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FISHERIES RESEARCH BOARD OF CANADA

ARCTIC UNIT

Montreal, Que.

Annual Report
and
Investigators' Summaries

April 1, 1960 to
March 31, 1961

H. D. Fisher,
In Charge

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REPORT FOR 1960-1961 OF THE

ARCTIC UNIT, MONTREAL, QUE.

by H. D. Fisher, Scientist in Charge

The primary objectives of the Arctic Unit are to assess aquatic resources in the arctic regions, and to establish a basis of biological information for management of the resources where exploitation produces a need for this. Marine mammal studies are carried out as well on the Atlantic coast.

The tremendous area to be covered would demand a far larger staff if large-scale exploitation, similar to that which can be endured by stocks to the south, produced the same kind of pressures for management. The relatively low fish productivity however, both in fresh and marine areas, dictates the exercise of caution in development of fishing projects, while marine mammal stocks as well are not particularly abundant, and have been proportionately more heavily cropped than have the fish stocks.

Inventory of stocks has been proceeding as a basis for the organization of small-scale fishing and marine mammal hunting projects designed mainly to improve the local economy. These are developing over the entire breadth of the arctic. There are still substantial blanks in our knowledge of stocks, particularly in the high arctic, and in fact in the whole field of arctic aquatic zoogeography and ecology, which our investigations are planned to fill in.

The Unit is presently headquartered in a small stone building at 505 Pine Ave. West, Montreal, owned by and leased from McGill University which has a strong interest in arctic work. This building will not be available indefinitely, and is now too small for efficiency. Plans therefore are under development for erecting new and permanent quarters for the Unit in the Montreal area.

The Unit operates two small vessels, the 49-foot wooden diesel ketch _Calanus_, built in 1948, for the eastern arctic, and the 38-foot exploratory fishing vessel _Salvelinus_, built in 1959, for the western arctic. In the winter of 1960 these vessels were based at Churchill, Man. and Aklavik N.W.T., respectively.

Fisheries Investigations

Western Arctic. The M.V. _Salvelinus_ carried out exploratory fishing in the coastal marine area between Herschel Island, Yukon, and Aklavik, N.W.T., with gill-nets and a small otter trawl. Bottom trawling to depths of 75 fathoms and drift gill-netting revealed no abundance of usable marine fish stocks, although echo sounder records prompted plans to experiment with a small mid-water trawl in 1961. Fairly rich hauls of small non-commercial marine fishes and invertebrates produced much life-history and distributional data on these forms. Of special interest was the abundance of the bottom dwelling large marine isopod _Mesidothea_, which quantitative hauls indicated to be 5,500 lb per square mile.

Beach seining at Herschel produced large numbers of capelin (Mallotus villosus), which were used to advantage as dog food by the R.C.M.P. there. The recent appearance of this species in the western arctic may lead to wider use of this resource locally.

An abrupt temperature change was noted in inshore waters at 12 metres, from about +3.5°C to -1.1°C. At 10 miles offshore this change was less marked and occurred between 5 metres and 10 metres (+0.38°C to -0.7°C).

Eastern Arctic. Surveys in Ward Inlet, Frobisher Bay and on the southwest coast of Baffin Island between Cape Dorset and Chorkbak Inlet were carried out to estimate char fishery potential in these areas and to select a site for construction of a small field station next year. Ward Inlet was found to be incapable of supporting a commercial fishery. Char were found in almost all freshwater areas, but very few areas suggested any appreciable exploitation was feasible. Char and nine-spined stickleback were the only fish species found in fresh water in these regions.

A study of the growth and production of char stocks in the Sylvia Grinnell River system of Frobisher Bay has indicated a potential annual sustained yield of 29,000 lb at an average weight of 4.8 lb per char. A higher yield is possible with a lower average weight as a result. Increased exploitation of char was found to reduce potential egg production of char.

Investigations in Richmond Gulf, eastern Hudson Bay, under study for potential fishery development by the Department of Northern Affairs, encountered relatively large numbers of sea-run brook trout (Salvelinus fontinalis), whitefish and ciscos. Arctic char were scarce.

