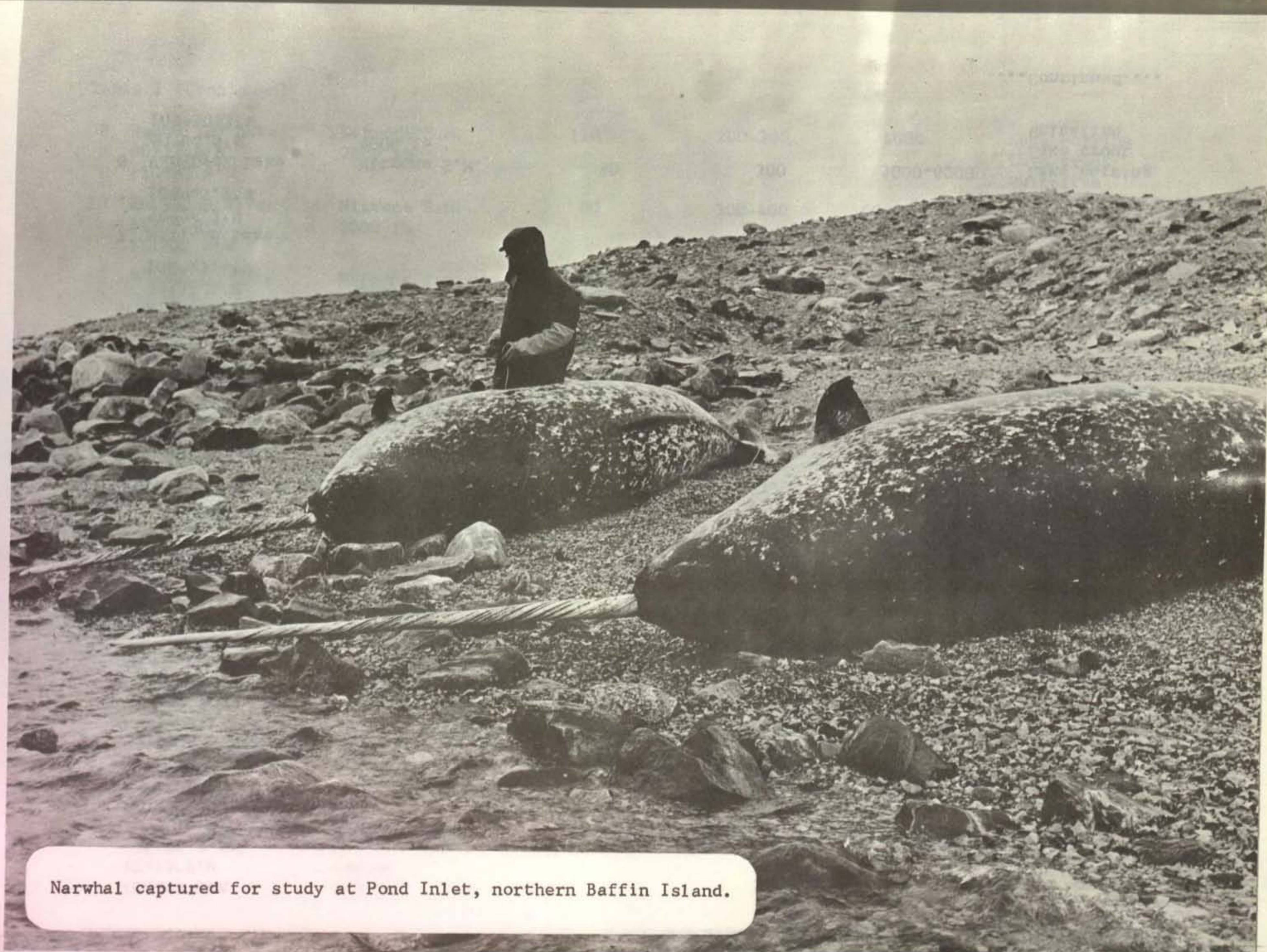
two-ton charges of Nitrone S.M. or Geogel. These were placed on the lake bottoms at a variety of depths (Table I) and were electrically detonated by personnel of the Department of Energy, Mines and Resources.

Dead or distressed fish began to appear at the surface in ever increasing numbers for a time interval of about 30 minutes after the explosion. Fish samples were collected by dip-netting or seining from the aircraft pontoons or a small inflatable dinghy. Data concerning species, sex, length, weight, age, and cause of death were collected. Kill radii and numbers were estimated from visual observations (Table I) and should be regarded as minimum values because of the possibility that some dead fish did not float.

An attempt to more accurately determine kill radius was made by placing caged live fish at known distances from the detonation area and then checking for fish mortality after the explosion. Gill-net captured fish used for this test were initially in poor condition so that the total mortality found after detonation could not strictly be attributed to blast effect. However, internal damage characteristic of blast-killed fish was found in some specimens which were located 300 yards from the detonation area and might be some indication of kill radius.

Mortality was highly variable from lake to lake. Causes of death were not externally visible but post-mortem examinations revealed extensive internal rupture and haemorrhage of blood vessels, organs and air bladders.

K. M. Muth



Narwhal captured for study at Pond Inlet, northern Baffin Island.

Table I. Detonations observed with species involved and estimates of kill radius and mortality.

	Detonation location	Type + weight of explosive	Depth in feet of explosive	Estimated kill radius in yards	Estimated fish mortality	Major species involved
1	Kamut Lake 66°42.7'N 116°21.1'W	Nitrone S.M. 4000 lb	170	200-300	500-1000	Lake herring Lake trout Whitefish
2	Great Bear Lake McVicar Arm 65°23.8'N 120°21.6'W	Nitrone S.M. 4000 lb (partial explosion)	180	200	9	Lake trout
3	Hornell Lake 62°21.6'N 119°31.4'W	Nitrone S.M. 4000 lb	66	200	2000-3000	Lake trout Whitefish Lake herring
4	Wentzel Lake 59°01.6'N 114°28.3'W					
5	Lac De Gras 64°32.5'N 111°00.7'W	Nitrone S.M. 4000 lb	120	200	3	2 Lake trout 1 Burbot
6	Alcantara Lake 60°54.1'N 108°15.4'W	Nitrone S.M. 4000 lb	90	300	10,000+	Whitefish Lake herring Lake trout
7	Milican Lake 59°26.2'N 108°45.2'W					
8	Van Dyck Lake 60°06.5'N 109°30.3'W	Nitrone S.M. 4000 lb	80	300	5000-6000	Lake herring Lake trout Whitefish

....Continued....

Table I (Continued)

9	Benna Thy Lake 60°37.4'N 110°32.9'W	Nitrone S.M. 2000 lb	110	200-300	1000	Lake herring Lake trout Whitefish
10	Rutledge River 61°09.9'N 111°42.7'W	Nitrone S.M. 2000 lb	90	300-400	5000-6000	Lake herring Whitefish Lake trout
12	"Unnamed" Lake south of Tache 63°48.8'N 119°56.3'W	Nitrone S.M. 4000 lb	120	500-1000	500	Lake trout
13	Stagg Lake 62°55.8'N 115°22.1'W					
14	Great Slave Lake No. 1 62°19.1'N 114°20.7'W	Geogel 2000 lb	288	1000	5000-10,000	Lake herring Whitefish
15	Great Slave Lake No. 2 61°57.0'N 113°43.7'W					
16	Great Slave Lake No. 3 61°49.0'N 113°26.2'W					
17	Great Slave Lake No. 4 61°36.4'N 113°19.5'W					
18	Great Slave Lake Christie Bay 62°39.4'N 109°49.0'W	Nitrone S.M. 2000 lb + Geogel 100 lb	155	1000	10,000+	Lake herring

No. 5

Tagging young harp seals in the Gulf of St. Lawrence.

The quota of 50,000 young harp seals for ships and aircraft applied in the southern Gulf of St. Lawrence since 1965 has allowed these seals to be tagged with high probability of escapement. With the cooperation of the Department of Fisheries, a total of 1345 young harp seals was tagged northwest of Cape Breton Island (Figure 1) from a Sikorsky 55 helicopter between March 16 and 21, 1966. Monel metal tail tags were used.

The prime purpose of the experiment was to determine the degree of mixing between Gulf of St. Lawrence and Newfoundland-Labrador or "Front" stocks of seals at ages of one year and up. Therefore, the main results of the experiment will not accrue till after the end of the sealing season in May 1967 when recoveries can be expected from the moulting one-year-old immatures. Preliminary results of this kind are reported below. Most recoveries to date add to knowledge of migratory movements obtained from tagging with the same type of tag in 1951 to 1954, particularly for the Gulf seals, few of which were tagged in the earlier set of experiments.

Recoveries reported to date (March 1967) total 110 animals or 8.1%. Distribution of recoveries was as shown in Table I.

Table I. Recoveries of harp seals in the first year after tagging in the Gulf of St. Lawrence.

Locality	Number	Locality	Number
Gulf of St. Lawrence, first spring	79	Labrador, fall migration	1
West Greenland, first summer	24	Quebec North Shore, fall migration	1
Baffin Island, first summer	1	Newfoundland East Coast, second spring	3

Of 79 recoveries in the Gulf of St. Lawrence dated recoveries are shown in Figure 1. Early recoveries came from the Magdalen Islands and drifted round Cape Breton Island; later, animals swam to the northern Gulf joining numbers of moulted young which contained no tagged animals and were probably born locally. The latest tagged young remaining in the northern Gulf was taken on June 15, except for one exceptional

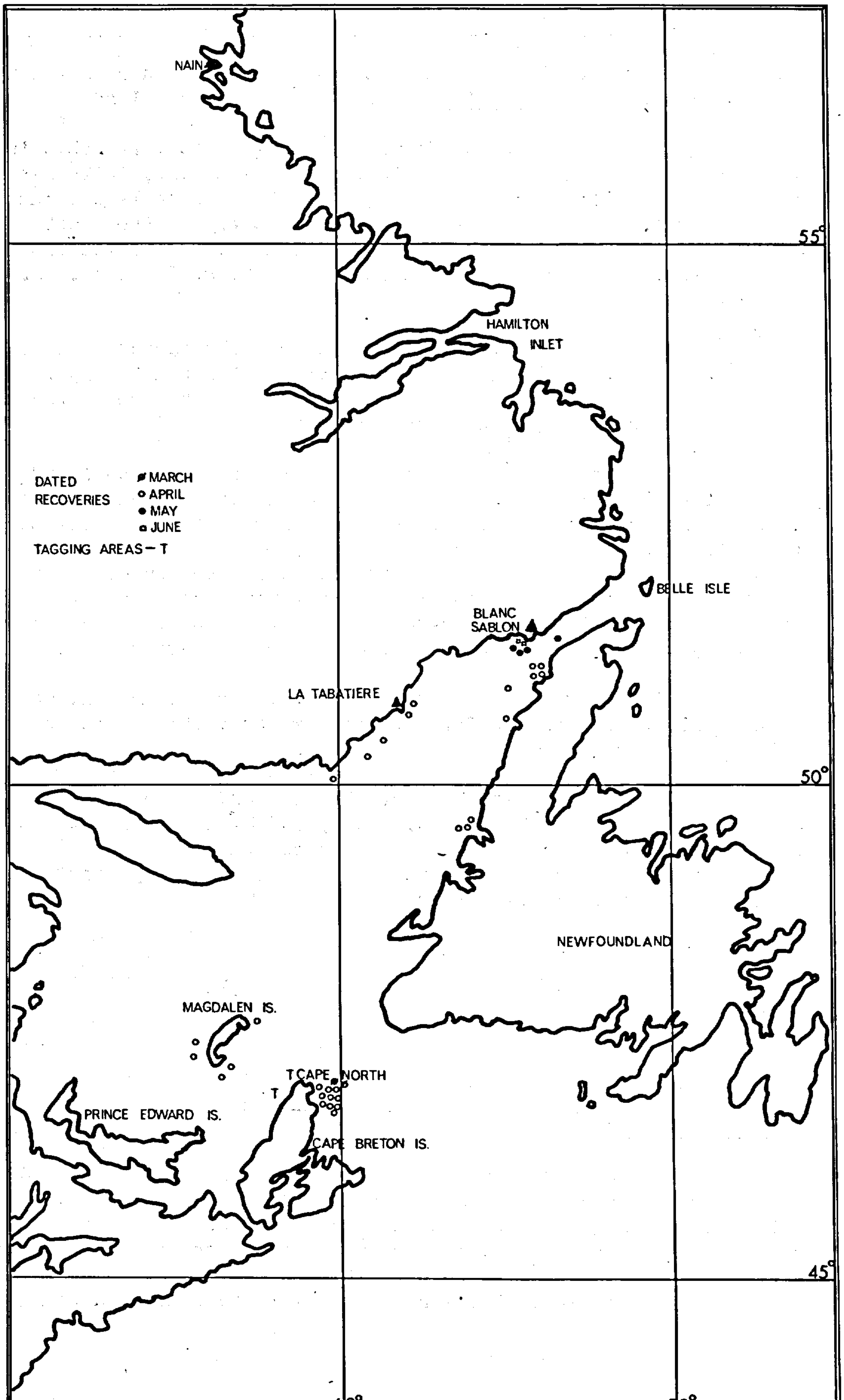


Figure 1. Recoveries March to June 1966 in eastern Canadian waters of young harp seals tagged at the indicated positions off Cape Breton Island in March 1966.

recovery in August of a tagged young taken in a net near a colony of harbour seals (Phoca vitulina L.) in western Newfoundland.

In West Greenland (Figure 2) young seals were taken in the southwest area near Julianehaab in late May and June, while later recoveries were largely in the Vaigat north of Disco Island and north to Upernavik. The single Baffin Island recovery is from Cumberland Sound in August. These findings agree with the recoveries from earlier experiments and reported in: Sergeant, D. E. 1965. J. Fish. Res. Bd. Canada 22(2): 433-464.

Autumn recoveries include two from the Labrador coast, and one from the Quebec North Shore. Few recoveries can be expected at this time since the one-year-old seals tend to move behind the main herds and do not fully enter the net fishery.

Three early spring recoveries are of exceptional interest as coming from Notre Dame Bay on the east coast of Newfoundland, in February or early March, 1967. These recoveries show that some seals born in the Gulf of St. Lawrence move as one-year-old immatures to the east coast of Newfoundland. The quantitative distribution of one-year-old immatures remains to be seen from the relative catches of immatures, and the numbers of tagged one-year-old seals recovered, in the Gulf of St. Lawrence and Newfoundland east coast in the spring fishery of 1967.

All recoveries reported above came from landsmen, mostly using small craft, except for one recovery by a ship in the northern Gulf of St. Lawrence.

Canadian Fishery Officers Stanley Dudka and Isaac Vigneault assisted our staff members I. G. Gidney and C. W. Nicol with the tagging. The Greenland Fishery Administration and Fishery Investigations of the Danish Government returned tags to us with very exact recovery data from Greenlandic fishermen.

D. E. Sergeant

No. 6

Capture-recapture tagging of young harp seals off the coast of Labrador in 1966.

A successful capture-recapture tagging experiment had been carried out in the Gulf of St. Lawrence in 1964 by a party of six men using an S-55 helicopter. Such an experiment off the Labrador coast required an icebreaker equipped with a helicopter since the southward-moving ice and the inaccessible coast made the logistics of a land-based experiment difficult. In 1966 we were fortunate in being promised

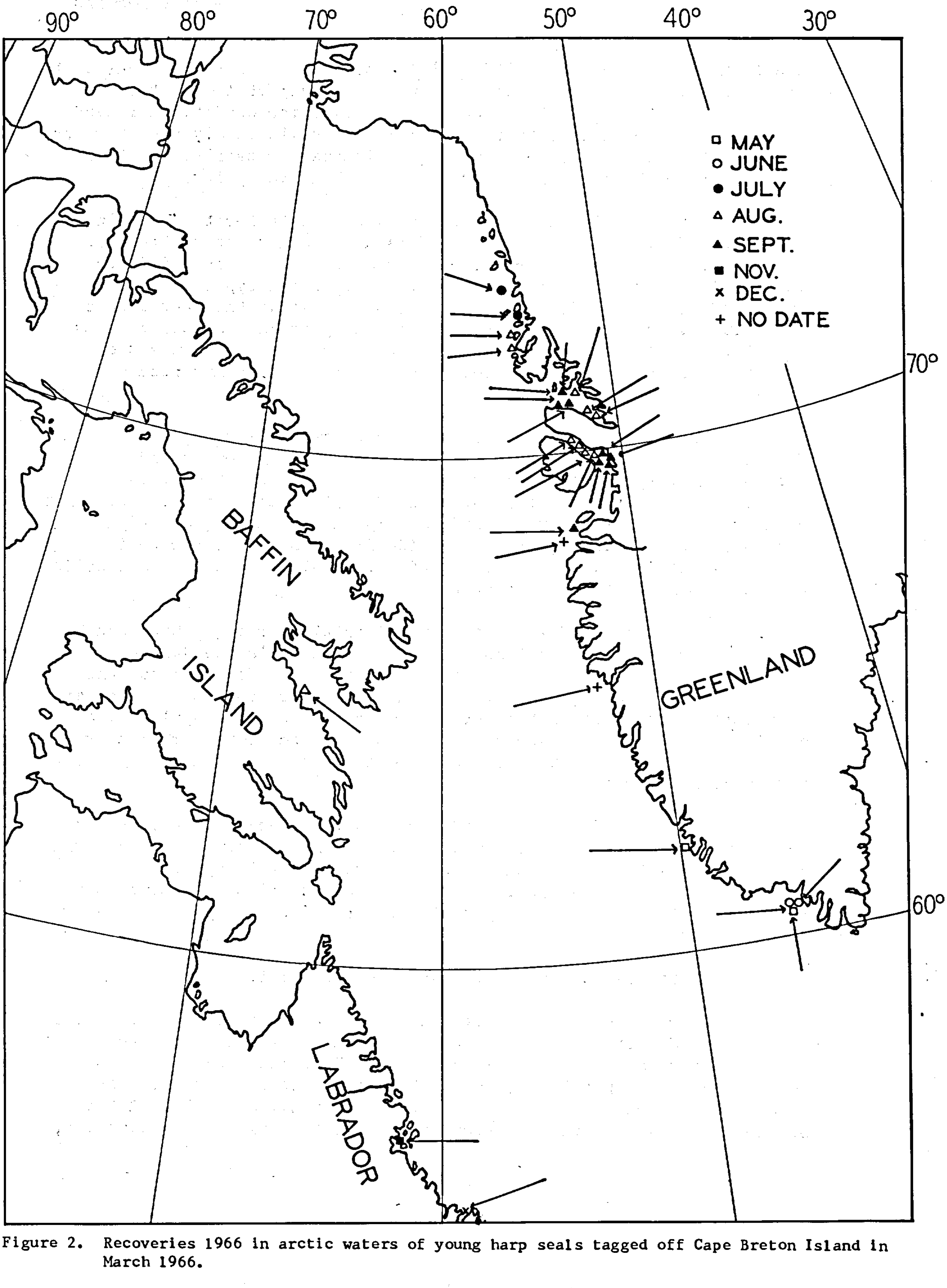


Figure 2. Recoveries 1966 in arctic waters of young harp seals tagged off Cape Breton Island in March 1966.

the loan of the icebreaker D'Iberville for 10 days from the Department of Transport to carry out such an experiment subject to light ice conditions in the Gulf of St. Lawrence. Light ice conditions indeed developed in the Gulf so that the icebreaker could be diverted for our use in the first 10 days of March. The icebreaker carried a Bell J-2 helicopter which could carry two men as well as the pilot.

An aircraft was chartered from Gander to locate the main seal herd off the Labrador coast. This herd turned out to lie near the expected area as deduced from ice conditions, namely off Grady Island, Labrador, and close to shore. This is the typical position when winds have been from the north or northeast in the second part of February, just before whelping of the harp seals. No other herds were located although fragments broke off from the southern end of this herd and drifted southward. Some of these fragments received tagging.

Between March 8 and 13 six men tagged 3581 young harp seals from the icebreaker making short flights on the helicopter and attempting to spread tagging evenly over the patch. Ships were already present in the patch and started sealing on March 12, the legal opening date. Ultimately 9 Canadian ships and 13 Norwegian ships sealed at the Front. Returns came also from Canadian landsmen in White Bay with a few in the Strait of Belle Isle, indicating the drift of the remains of the seal patch.

The tags used were monel metal cattle ear tags which can be applied about twice as fast as the disc tags used in the Gulf where the situation was less urgent. (See Appendix 5.) Nevertheless the fact that the same tag was not used in both experiments makes analysis of results more difficult; a correction factor has been applied from previous results of the use of cattle ear tags on young harp and grey seals to indicate expected rate of return of these tags after escapement from sealing by ships.

Returns (from Canadian ships and landsmen) are believed to be virtually complete. Unfortunately we did not advertise the program ahead of time, because of uncertainty about availability of the icebreaker. As a result returns from Norwegian ships are known to have been rather incomplete, considerable numbers of tags apparently being discarded by sealers.

Estimates of population are shown in Table II.

A wide variety of estimates is presented so that results are selective. Nevertheless, estimates 1, 5, and 6 broadly agree to give an estimate of about 200,000 young seals. Estimate 1 was based on total Canadian ship returns and has the disadvantage that half the returns came from one ship from one day's tagging, March 13. After eliminating tags and returns from this day's tagging as in estimate 8,

Table II. Recoveries of young harp seals and resultant population estimates.

	Number tagged	Agency	Catch of young harp seals	Recoveries	Population estimate
1	3581	All Canadian ships	54,955	985	199,795
2	"	All Norwegian ships	107,213	595	645,260
3	"	All ships combined	162,168	1570	376,286
4	"	Canadian landsmen, White and Notre Dame Bays and Strait of Belle Isle	5,249	30	626,557
5	3581	Norwegian ship 1	12,400	240	185,017
6	"	Norwegian ships 2 and 3	ca 12,000	212	202,698
7	"	Norwegian ship 4	15,500	est 200-250 (say 225)	246,689
8	2440	Canadian ships, less tagging and recapture on March 13	54,955	463	289,612
Totals		All ships and landsmen	168,417	1610	

returns are more evenly distributed between Canadian ships and estimate 8 is therefore probably better. Estimates 5, 6, and 7 are based on Norwegian ships with highest numbers of tag returns (supposing these returns to be most complete), and are therefore probably somewhat biased towards ships with highest rates of return and therefore towards a low result. Estimate 3 based on all ships is certainly too high because of the incomplete Norwegian ships' returns.