Marine Mammal Investigations

Harp seal studies. Aerial photographic surveys carried out over the whelping patches off the east coast of Labrador or "Front" and in the Gulf of St. Lawrence, compared with similar surveys in 1950, indicate an order of decrease in the last 9 years from 730,000 adults and 440,000 pups on the "Front" to 215,000 adults and 160,000 pups; and from 350,000 adults and 215,000 pups in the Gulf to 150,000 adults and 75,000 pups. The price of pelts of the young in the last four years of this period has increased two and a half times. Continued and unregulated exploitation at the level of the last 10 years would thus almost certainly result in virtual commercial extinction.

Harbour seal studies. The lower jaws of seals killed for bounty in the Maritimes have been furnished to the Arctic Unit as a check on the effect of the doubling in 1950 of the bounty on seals older than one year. The age analysis (from canine teeth) of bounty kills suggests that a marked reduction in the annual kill of young of the year which has occurred since 1950 represents a true decline in the total population.

Netting of sea mammals, Belcher Is. The

M.V. Calanus program in 1960 concentrated on the experimental use of special nets to capture marine mammals, principally ringed seal, bearded seal, and white whale. The experiment was successful in demonstrating this method to be of considerable advantage to the personal economy of Belcher Islands residents, without interfering with other hunting activities.

Grey seal studies. Field work on grey seals was resumed in January 1961 in the Maritimes, chiefly to check on abundance and distribution of breeding groups of this big resident seal in the Northumberland Strait and Strait of Canso areas. Exceptionally heavy ice resulted in the usual breeding concentrations of years of more open waters being spread out on ice along the north shore of Nova Scotia. A method of branding, rather than the short-lived tail tagging method, was developed, some stomach samples were collected for determination of incidence of the reproductive stage of nematode cod parasites, and some life-history details were gathered.

Whale distribution in relation to zooplankton biomass. With the cooperation of the Atlantic Oceanographic Group and the Biological Station at St. Andrews, sightings of whales and sampling of zooplankton were carried out from two autumn cruises of C.N.A.V. Sackville, from Bermuda northward to Cape Hatteras, the Continental Shelf and Slope and Cabot Strait. A positive correlation of whale abundance with zooplankton density suggests that a knowledge of zooplankton biomass may serve to indicate the expected abundance of whales.

Biological Oceanography

Zooplankton of Foxe Basin. The time-consuming task of analyzing plankton collections from 100 stations in Foxe Basin, from 1955 to 1957, was completed. Plankton distribution suggests that subarctic elements enter the arctic basin from the south through eastern Foxe Channel, and that northward extension is largely limited to southern central Foxe Basin. A few essentially subarctic forms occurring up to northwest Foxe Basin appear to be carried in by northward flow in the east. Studies are being made on variations in development rates of copepods in different parts of the basin in different years, with respect to ice conditions and their influence on food supply.

Copepods as indicators of arctic and Atlantic mixing. A large form of what was formerly included in the species *Calanus finmarchicus* in arctic and subarctic waters of the U.S.S.R. was given the name *Calanus glacialis* in 1955 by a Russian biologist. A study at the Unit of *Calanus* sp. copepods from the Beaufort Sea to the Gulf of Maine has revealed that *C. glacialis* exists as well in arctic Canada, and that some of the former records of *C. finmarchicus* in northern Canada must refer to the larger form, *C. glacialis*. This large form appears to be specific to arctic water, and its occurrence in the absence of the small C. finmarchicus shows close agreement with our present knowledge of the range of true polar water. The small form, C. finmarchicus, appears to be specific to boreal water and extends northward in the Atlantic only to the southern limit of subarctic water. The two species occurring together apparently indicate mixed polar and Atlantic water, the ratio in such cases showing a decreasing proportion of glacialis from arctic south to boreal seas.

Polar Continental Shelf Project. Preliminary analysis of material collected in conjunction with the Polar Continental Shelf Project of the Department of Mines and Technical Surveys at Ellef Ringnes Island in 1960 has been done. Gross primary production rate, during a very brief period, reached the order of 2 mg $C/m^3/hr$ at maximum, and showed over the short period of measurable productivity a significantly lower rate than was found at the Belcher Islands. The zooplankton standing crop was extremely small. The most numerous phytoplankton species were diatoms with long needle-like cells which were not much grazed because of difficulty of ingestion.