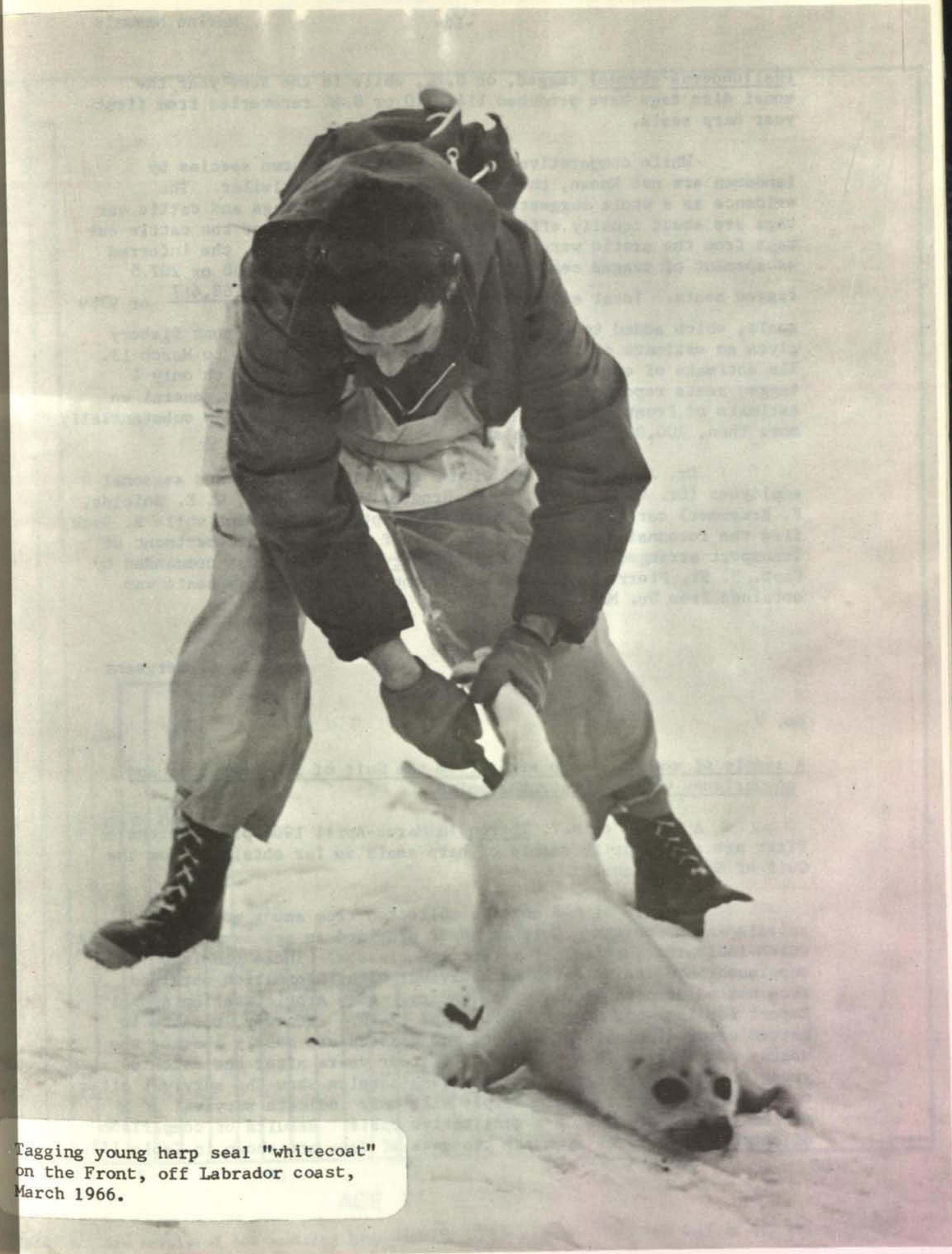
Therefore, the most likely estimates of production by this method lie between a minimum of 200,000 and a maximum of 376,000 young seals, with a mean of about 288,000 young seals. This is very close to what is regarded as the best estimate, namely that for Canadian ships exclusive of tagging and returns on the one day of March 13. These estimates must be raised by an unknown per cent (probably near 20%) to allow for seals born after tagging ended.

Estimate 4 from landsmen's catches is inaccurate, presumably because of the small number of landsmen's returns. However, the fact that returns by landsmen were few is itself interesting, since the seal patch drifted into a main area of shore-based sealing. It suggests that the ships left few young seals alive to be taken by landsmen.

This supposition is supported by the low returns of this tag from landsmen in areas of expected equal recovery of both tags, i.e. West Greenland and Baffin Island in summer 1966 and Labrador in fall 1966. A total of 1350 harp seals tagged in the Gulf with disc tags produced 26 recoveries of this kind. The number of cattle ear tags returned from these areas however was only 4. If it is assumed that all tags taken by ships on the Labrador coast were reported (which is known not to be the case), escapement would have been 3581 less 1610, or 1971 tagged young seals. If the two types of tag (monel disc and cattle ear) stay on equally well, the expected number of returns from the arctic would have been $\frac{1971 \text{ X } 26}{1350}$ or 38. A correction must be applied for differences in the efficiency of the two tag types. In 1950 and 1951, both types of tag were applied to young harp seals. Recoveries were as follows:

Tag type	Tagged number	Recovered	
		Number	Per cent
Monel disc	249	5	2.0
Cattle ear	55	1	1.8

The probability P for a 2 x 2 contingency test between these two results is 0.702, therefore the nill hypothesis is upheld that the two tags are not returned at different rates. This, however, is not surprising from the small number of tags recovered. In 1966 the cattle ear tags produced 30 recoveries from 345 first-year grey seals



Tagging young harp seal "whitecoat" on the Front, off Labrador coast, March 1966.

(Halichoerus grypus) tagged, or 8.7%, while in the same year the monel disc tags have produced 114/1350 or 8.4% recoveries from first-year harp seals.

While comparative fishing rates of the two species by landsmen are not known, they are probably not dissimilar. The evidence as a whole suggests that the monel disc tags and cattle ear tags are about equally efficient. Since recoveries of the cattle ear tags from the arctic were 4 instead of an expected 38, the inferred escapement of tagged seals to the Arctic was 1971 X 4/38 or 207.5 tagged seals. Total escapement was therefore $\frac{207.5 \times 168,417}{3581}$ or 9759 seals, which added to the 168,417 seals killed at the Front fishery gives an estimate of 178,176 seals born at the Front up to March 13. The estimate of escapement is subject to a wide error with only 4 tagged seals reported from the arctic but it supports in general an estimate of Front production in 1966 close to, rather than substantially more than, 200,000 young seals.

Dr. A. W. Mansfield with a team of five staff and seasonal employees (Dr. W. F. Black, P. F. Brodie, W. J. Hansen, W. F. Shields, F. Bruemmer) carried out the capture-recapture experiment while B. Beck flew the reconnaissance. A. H. Storrs of the Canadian Department of Transport arranged our use of the D'Iberville, which was commanded by Capt. H. St. Pierre. Information on the tagging of grey seals was obtained from Dr. Mansfield.

D. E. Sergeant

No. 7

A sample of moulting harp seals from the Gulf of St. Lawrence, and comparisons with net-caught samples.

A voyage on M.V. Theron in March-April 1966 provided the first age and maturity sample of harp seals so far obtained from the Gulf of St. Lawrence.

A sample of 648 animals collected from among moulting animals in the northern Gulf in April provided an age sample (Figure 3) which indicates survival of recent age classes. These findings supplement studies of catch and survival with information obtained from netted samples annually in January. (See Arctic Station Annual Report for 1965-66, Summary No. 6, pp. 12-15.) However, because in netted samples animals of younger age-classes are mostly absent, the degree of survival is not shown until four years after the catch of young of that year-class. The moulting samples show the survival after one year, although a single sample will only indicate survival of a series of year-classes on a qualitative basis. Results of comparison of catch and survival from the two sets of data are shown in Table III.

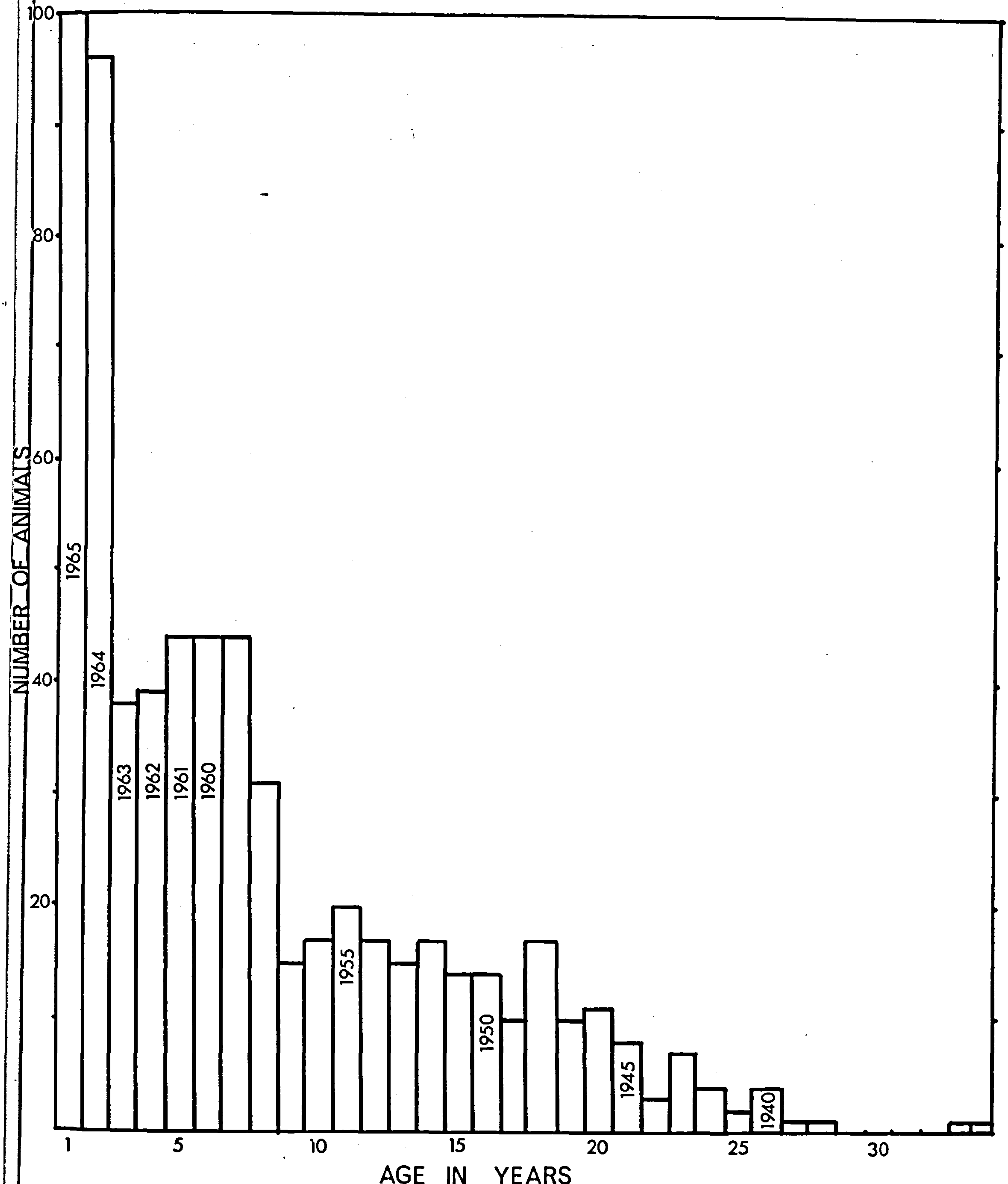


Figure 3. Age sample of 648 moulting harp seals collected in the northern Gulf of St. Lawrence in April 1966.

Table III. Catch and survival of Gulf of St. Lawrence harp seals.

Year-class	Catch of year-class as young	Subsequent survival of year-class --from moulting sample of 1966 (see Figure 3)	--from netted samples
1965	83,000	Good	No data
1964	81,000	Good	No data
1963	95,000	Poor	No data
1962	91,000	Poor	0.12*
1961	43,000	Good	0.17
1960	84,000	Good	0.17

* for netted samples, maximum sustainable yield is believed to be exceeded when survival at 4 years falls below 0.10 of the total sample.

According to Table III a catch of around 90,000 young in the Gulf gives a border-line survival close to maximum sustainable yield, since a catch of 95,000 is too high while a catch of 84,000 or 83,000 is below the catch allowing maximum sustainable yield.

For the smoothed sample of moulters' mean annual mortality rate, Heincke's method, for ages 1 to 20 is 0.135. For immatures age 1 to 4 it is 0.20 and for adults aged 7 to 20 it is 0.095. These values are close to the values previously used in life tables and computations of maximum sustainable yield.

Mean age at sexual maturity of female harp seals of the Gulf herd was studied from ovary pairs of 120 aged females collected from among the moulting herds. This sample could be compared with a sample of 118 ovary pairs collected at the net fishery in January, 1966. Results (Figure 4, left) show that the mean age at sexual maturity is almost the same, 5 years, in the two samples. This finding shows that both winter entrant seals taken in the Gulf net fishery and moulting seals in the Gulf are samples of the same herd. Moulting animals taken off eastern Newfoundland and Labrador show a lower mean age at sexual maturity and are presumably a distinct herd (Sergeant, D. E. 1966. J. Fish. Res. Bd. Canada, 33(5): 757-766). In the net samples of Gulf seals (Figure 4, right) the mean age at sexual maturity has remained at 5 years for three successive years to date.

Age and sex distribution of the moulting sample by date (Table IV) show an excess of immature animals of both sexes (over mature) on April 8 only, an overall excess of males over females, and adult

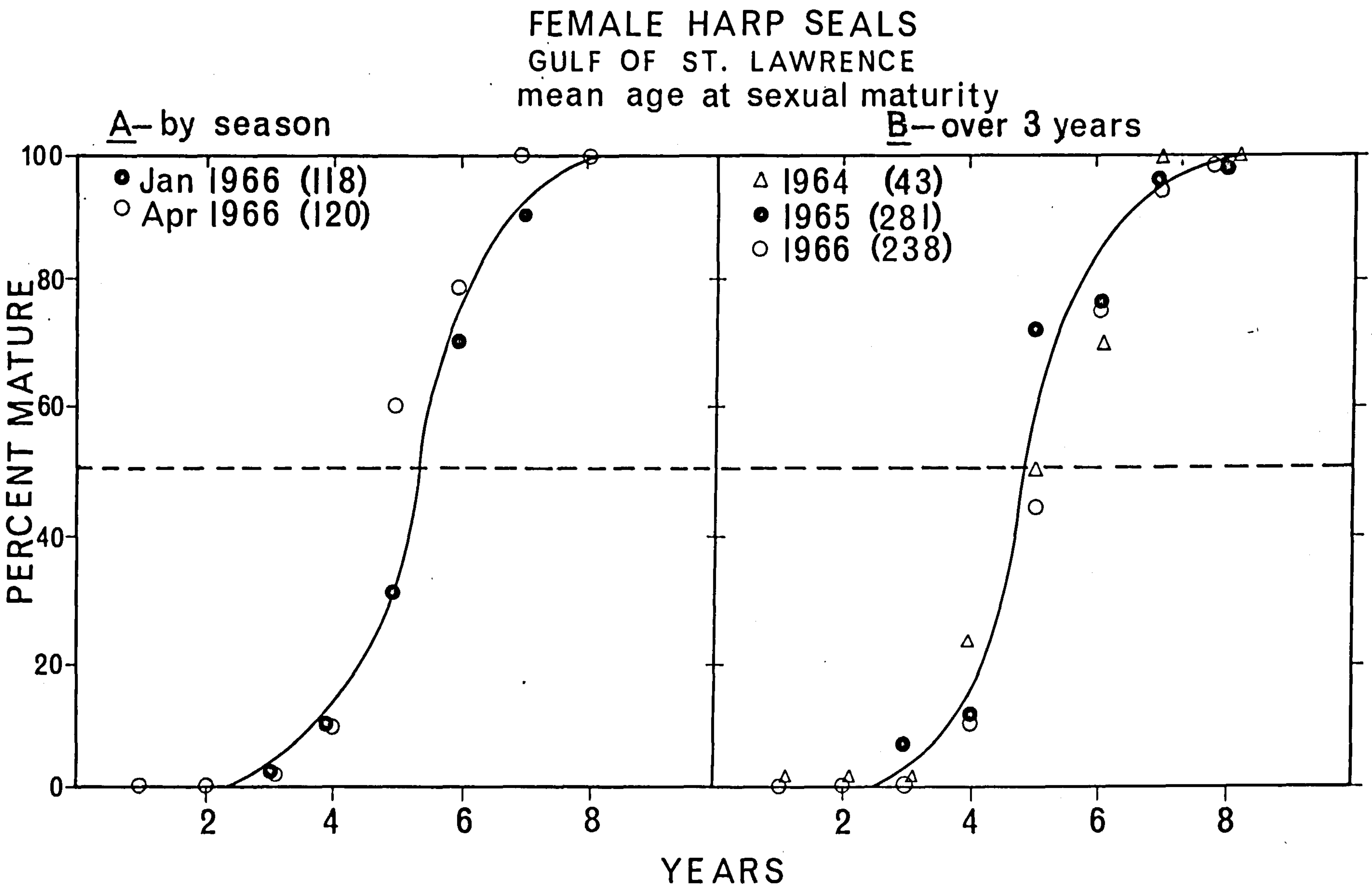


Figure 4. Percentage of mature female harp seals by age in the Gulf of St. Lawrence from different samples. (A) netted and moulting animals from the same year, 1966; (B) netted animals for the three years 1964 to 1966.

Table IV. Age (in years) and sex distribution of Gulf moulting harp seals by date in 1966.

	Number of males			Number of females		
	Age 1-5	Age 6 and up	(total)	Age 1-5	Age 6 and up	(total)
April 8	33	16	-49-	23	7	-30-
9	28	57	-85-	28	6	-34-
11	7	9	-16-	6	1	-7-
16	39	54	-93-	32	39	-71-
17	14	18	-32-	12	19	-31-
23	1	1	-2-	3	2	-5-
Totals	122	155	-277-	104	74	-178-

females in excess of adult males on April 17 only, there being no adequate later samples. On the Labrador coast immatures and adult males were found to be dominant but poorly mixed in early April, mixing later in the month. Adult females entered the moulting herds starting about April 20 and becoming fully represented by April 25, (Sergeant, D. E. 1965. J. Fish. Res. Bd. Canada, 22(2): 433-464). In the Gulf of St. Lawrence the mean birth date of the young seals is 5 days earlier than east of Newfoundland, so that the moult cycle might be expected to be 5 days earlier. This would put female entry between April 15 and 20. The data for 1966 indicate massive female entry taking place during April 16 and 17, in agreement with this hypothesis.

Fishery Officer E. McKay helped the author with collecting. For the opportunity to travel on M.V. Theron, I am indebted to Christiansen Canadian Enterprises Ltd., Capt. Harold Marø, his officers and crew.

D. E. Sergeant

No. 8

Hood seal populations.

The catch of some 900 adult hood seals taken from M.V. Theron was sampled in Notre Dame Bay in late March, 1966.

Sexed samples of catches of adults were as shown in Table V. It can be seen that catches of adult females greatly exceeded those of adult males, as is usual at the fishery.

Table V. Sex ratio of adult hood seals in catch of M.V. Theron 1966.

Date	Number		Total	Per cent
	Females	Males		females
March 20	17	13	30	57
21	35	18	53	66
22	42	11	53	79
23	9	4	13	(-)
24	35	8	43	81
25	5	3	8	(-)
29	8	1	9	(-)
Overall	151	58	209	72

The age frequencies of these samples were constructed, from which mean mortality rates of males and females were calculated. These mortality rates were compared with those for a similar sample collected by Dr. H. D. Fisher and the author in the same area in 1953, and compared also with mortality rates of male and female hood seals at the West Ice. The main hood seal herd lives at the West Ice, east of Greenland, and has been hunted heavily there. Soviet-obtained age frequencies of hood seals from the West Ice were kindly sent by Mr. T. Øritsland, Bergen, Norway. (Norwegian age frequencies did not separate the sexes.) Table VI shows the comparisons.

Table VI. Arithmetic mean of mortality rates of male and female hood seals aged 4 years and up.

Method as in Ricker, W. E. 1958. Bull. Fish. Res. Bd. Canada, 119, p. 41.

Area of catch	Year	Males		Females	
		N	$\hat{a}$	N	$\hat{a}$
West Ice*	1962	790	0.121	599	0.175
Newfoundland	1953	37	0.124	112	0.125
Newfoundland	1966	56	0.128	150	0.120

*Calculated from Soviet age frequencies supplied by T. Øritsland.

It can be seen that at the West Ice, mortality rates of adult female hood seals are considerably greater than those of adult males. At Newfoundland, this is not the case, and moreover there has been no increase in mortality rates of either sex between 1953 and 1966. This has been true in spite of heavy hunting of hood seals when available in the area, and heavier hunting of females than males.

One may conclude that the hood seals available to hunting at present in the Newfoundland (and Gulf of St. Lawrence) areas do not represent an indigenous stock, but the southern fringe of a larger stock, which is not substantially a part of the West Ice stock. Other evidence bearing in this direction is that the availability of hood seals varies from year to year more greatly than that of harp seals, and varies also slowly with long-term climatic variations. Thus hood seals were scarce or absent at Newfoundland through the 1930's, but have increased since 1945 up to the present time. The evidence of hood seals occurring to the northward is sparse, since a single industry-sponsored aerial survey from Frobisher in 1959 did not reach the ice edge. However, during the drift of the party from the wrecked United States Ship Polaris on the ice with whaleboats from Davis Strait to the Newfoundland area in the winter and spring of 1873, hood seals with pups were met with near the ice edge off Cape Chidley, Labrador.

I conclude that though the hood seal stock at Newfoundland appears to be under heavy pressure, in fact it is not.

D. E. Sergeant

No. 9

The beluga fishery in western Hudson Bay.

To quote from Circular 8, pp. 8 and 9, 1962: "The plant at Churchill, built in 1948 and operated till 1960, was the only integrated plant for processing beluga in Canada." "The total catch at Churchill was limited by the Department of Fisheries first to 600, later to 800. This quota was never reached in practice. With a 12-year average annual catch at Churchill of about 450 animals, there was no visible diminution in numbers in the local herds, and in spite of considerable selection of large animals by harpooning, no detectable decrease in size of the more heavily hunted (and larger) males."

This was the situation up to 1961. In 1961 the Department of Northern Affairs and National Resources (now Department of Indian Affairs and Northern Development) started an industrial fishery with nets at Whale Cove, 300 miles north of Churchill and 100 miles north of Eskimo Point (a small fishery at Eskimo Point in 1957-60 had been unsuccessful).

The Department of Fisheries granted a quota of 400 animals for this operation. Meanwhile, the fishery at Churchill was dormant. However, with a combined quota of 1200, and if the stock was essentially the same, there was a risk that sustainable yield might be exceeded. Hence, with unselected netted samples available at Whale Cove, we returned to research on population dynamics in 1962, 1963, and 1964. This research has yielded the necessary information,-and is being written up.

The combined fisheries have now returned, with Whale Cove taking 325 animals (in 24 nets) in 1966 and Churchill catches returning to their old value of 450 in 1966 under the efficient management of Hickok Belt Company, who began operation and remodernized the old Churchill factory in 1964. Moreover, this company has big plans--too big in my opinion for the whales available under the quota, probably because the company has no idea of the limited populations of this species, nor realize that the whales are primarily reserved for Eskimo (or DIAND sponsored) fisheries further north.

We have (1965) surveyed the population in the neighbourhood of Churchill, from the Nelson River to Eskimo Point, and find between 5000 and 10,000 animals, probably nearer the latter figure. There are gaps in distribution south of the Nelson and north of Eskimo Point, so I think we may take this as one intergrading population. Population dynamics studies suggest a yield of 8% so that 800 animals from 10,000 looks about right. I wouldn't opt for more at present. To improve the aerial survey we need photography but to make this worth while a combined survey with A. W. Mansfield and his walruses at Southampton Island is planned in summer 1968.

One prime biological task remains to us, that is to delimit the populations by some method of tagging. I think the population in the Whale Cove area is distinct, but tagging is much needed to settle the problem. Also we have a public relations job with Hickok, to tell them what we are doing and publish results to date.

Finally, mention should be made of the "sport" hunting at Churchill but this will not contribute significantly to the catch.

D. E. Sergeant

No. 10

First approximation of northwestern Atlantic fin whale stock.

The general problems of migration, discreteness, and size of the population or populations of fin whale, Balaenoptera physalus, in the western North Atlantic are being attacked from a number of different angles. Most of the approaches involve much lab work, still being done.

Accordingly the following is an estimate based upon data collected during the whale marking cruise of the M.V. William S. in 1966.

The William S., a 165-ft steel refrigerated cargo ship, was leased for the period July 17 to October 17, 1966, and operated out of Halifax. A shakedown cruise covering much of the southern Nova Scotian shelf lasted from July 20-31 and resulted in a number of locally marked whales. From August 2 to September 6 the vessel operated in waters to the north of Halifax, off Newfoundland, Labrador, and West Greenland. From September 10 to October 16 the waters south of Halifax were covered, from the eastern United States to Jamaica down off the coast of Venezuela, thence to Puerto Rico, off Bermuda and back to Halifax. During the entire cruise, approximately 238 fin whales were sighted, and 76 or 31.95% of these were marked. Also marked were 62 sperm whales and 30 whales of seven other species.

Two independent estimates of fin whale stocks in the region can be made from this data, one based upon a strip census and one based upon mark returns.