Ogac Lake (Frobisher Bay). Available data from intensive investigations into the biology and hydrography of this landlocked fiord have been analyzed, and the basic features of bathymetry, tidal inflow, the salinity cycle, thermal regime and oxygen cycle have been established.

The thermal regime of this peculiar fiord has proved most interesting. The entire heat increment of the lake below a few metres depth can be accounted for by insolation alone, without downward mixing. In this completely stable system, there is sensible temperature increase below 40 metres, which may be deeper than solar radiation heating has hitherto been detected.

The life cycle of all dominant plankton organisms in the lake have been established in detail, and measurements of numbers and biomasses have been made. Estimates of secondary (phytoplankton consuming) and tertiary (predator) production and ecological efficiencies can be made, and it is hoped that exchanges throughout the entire food web can be measured quantitatively.

PERSONNEL

(April 1, 1960 to March 31, 1961)

Scientific

H. D. Fisher, M.A., Ph.D.	Principal Scientist, in charge
J. G. Hunter, M.A.	Senior Scientist
E. H. Grainger, M.Sc. Ph.D.	Associate Scientist
L. Johnson, M.Sc., Ph.D.	Associate Scientist (from Jan. 30, 1961)
A. W. Mansfield, M.A., Ph.D.	Associate Scientist
D. E. Sergeant, M.A., Ph.D.	Associate Scientist
A. S. Bursa, M.Sc.	Assistant Scientist
I. A. McLaren, M.Sc.	Assistant Scientist (Educational leave to August 14, 1960)

Administrative and Clerical

G. F. Hart	Administrative Officer 3 (from Sep. 1, 1960)
Lois G. McMullon	Clerk 4
Gertrude I. McNulty	Stenographer 1 (to May 9, 1960)
Emmy K. A. Dreyer	Stenographer 2
Catherine F. Quick	Stenographer 2 (from Mar. 3, 1961)

Technical

B. Beck	Technician 1 (from Sep. 1, 1960)
I. G. Gidney	Technician 1
Barbara M. Barry, B.Sc.	Assistant Technician 3
Elizabeth E. A. Cleaver	Assistant Technician 3 (from Feb. 1, 1960)
M. A. R. Day, B.A.	Assistant Technician 3 (to Sep. 19, 1960)
Carroll M. Hutchinson, B.A.	Assistant Technician 3 (to Dec. 9, 1960)
Shirley T. Leach	Assistant Technician 1 (from Jan. 19, 1961)
Baerbel A. vonNida	Assistant Technician 1 (to Jan. 18, 1961)

Seasonal and Term

M. J. Dunbar, M.A., Pn.D.	Associate Scientist (May 16-July 15, 1960)
J. R. Bray, B.A.	Student Assistant (May 16-Sep. 26, 1960)
S. S. Ferguson	Student Assistant (June 15-Sep. 23, 1960)
J. D. McEachern	Student Assistant (May 16-Sep. 21, 1960)
A. E. Peden, B.A.	Student Assistant (May 24-Sep. 28, 1960)
D. Y. E. Perey, B.A.	Student Assistant (June 15-Sep. 19, 1960)
J. H. Todd	Student Assistant (May 16-Sep. 30, 1960)
A. S. Yetter	Student Assistant (May 2-Oct. 10, 1960)
B. D. Margetts	Technician 3, term (May 2-Oct. 31, 1960)
R. Cruickshank	Technician 1, term (June 26-Oct. 3, 1960)
Joyce D. Lally, B.Sc.	Technician 1 (half-time term from Jan. 13, 1961)
Suzanne Brochu	Stenographer 2, term (Sep. 28-Oct. 27, 1960)
Marjorie Lecker	Stenographer 2, term (Dec. 1, 1960-Feb. 28, 1961)

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(January 1 to December 31, 1960)

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INDEX TO SUMMARY REPORTS

Fisheries surveys were carried out in three widely separated areas of the arctic in 1960:

1. Species distribution and abundance in the marine environment of the waters around Herschel Island, Yukon Territory;
2. Arctic char abundance in Ward Inlet, Frobisher Bay and along the south coast of Baffin Island from Dorset east to Shugba Bay;
3. Arctic char and brook trout abundance in the Richmond Gulf, Hudson Bay region.