The mark return estimate is based upon the simple ratio number of whales marked/number of marks recovered = total number in population/number captured. Of the 76 whales marked, three were undersized and not therefore in the population being hunted, so the number effectively marked (n_m) is 73. Up to November 10, 1966, four marks had been recovered by the Nova Scotian (Blandford) and Newfoundland (Dildo) whaling stations (n_r). To this same date, the stations had taken a total of 372 fin whales (n_c). Then,

$$\frac{n_m}{n_r} = \frac{N}{n_c}$$

$$\frac{73}{4} = \frac{N}{372}, \quad N = 6790 \text{ legal-sized fin whales}$$

Some obvious corrections could be made on these figures, but the approximation is so gross that it would be an unnecessary sophistication.

The strip census is based upon a detailed log of the cruise. The track of the ship was plotted on appropriate charts, and the number of whales sighted on a given day was recorded. In order to calculate the area searched, the elapsed time run in daylight over a known course (T_e) was divided into the time on watch (T_o). The resulting percentage of time actually on watch ($T_\%$), times the distance travelled (D_t), gives the distance in nautical miles over which a whale watch was kept (D_s). The average visibility, assuming that a whale could be sighted a maximum of four miles away on the best of days, was doubled (V) and multiplied by the distance searched (D_s) giving the area searched (A_s). That is:

$$\frac{T_o}{T_e} = T\%$$

$$D_t \cdot T\% = D_s$$

$$D_s \cdot V = A_s$$

Since fin whales were not seen far off the continental shelf, south of Cape Cod or north of about 57°N on the Labrador coast, I have limited the calculations to the area of the continental shelf between 57°N and Cape Cod. Calculated from map USHO 0955, the area of the continental shelf in this region is 386,900 miles^2. Addition of the daily totals of fin whales seen per unit area searched reveals 238 fins (N_f) seen in 13,903 miles^2 (A_s). Then the simple ratio of area searched divided by total area equals number of fins seen divided by the total number of fin whales:

$$\frac{A_s}{A_{total}} = \frac{N_f}{X}, \quad X = \text{total number of fin whales}$$

$$\frac{13,903}{386,900} = \frac{238}{X}, \quad X = 6620 \text{ fin whales of all sizes.}$$

Note that here too a number of corrective factors might be applied, but to do so would imply an exactness not justified in this gross approximation.

Given two independent estimates of fin whale population size (one for legal-sized fins only, the other for all fins), and use of the figures on sustained yield from Antarctic fins (admittedly not directly applicable without modification), then:

$$(r-M) = .12$$

$$.12 \cdot 6790 = 814 \text{ fins}$$

$$.12 \cdot 6620 = 794 \text{ fins}$$

Thus there is suspiciously close agreement between the two analyses that about 800 fin whales might be killed per year off the Canadian east coast without seriously damaging the whale stock. I would be the first to point out that these are nothing more than guesses with numbers attached. New data already in hand and more forthcoming will change these, and other methods of population assessment now being pursued will serve as a check.

E. D. Mitchell

No. 11

Ringed seal population study, Cumberland Sound.

The rise in the market price of hair seal skins in 1962 led to a marked increase in the number of ringed seal skins traded by Eskimos in nearly all arctic localities. Available catch statistics have not enabled us to determine whether this increase has resulted from intensified hunting pressures, but they do show that in some areas the seal populations may now be over-utilized.

The present study is an attempt to estimate the most heavily utilized ringed seal population in the eastern arctic, that of Cumberland Sound, and to compare it with an under-utilized population in an area where similar ice conditions prevail, namely Home Bay in eastern Baffin Island. Populations of ringed seals are particularly amenable to quantitative analysis since the species depends heavily on the extent and suitability of fast ice for reproductive success. The detailed life-history study of the ringed seal carried out by McLaren (1958a) enabled him to estimate populations and maximum sustainable yields for all the coastal areas of Ungava Bay, Hudson Bay, Foxe Basin and Baffin Island (1958b). This analysis was a preliminary study, based on meagre data at times, but it is of great value in showing the methods used in estimating population parameters, and their limitations. These methods have been redefined (McLaren 1961) and a more succinct account of population dynamics and exploitation of seals prepared (1962). These two papers form the fundamental basis of the present study.

Observations on seal abundance

During the period May 19 to June 7, A. W. Mansfield, P. Brodie, and F. Keith travelled extensively by dog team and "Skidoo" on the ice of Cumberland Sound, hunting ringed seals with the Eskimos. An attempt was made to count birth lairs on the fast ice at the heads of fiords, but deep snow prevented the dogs from finding any. However, many birth lairs were seen in the middle of Cumberland Sound, 15 miles from the nearest land, where they would not be expected if McLaren's assumptions about offshore limits of seals are correct (1962, p. 173). It might be assumed that offshore distribution of seals under the ice is a response to intensive hunting in the bays and fiords of the complex coastline of Cumberland Sound, but information obtained from J. Dewey Soper (in litt.), who carried out biological surveys in this area in the years 1925 to 1931, shows that this pattern of behaviour occurred at that period.

Since the average width of Cumberland Sound is about 25 miles, the area of good fast ice offshore available to ringed seals is increased by about 1200 square miles over McLaren's estimates (1958b, Table III). Though the density of seals is not known for this area of ice, McLaren's estimate of 5 seals per square mile for ice greater than one mile offshore (1958, p. 24) may be used tentatively. This would increase the estimated seal population by 6000, representing a sustainable yield of nearly 500 seals. When added to McLaren's estimate of the sustainable yield of seals for Cumberland Sound (1958b, Table III) this gives an approximate figure of 6000, about 50% of the present catch. However, if it is assumed that immigration occurs from unexploited populations of seals on adjacent areas of coastline (Loks Land to Hall Island, and Leopold Island to Cape Dyer--areas 7 and 5 on McLaren's map, 1958b, p. 26), then a sustainable yield of over 11,000 seals is possible. This is still less than the present catch, which emphasizes the need for re-assessment of the population in this area.

A factor which may contribute to the presence of seals under fast ice far offshore is the large tidal range in this area: 25.2 feet in Clearwater Fiord at the head of the Sound, and 21.4 feet at Brevoort Harbour, well out of the mouth of the Sound to the southwest (63°20'N, 64°13'W). Tidal races and swift currents in the fiords and maze of islands in the Sound cause considerable undermining of the ice, and pose hazards to Eskimos travelling by dog team and "Skidoo". Similar hazards may be presented to ringed seals which seek to pup in such areas.

Following break-up of the fast ice in Cumberland Sound, intensive hunting is carried on from small craft. By early August there appears to be a marked reduction in seal numbers, though whether this results primarily from hunting pressure, or dispersal of the seal population, is not known.

During the period August 7-17, 14 counts of seals in open water were made from M.V. Calanus and a 22-ft freight canoe. The density of seals per square nautical mile was estimated for each census area by using the formulae from McLaren (1961):

$$\bar{p} = \frac{2r}{v(s+u)} + \frac{s}{s+u} \qquad \text{----------- 1}$$

where $\bar{p}$ = average probability of seeing a seal
r = limit of visibility of seal's head
v = speed of boat in nautical miles per minute
s = time seal spends on surface in minutes
u = time seal spends underwater in minutes

$$N_t = \frac{N_O}{\bar{p}} \qquad \text{----------- 2}$$

where N_t = theoretical number of seals present
No = number of seals counted

As McLaren points out (1961, p. 65) there are certain assumptions underlying this method which influence the accuracy of the estimates. The limit of visibility of a seal's head is an average figure, but we found this always to be close to 0.3 nautical miles. The average time a seal spends on the surface and underwater is much more variable, our estimates ranging from 20 to 135 seconds for values of s, and 30 to 720 seconds for u. These figures give means of s = 0.86 and u = 4.4 minutes compared to McLaren's values of 1 and 3 minutes. When substituted in equations 1 and 2, they give about a 30% increase in the theoretical number of seals present.

Though our figures were obtained by observing the behaviour of undisturbed seals, they may be safely applied in formula 1, since it is doubtful whether seals would react to a steadily moving boat beyond the limit of the observer's visibility. Indeed seals near to the ship might surface prematurely and thus be counted where normally their length of dive might have enabled them to escape detection.

Catch statistics

During the period May 20 to September 5, 1966, nearly 2000 jaws for age analysis were bought from Eskimo hunters. By issuing each man with an illustrated booklet containing tear-out labels, a map and plastic bags, we were able to collect information on time and place of kill. Eskimos were encouraged to use the grid reference on the map which divided the Sound into areas of 5' of latitude by 10' of longitude, approximately 20 square miles.

When completed the analysis should provide us with a distributional record of different age classes of seal and the mortality rates for each age class. A comparison with McLaren's data for Cape Dorset (1958a) and data to be collected in other Arctic localities over the next few years will provide a basis for future management of this population.

Netting operations

Nets of 12-inch mesh, 100 yards long and 25 meshes deep were set on different occasions in the western part of the Sound during the open water season, but no seals were caught in 17 net days. This emphasizes the lack of seals indicated by the counts made from boats.

Further work

A large sample of female reproductive tracts will be collected in Cumberland Sound in 1967 to provide data on age specific birth rates. This will enable us to construct a meaningful life table for the ringed seal in this area. Jaws and reproductive tracts will also be collected from eastern Baffin Island, Cape Dyer to Cape Henry Kater, to provide comparative data for this apparently under-exploited area.

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A. W. Mansfield

No. 12

Grey seal survey, Northumberland Strait.

On January 17, 1967, M. W. Cawthorn and C. W. Nicol flew out of Sydney, N.S., in an Apache aircraft chartered from Eastern Flying Services. They searched the Prince Edward Island coast from East Point to Prim Point, and the Nova Scotian and Cape Breton coasts from Malagash Point to Margaree Island, looking for breeding grey seals. On January 17 there was very little ice in that section of Northumberland Strait, except along the shore. An estimated 300 adult seals with many pups were seen on Amet Island. Counting from the air proved very difficult owing to the confusion of movement of the seals. Two solitary seals were seen in the rest of this section of the survey, one at Pictou Island and one off Tracadie.

The second half of the aerial survey was flown on January 19 out of New Glasgow.

New ice had formed, and much ice had drifted down Northumberland Strait. However, it was unsuitable for the seals, being very broken and thin.

A group of breeding grey seals was found on ice jammed in against the peninsula of which Prim Point forms the tip. Forty-five adults were counted, an estimated 80% of these being female. Pups were seen but difficult to count. The search was continued along the P.E.I. coast from Prim Point to Sudbury Point, and thence from Cape Bruin back to Malagash Point. No more seals were found.

On the morning of January 20 a Bell helicopter, chartered from Eastern Flying Services, was used to take Cawthorn and Nicol from Tatamagouche to Amet Island. Tagging with monel metal tags began at 8:45 a.m. All newborn pups were weighed and sexed. The work continued for three days during which time 528 pups were tagged and 42 newborn pups were weighed. The newborn pups on the shingle spit off Amet Island had an average weight of 39.5 lb. Only two newborn pups, both females, were found on the grassy top of Amet Island weighing 32 lb and 35½ lb. Most of the pups were born on the narrow rocky shore of the island. Here the seals were extremely crowded, a large percentage of pups being abnormally thin, and apparently deserted by the females. Newborn pups were found to have an average weight of 32.5 lb.

The following counts of seals using binoculars and hand tallies, were made from behind clumps of grass on the top of the island.

	Adults	
	Female	Male
On the spit	7	1
On the top of Amet Island	8	0
Around the shore, and in the sea around the island	159	26

This count was made on January 22, by which time much ice had drifted against the island, possibly obscuring several adults. However, there is a marked disparity between the number of pups (528 tagged, 82 counted dead) and the number of adult females.

Many pups had infected sores on their hind flippers and around their eyes, some completely blind with eye sockets filled with pus. Many had a bloody discharge in the faeces, probably from a gastro-intestinal disorder. All pups found on the shore had filthy pelts, encrusted with frozen mud, excrement, and blood. Eighty-two dead pups were counted on January 22 but many had been covered by rafting ice piled against the shore. An estimated 150 dead pups were along the shore.

On January 22 ice was becoming firm enough for females to pup on. About 20 females were counted from the shore, most of them in broken pressure ice. Most of these had pups.

To date, March 20, 26 grey seal pups tagged on Amet Island have been taken along the coast of Nova Scotia and Cape Breton from Cape John to Judique, Inverness Co. Seven of these have been killed or captured inland, one as much as four miles from salt water. This seems to indicate that the seals have drifted with ice down Northumberland Strait, and that many have come into shore with drifting ice.

It is of interest to note that in 1966, when ice conditions in Northumberland Strait and George Bay were suitable for pupping, 37 seals were counted on Amet Island on January 20. Three hundred forty-five pups were tagged on the ice in George Bay and the eastern part of Northumberland Strait and only two dead (stillborn) pups were found. About 100 pups were reported killed near Malignant Cove prior to tagging.

The minimal estimate of pup production in the Northumberland Strait area in 1966 was 570. On January 23, 1967, 528 pups were tagged on Amet, 150 estimated dead, and 50 pups were born on the ice, but were not tagged. Since we know from previous counts that approximately 70% of the pups are born by January 23, we may assume that the final pup production in Northumberland Strait would be about a thousand.

C. W. Nicol

No. 13

Grey seal survey, Sable Island.

In previous years counts of grey seals at Sable Island had been made well after the peak period of pupping when many newly-moulted young had probably gone to sea. In 1967 an earlier start was made in order to determine the pup production more accurately, and to observe some facets of breeding behaviour.

A. W. Mansfield and F. Bruemmer flew out to the island in an "Apache" chartered from Air Atlantic on January 12 and were taken down to the house at Eastlight by Muskeg tractor on the following day. During the following eight days, observations were made on an undisturbed group of grey seals, and 200 pups were tagged.

Breeding behaviour

The distribution of seals on the eastern spit is shown in Figure 5. Group A on the narrow beach, north of Long Dune, remained isolated for the eight days of observations, which helped to simplify counting. The results are shown in Table VII.

The number of pups increased until January 20 and then decreased suddenly. By next day six of the seven pups had returned, suggesting that the movement had been caused by some temporary

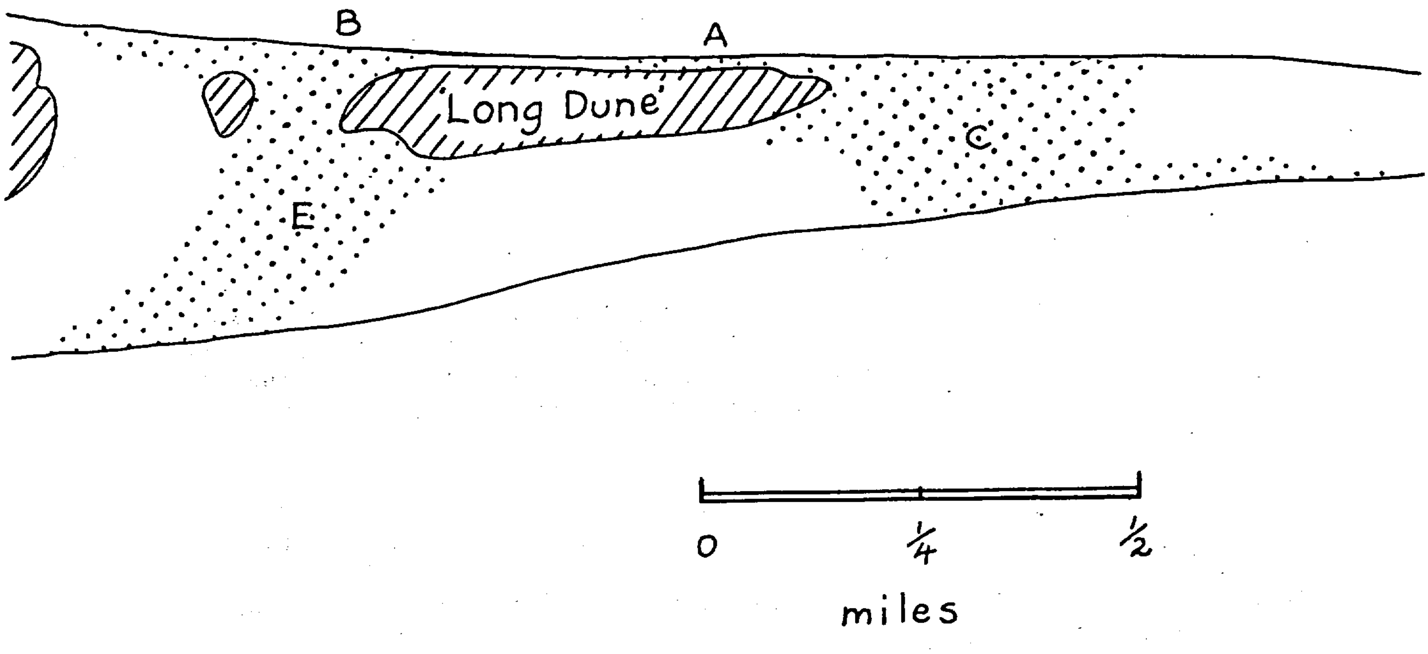


Figure 5. Distribution of grey seals on the eastern spit of Sable Island, January 14-22, 1967. Shaded areas--consolidated sand dunes, dotted areas--breeding grey seals.

Dr. Mansfield observing grey seals on Sable Island, January 1967.

Table VII. Numbers of grey seals on Beach A, Sable Island, from January 14-21, 1967.

	January							
	14	15	16	17	18	19	20	21
Bulls	20	25	26	19	-	29	30	29
Cows	54	54	68	65	-	69	63	63
Pups	46	49	58	58	-	67	60	66

disturbance, probably the lone bulls at the seaward edge of the beach invading the territories of established bulls. Undisturbed pups probably do not leave their birthplace until after the moult. The decrease in the number of cows at this time probably represents the beginning of their dispersal to sea after mating and weaning of the pup. Separation of the cow and pup must begin to occur at this time since 15% of the pups appeared to be fully grown and ready to moult.

The ratio of cows to bulls on beach A, between two and three to one, does not reflect the territorial behaviour of the bulls. Though no individual bulls in this group were observed for more than a few minutes, the association of bulls and cows was easily seen from their general disposition on the beach during the counts. The marked fluctuations in the number of cows grouped around each bull (Table VIII) agrees with what is known of grey seal

Table VIII. Disposition of grey seals on Beach A.

	January							
	14	15	16	17	18	19	20	21
Bull, 7 cows	0	0	2	0	-	1	1	1
Bull, 6 cows	0	1	0	0	-	1	0	1
Bull, 5 cows	2	0	4	1	-	3	1	2
Bull, 4 cows	2	1	2	4	-	3	2	0
Bull, 3 cows	4	0	4	5	-	5	3	7
Bull, 2 cows	3	6	2	5	-	1	6	2
Bull, 1 cow	5	10	7	2	-	4	8	6
Lone bulls	4	7	5	2	-	11	9	10
Average: cows per bull	2.6	1.8	3.0	2.8	-	3.4	2.3	3.2

(groupings include cows with and without pups) behaviour in the British Isles, particularly at the Orkney Islands (Smith 1966); that is, the bull is territorial, and defends an area of beach rather than actively maintaining an assemblage of cows. Movement of the cows, usually in following their wandering pups, does not appear to be resisted by the bull as in the true harem-forming species such as the elephant seal.

Counts of seals on the open sand spit east of Long Dune (area C) showed that there the ratio of bulls to cows was almost one to one. This has been noticed in past years and was attributed to the unlimited space available to all adult and sub-adult males. This increase in the number of bulls did not appear to decrease the number of cows associated with the territorial bulls. For example, on January 17, a count of all the seals in the groups nearest the eastern end of Long Dune revealed the following pattern of distribution: 20 lone bulls, 2 bulls with 4 cows, 3 bulls with 7 cows, 7 bulls with 2 cows, and 4 bulls with 1 cow. On January 19 one of these bulls had accumulated 10 cows, but this number had dropped to 3 on the following day, and then increased to 6 on January 21. Several hours of continuous observation on this bull confirmed that disturbances caused by non-territorial bulls, and the restlessness of some pups, led to fluctuations in number of cows in the group.

Pup production

On January 15 and 16 a sample of 275 pups gave the following distribution of estimated age categories:

	No.	Per cent
I (0-1 week)	124	45
II (1-2 weeks)	106	39
III (2-3 weeks)	42	15
IV (3-4 weeks, moult beginning)	3	1
V (over 4 weeks, moult complete)		

If we assume that the frequency of births follows a normal distribution, then it is likely that the peak of pupping occurs not before mid January, since the largest age group (I) is recorded then (Figure 6). Assuming that pupping declines after this time, then we might expect a further production of pups similar to the production before the peak class, that is, about 150. This would bring the total production of pups to about 425 for a population of 275 pups in mid January. Since we know that at least 400 pups were born by mid January, then the total pup production should be approximately $\frac{425 \text{ X } 400}{275} = 620$.

A. W. Mansfield

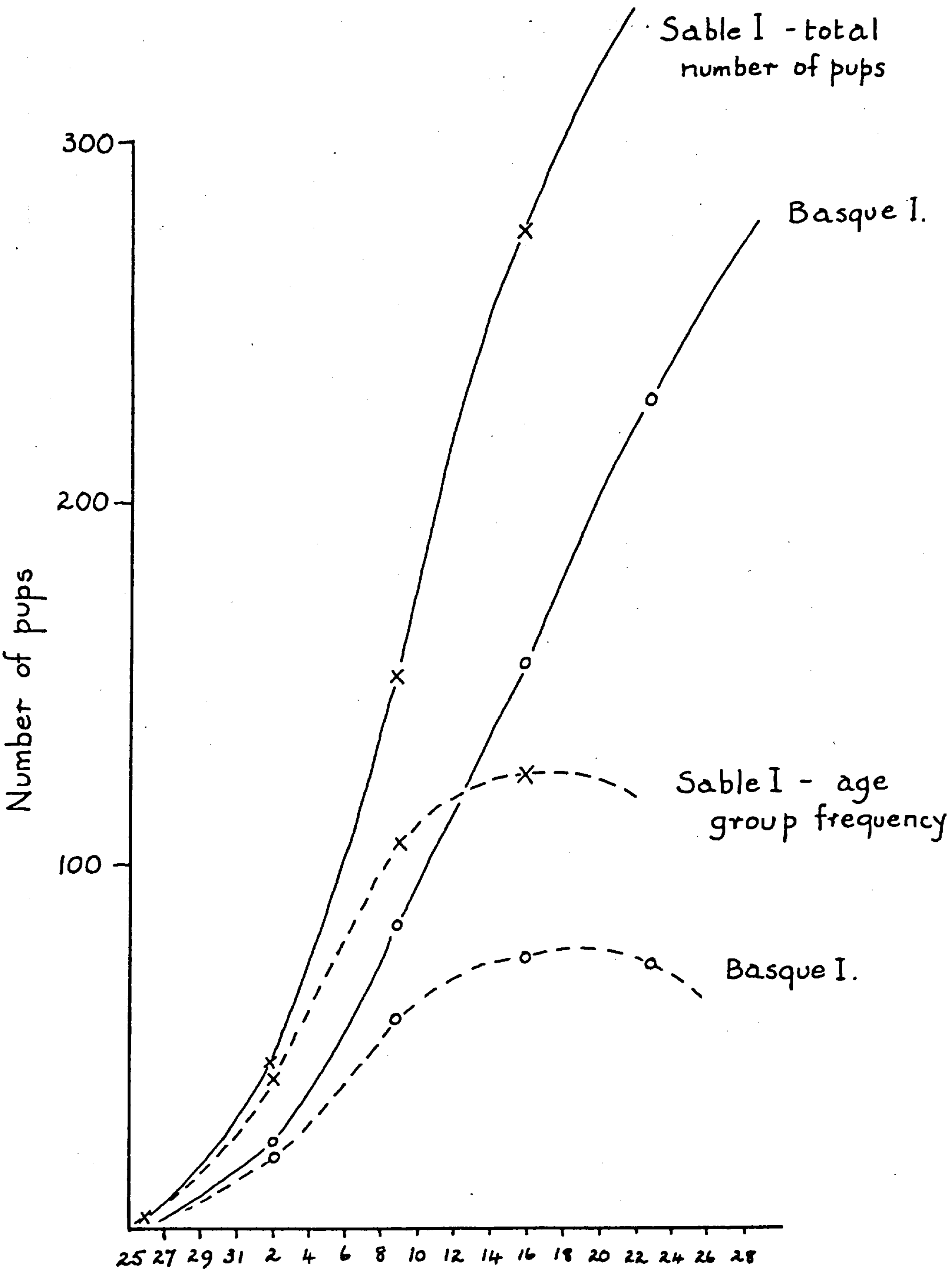


Figure 6. Age frequency distribution of grey seal pups and total pup production at Sable Island and Basque Island, 1967.

Grey seal pup with mother, Sable Island, January 1967.

No. 14

Grey seal survey, Basque Island.

On January 23, A. W. Mansfield, C. W. Nicol, and M. W. Cawthorn, using the Bell helicopter chartered from Eastern Flying Services, tagged 197 pups on Basque Island off Point Michaud, southeast Cape Breton Island. A total of 237 pups was counted, as follows:

Age category	I	II	III	V	Dead	Total
	73	75	58	2	9	237

This age frequency analysis suggests that the peak of pupping has passed and probably occurred about mid January. A total of 300 pups would be a reasonable estimate for the expected production (Figure 6).

At the time the tagging was carried out, we were not aware that the Department of Fisheries intended to implement previous suggestions that the Basque Island population be culled. On January 27, 212 pups, 14 adult males and 3 adult females were killed under the supervision of Mr. S. Dudka, Fishery Officer, New Glasgow. About 30 pups were left alive. All of the 148 tags taken were returned to this office.

A. W. Mansfield

No. 15

Vessel operation, M.V. Calanus.

Preparation of M.V. Calanus began on June 8, 1966. She was found unharmed after a winter spent in her cradle on the DOT beach at Frobisher Bay. Rotten gunwale sections were removed and replaced, and the leaks of the previous year traced to faulty caulking aft which was replaced with new synthetic material. The ship was completely cleaned and painted and all mechanical gear inspected and conditioned for the season.

From July 21 to September 14, 1966, M.V. Calanus was used principally for the ringed seal study in Cumberland Sound. Owing to the sudden resignation of the Captain, W. F. Shields, before the season began, the ship had to be crewed by a non-professional staff; but this presented no difficulties since the engines and other equipment were very capably maintained by the Engineer, D. B. Fleet.

In 1965 much concern had been expressed over vibration of

Grey seal studies on Basque Islands, southeast Cape Breton Island, N.S., reached by helicopter.

the propeller and shaft but this was kept to a minimum by running the engine at no more than 1600 r.p.m. (maximum output 1800 r.p.m.) and caused no significant effect on the operation of the vessel. Even at 1500 r.p.m., the vessel made over 8 knots which was considered quite adequate for all normal cruising.

All electronic equipment performed well and both radar and gyrocompass were found to be indispensable. Attempts were made to use the magnetic compass, but local variations were so erratic and unpredictable, that it was entirely dispensed with. The gyrocompass was left running for most of the period at sea and made navigation an easy task.

The electrical power supply still needs improvement since the high voltage needed to recharge the NIFE batteries represents an unsafe overload to all fixtures and electronic equipment drawing current during the lengthy recharge cycle. A transistorized regulator to be placed only on that part of the circuit drawing current has been proposed and is in design-testing at present. The necessity of removing the bulky NIFE batteries for heated winter storage will cease once the proper "Arctic" electrolyte is installed in 1967.

The water supply is still inadequate owing to the rusty condition of the two forward storage tanks under the laboratory (approx. 2 X 80 gal). The after cabin tank is clean and holds approximately 100 gal. Two 25-gal drums on the after deck help to prevent too frequent refilling of the after cabin tank.

The hull was gradually inspected for rot during the summer but the only area of poor wood was found in a non-structural wheelhouse timber.

The sails were not used at all, but attention should be paid to their design if they are to be considered as a reliable source of auxiliary power. Both the mainsail and mizzen sail need reef points and the mainsail should perhaps be shortened and widened. This would allow the main boom to be carried a little higher up the mast and prevent the radar scanner being carried away during a sudden gybe.

For marine mammal work while in Cumberland Sound, a 22-ft canoe was carried aboard the vessel, slung from the davits on the port side. This was used in establishing shore camps and in setting and tending seal nets.

No difficulty was experienced in launching the vessel. A D-8 Caterpillar tractor and a TD-25 International tractor were hitched in tandem to the cradle and the vessel was moved down to half-tide level in one uninterrupted pull. It floated off easily at high tide.

Hauling out M. V. <u>Calanus</u> on cradle for wintering, Frobisher Bay.

Beaching the vessel at the end of the season was a more difficult procedure. The cradle was hauled down to half-tide level (high tide 33 ft on September 14) and weighted down with a total of thirteen 45-gal drums of shingle. This had proved necessary after the cradle floated with only 8 drums attached. The Calanus was positioned over the cradle at high tide and allowed to sink into position as the tide fell. Since only two uprights are attached to the cradle, accurate positioning of the vessel is difficult, especially if there is any wind. It is recommended that in future four large grapnels with buoyed lines be laid out at suitable distances from the cradle; then at high tide these can be picked up from the dory, taken aboard Calanus and secured. By careful adjustment of the four lines, the vessel could be settled on the cradle accurately.

At low tide Calanus was found to be 15 in too far forward in the cradle, but she was pushed back in place with little effort by the elevated blade of one of the bulldozers. The two bulldozers in tandem hauled the loaded cradle to just below high tide mark with little difficulty, but at this point soft sand was struck and further hauling was greatly impeded. Eventually one tractor was forced to use its winch to haul the second tractor and cradle a few yards at a time. Two one-inch diameter steel wire bridles were broken before the cradle was finally in its winter berth.

The strain on the wooden cradle was considerable, and the leading crosspiece cracked, Two of the three metal shoes were also stripped from the runners. Plans are now under way to construct a new cradle from steel for the coming season. Since the friction is so great between sand and loaded cradle (approximately 60 tons), consideration is being given to fitting the cradle with surplus aircraft wheels and tires.

A. W. Mansfield
D. B. Fleet

No. 16

Pelagic phytoplankton of the Arctic Ocean.

Qualitative and quantitative analysis by the sedimentation method of standing crops, taken in 1958 and 1964 from T-3 ice island, (now north of Alaska), revealed only small populations of phytoplankton contributed by 10 species and not exceeding 1500 cells per litre in three samples collected between 0 and 5 m depth. In fact a column of water 3000 m deep invariably contained bacteria, cellulose fibres of higher plants and algae, angular particles of sawdust, pollen and starch grains, animal hairs, cysts of dinoflagellates and fungi, free droplets of lipids, diatom frustules, skeletons of silicoflagellates, empty eggs and carapaces of zooplankton, particles of jelly from coelenterates, scales of butterfly wings and sand grains.

Well preserved starch grains occurred in all samples in fairly large quantities. Rather slow biochemical degradation of carbohydrates and lipids is conditioned by subzero temperatures, retarding lytic activities of the bacteria which decompose starch and cellulose. Slow destruction of organic detritus, possibly introduced to the Arctic Ocean from the Mackenzie River system, results in its accumulation increasing the level of pollution. Bacterioflora of pelagic waters is dominated by Cocci, which are particularly abundant at 5-m depth. Phytoplankton populations of T-3 and probably of other areas of the Arctic Ocean are reduced to a minimum by sinking cellulose particles, which take them down to the aphotic water layers, where bacteria destroy them.

Unpublished records permit the classification of the pelagic waters of the Arctic Ocean as a saprobiontic ecosystem dominated by bacteriophyta. Obvious ammelioration of adverse ecological conditions towards the Canadian Arctic Shelf is shown by the increasing number of phytoplankton species and standing crops consisting of Pacific-Arctic-Atlantic biogeographical groups.

A. S. Bursa

No. 17

Primary production of Keyhole Lake.

Present preliminary identification of the Keyhole Lake flora shows 150 taxons of nannoplankton including periphyton. Dinophyta dominate the microplankton quantitatively, although Chrysophyta and Chlorophyta are fairly abundant. Diatoms are rare, except for *Nitzschia cyclopum*, a tiny epizoic form exceeding 300 cells, found on a single crustacean. Monotypic blooms of *Glenodinium* bioculatum, whose summer climax reached 167,000 cells per l, characterizes the ecological conditions of the lake specifically, since, as far as I know, no such phenomenon has been reported from arctic or antarctic lakes.

A. S. Bursa

No. 18

Taxonomy of Dinophyta, especially the Family Gymnoasteraceae.

Among 1000 taxons of Dinophyceae, only Gymnoasteraceae secrete silicious, star-shaped skeletons called pentasters. Newly described here, *Gymnaster pentasterias* var. *arcticus*, from the Arctic Ocean (Fig. 1, 2, 3), *Gymnaster canadensis* from Great Bear Lake (Fig. 4, 5), and *Pseudogymnaster apentasterias* (Fig. 6) from Keyhole Lake, appear to be the descendants of the marine *Gymnaster pentasterias* Schutt. Ecological evolution and morphological transformations of the primary Gymnasters into relict limnobionts began in the prelimnic marine habitats and during glacial and post-glacial periods. Atrophy of freshwater pentasters of *G. canadensis* and in *P. apentasterias* indicates the recessive process induced by deteriorating ecological conditions as also took place in the sea. The contemporary Gymnasters secrete only rudimentary skeletons, which are exceptionally well formed in *G. pentasterias* var. *arcticus*, consisting of 14 tiny peripheral and 4 large perinuclear pentasters (Fig. 2). However, paleozoic *Gymnaster*-*Radiolaria*, according to my interpretation, secreted double-layered, solid skeletons and the central capsula.

Present findings confirm the hypothesis of French micropaleontologists that Radiolaria were derived from the archeotypic group of the Family Gymnoasteraceae.

A. S. Bursa

No. 19

Intracellular and extracellular lipids of arctic diatoms and dinoflagellates and their importance to fisheries and human nutrition.

Oils in aquatic habitats, rocks, biosediments, plants, animals, and organic detritus, are intensively studied because of the many possible practical applications. No such attention is paid to the biotaxonomic aspects of lipids synthesized by diatom standing

Species newly described from the Canadian Arctic.

Figure 1. *Gymnaster pentasterias* var. *arcticus*. Arrows show two perinuclear pentasters.

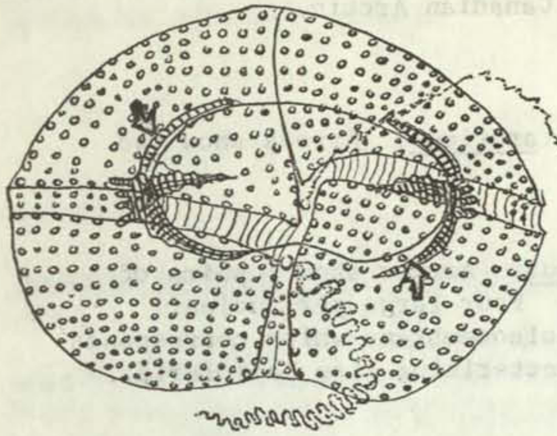
Figure 2. *G. pentasterias* var. *arcticus*. Arrows show 7 pairs of tiny peripheric pentasters. Four large perinuclear pentasters adhere to the nucleomembrane which corresponds to the central capsula characterizing also Radiolarias.

Figure 3. Seven-arm pentaster from the marine *G. pentasterias* var. *arcticus*. Two rudimentary pentasters at right from a freshwater relict species *G. canadensis*.

Figure 4. *G. canadensis* in ventral view. Arrows show secretory vacuoles.

Figure 5. Partially disintegrated *G. canadensis*. (n) nucleus and a single pentaster.

Figure 6. *Pseudogymnaster apentasterias* from Keyhole Lake, in ventral view, shows central nucleus, and darker trichocysts. It is characterized by a complete atrophy of pentasters.



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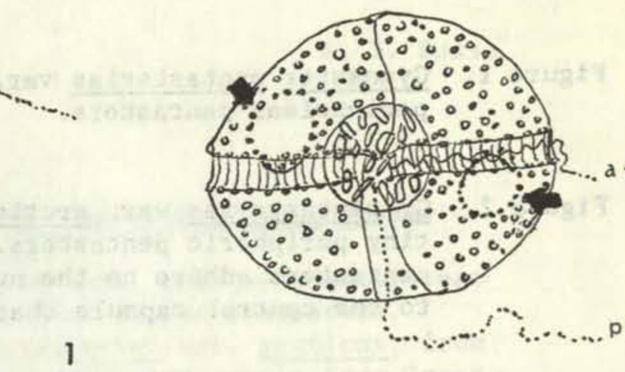

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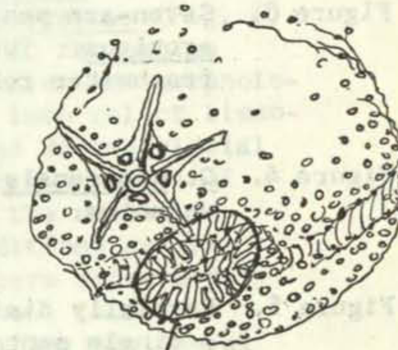

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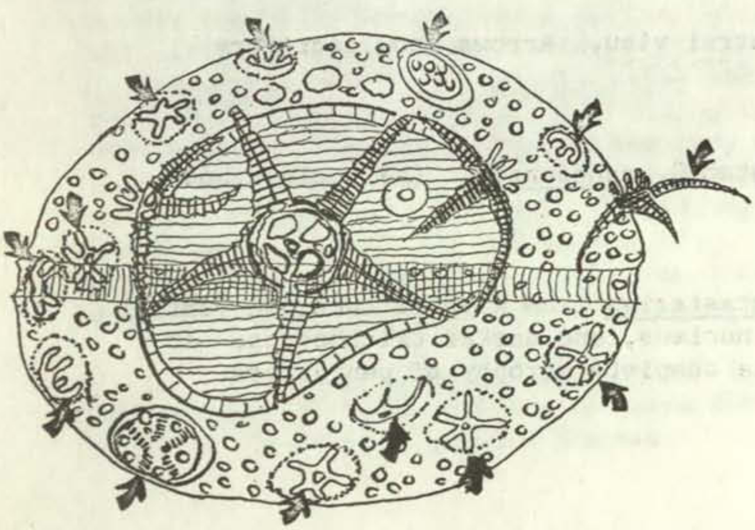

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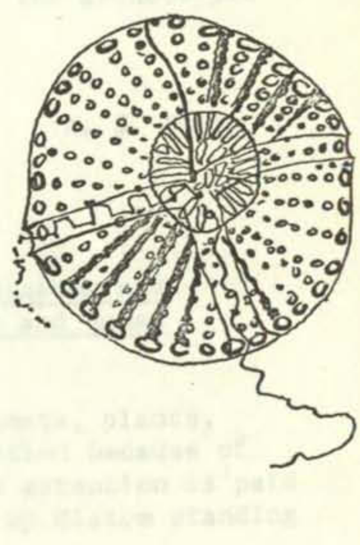

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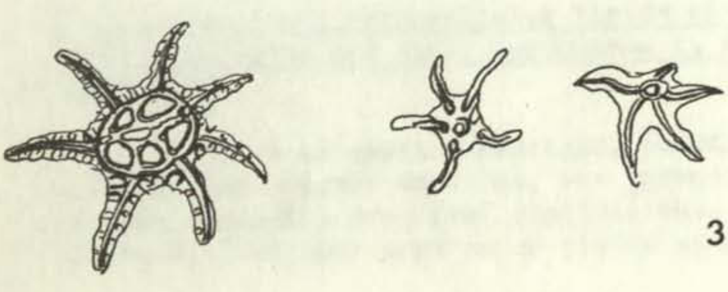

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crops existing under ecological extremes of arctic waters. Diatoms of these waters constitute a basic primary foundation of the arctic bioeconomy, photosynthesizing the highly calorific lipids. Though preliminary observations on diatom and dinoflagellate lipids in situ were occasionally made at the same time as analysis of the phytoplankton standing crops, oily droplets found in plankton beneath the under surface of the ice and in surface sediments were almost neglected until living plankton became available during the Calanus expedition to the Belcher Islands in 1959. However, my active interest in lipids was stimulated by diatom slicks noticed on the surface of Hudson Strait during the summer cruise of H.M.C.S. Labrador in 1956. Similar phenomena were observed also in other northern seas by Cleve (1897), Gran (1930), and Grontved (1952). The amount of oil in surface slicks was so abundant that industrial exploitation was advised, and the phenomenon is studied in some countries. Since practice has to follow theory, painstaking research on the biotaxonomy, ecology, seasonal successions, and dynamics of standing crops was carried out. Thus, a preliminary taxonomic list of more than 1000 diatoms and dinoflagellates is being completed and accompanied by photographs. Such a collection of facts is required to organize species according to individual quantitative levels contributing to the total production of biomass.

Though arctic phytoplankton includes fewer than 100 species, their productive efficiency is comparatively high because of rapid reproduction, neritic-pelagic distributions and colonial habit, and because benthic diatoms exist within a narrow shallow fringe of inshore beaches possibly not exceeding 60 m depth, where photosynthesis may proceed. The total primary biomass synthesized by the planktonic and benthic diatoms depends directly on the number of species, their size, and the number of cells produced within the annual cycle in different habitats. At this initial stage of the project there appears to be a gradual decrease in fertility of arctic waters from Newfoundland towards the Arctic Ocean. Within this vast area the ribbon-shaped cryoflora of Pennatae diatoms contributes mainly to the intensive production of lipids which begins in early summer under the ice and extends through to mid July. The Centriceae diatom and dinoflagellate successions reach their annual climax of lipids and standing crops in August. However, the size of the total biomass varies considerably from year to year with thermal and ice conditions in each habitat. At this stage of research on can define the species of Chaetoceros as very efficient producers of tiny lipid droplets, usually between 0.5 to 6 μ in diameter (Fig. 12).

Chaetoceros must exude millions of tons of lipid droplets, since its populations recorded for Ch. socialis may reach 25,000,000 cells per litre. Sixteen species of Chaetoceros appear to be the most efficient food producers in the Centriceae group, because they form enormous quantities of cysts which are loaded with lipids. These species of Chaetoceros are grazed by planktonic herbivores which

Figure 7. *Coscinodiscus concinnus*, with exuded peripheral oil droplets, from Arctic Ocean, Ice Island T-3, 1964.

Figure 8. Oily droplets exuded by diatoms, found abundant in detritus and surface sediments all over the Canadian Arctic.

Figure 9. A drop of oil found in plankton could be identified as a product of *Coscinodiscus* because of tiny rings, shown by the arrows.

Figure 10. Empty frustule of *Thalassiosira nordenskjoldi*, and attached to it a reticulated bubble of oil.

Figure 11. Unidentified fecal pellet of an herbivorous crustacean consists of empty silicious cysts of *Chaetoceros furcellatus* cleared from fat by digestive acids and the enzyme lipase.

Figure 12. *Ch. wighami* seems to be the most important producer of tiny lipids (arrows) floating in brackish seas and contributing to production of petroleum in sediments.


7


10 μ
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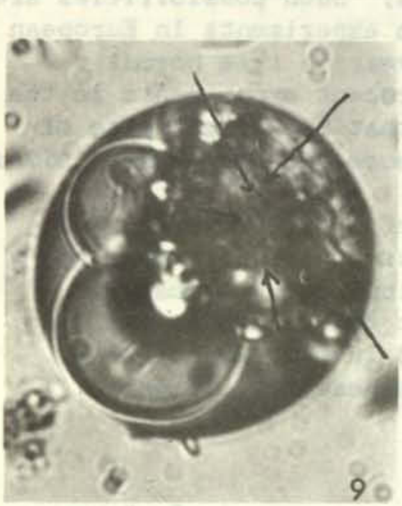
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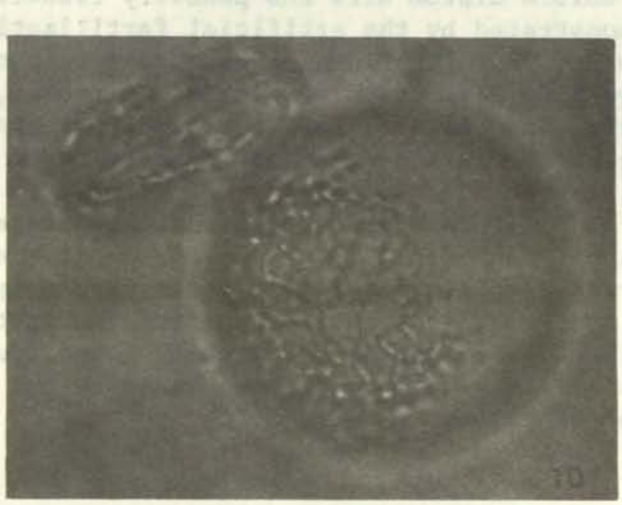
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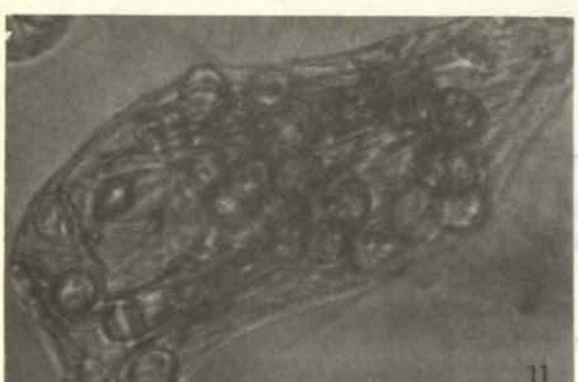
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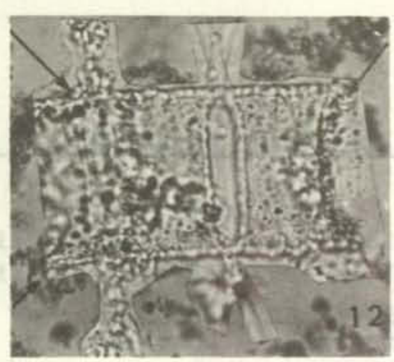
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extract oils through thick silicious cyst membranes, which they digest by the enzyme lipase and acids (Fig. 11). However, unicellular species of the Genus Coscinodiscus, the diameter of which may reach nearly 500 μ (0.5 mm), appear to be very efficient producers of lipids within pelagic-neritic, shallow and deep, Arctic-Atlantic waters. When its lipids become saturated their consistency becomes liquid in summer. Their superabundance is exuded from the frustules, through the tiny edge pores into the sea water (Fig. 7), and contributes mainly to the formation of the oily slicks of Hudson Strait. The collection of Coscinodiscus is possible between 10 and 25 m with net no. 20. Lipids discharged from diatoms and dinoflagellates exist in suspension only for a certain and yet undetermined period of time, after which they sink to the bottom contributing to the formation of petroleum deposits (Fig. 8, 9). Some diatom lipids may expand and form reticulated bubbles (Fig. 10), or droplets (Fig. 8, 9), initially olive-green in colour, later colourless, and finally black when oxidized.

In the long run man has to organize exploitation of all resources of land and seas to maintain his demands of food supply. Still uneconomic arctic seas could supposedly be changed into sources of edible diatom oils and possibly fisheries. Such possibilities are demonstrated by the artificial fertilization experiments in European fiords, in which flatfish can reach in two years a size normally requiring five years of growth. Moreover, recent experiments in the marine Ogac Lake on Baffin Island indicate that the normal size of the phytoplankton standing crops could be increased one hundred times.

Though the nutritional advantage of oils, proteins, and starch synthesized by phytoplankton is the exclusive privilege of marine and freshwater herbivores, and only indirectly of man, it is obvious that countries sharing the arctic coast have to exploit all available marine resources. These would include even marine biosediments which have been baked by the Chinese for lipids in time of famine.

A. S. Bursa

No. 20

Sabbatical leave in Europe, E. H. Grainger.

The period April 1, 1966 to April 1, 1967 was spent on sabbatical leave in Europe, mainly at Copenhagen, Denmark. While there I worked on the systematics and biology of the copepod genera Calanus and Pseudocalanus, two of the dominant cold-water calanoids. From preliminary assessment of the results, the systematic position of three long-troublesome species of the two genera has been established on the basis of morphological and growth-temperature criteria. The results permit generalizations on growth-temperature relationships of northern pelagic forms, and the overall problem of cold-water adaptation with respect to growth rate, development rate and ultimate size. Additionally in Copenhagen, I carried out comparative morphological studies on a number of North American arctic and northwest Atlantic copepods, and completed a study on arctic octocorals.

E. H. Grainger