No. 1

M. V. Salvelinus

This was the first year of operation of the M.V. *Salvelinus* and although considerable preparation was required, the vessel was readied and waiting for open water before the inshore coastal ice had cleared. The vessel arrived at Herschel Island July 24 and fishing commenced the following day. A small mesh otter trawl and gill nets were the principal gear employed. Set lines proved to be useless in that all bait was quickly removed by the amphipod *Pseudalibrotus* sp.

Few fish of economic importance were caught in offshore waters by either trawling or gill netting.

Anadromous species were taken in fair numbers by gill nets set along the shore line. Fully marine species, apart from cottids, were also taken most numerously from shoreline areas.

Trawling was carried out at depths from 2 to 75 fathoms and a fairly rich benthic fauna was found at all depths.

Species of fish collected from the area around Herschel Island included:

Pungitius pungitius	freshwater ponds
Salvelinus alpinus	anadromous
Leucichthys autumnalis	anadromous
L. sardinella	anadromous
Coregonus nasus	anadromous
C. clupeaformis	anadromous
Stenodus leucichthys	anadromous
Osmerus eperlanus	anadromous
Mallotus villosus	marine
Myoxocephalus quadricornis	marine
M. scorpiodes	marine
Triglops pingeli	marine
Artediellus uncinatus	marine
Gymnocanthus tricuspis	marine
Icelus bicornis	marine
I. spatula	marine

Aspidophoroides olriki	)
Boreogadus saida	)
Eleginus navaga	)
Clupea harengus	)
Liopsetta glacialis	)
Lycodes reticulatus	) marine
L. mucosus	)
Lumpenus fabricii	)
Liparis herschelinus	)
L. koefoedi	)
Ammodytes hexapterus	)

Capelin, *Mallotus villosus*, occurred on the beaches in fairly large numbers during the latter part of July and early August and could be of local economic importance if they were to appear annually.

A series of seven hydrographic stations were taken during the course of the summer. Salinities have not yet been determined from the water samples collected but temperatures showed that a very distinct change occurred at about 12 metres depth in near shore waters while at 10 miles offshore this change occurred between 5 and 10 metres depth.

J. G. Hunter

No. 2

Growth and Production of Arctic Char

A report on the growth and production of arctic char populations was completed and may be summarized as follows:

The history of the char's taxonomic position in Greenland and North America is reviewed.

The central core of the otolith, hitherto considered as winter growth, is interpreted as the first summer's growth.

The annual catch by sport and Eskimo fishermen at Frobisher Bay, determined by interview, was found to be 5,750 char.

Analysis of the length-frequency distributions and sex ratios indicated equal mortality for the sexes throughout all ages, and different growth rates for male and female char. This was subsequently confirmed by age analysis. Average growth is completed at 20 years of age at an average maximum fork length of approximately 70.0 cm. Males show a more rapid growth rate than females after 14 years of age. Male char grow larger and reach an average maximum length of approximately 72.0 cm. Female char show asymptotic growth at about 65.0 cm.

The increase in weight with increase in length was not the product of a simple exponential function throughout life. The smaller char represented by lengths from 26.0 to 45.0 cm, showed a lower proportionate weight increase with length than did char of lengths outside this range. A difference was found between the length-weight relationship of char that had recently arrived in the sea and those that had been in the sea for the greater part of the summer. The weight increase of smaller char is proportionately greater than in larger char between the two seasons.

The greatest growth in weight in the char occurs from the 14th to the 18th year of life when it amounts to an average gain of 400 gm per year. Sex ratio of char caught by gill nets in Sylvia Grinnell River were approximately equal but males represented over 58% of the weight of the sample.

The average fecundity of the female char of different sizes was determined and it was concluded that spawning occurs every other year after maturity. The smallest mature female anadromous char found was 46.0 cm long though the majority did not mature until they were 49.0 cm long. Maturity occurs in the 14th to 15th year although a few younger mature individuals may be present.

Anadromous male char were found to mature at 15 years of age and 60.0 cm length.

First migration to the sea occurs over a series of ages which conform to a length size of about 20.0 cm. In the Sylvia Grinnell River first migration probably occurs for the most part in the 7th, 8th and 9th year. Seaward migration takes place in late June when the ice moves out of the river. Upstream migration generally occurs in two movements, the first in late July and the second about mid August. The later run continues until at least early September. All char, as far as is known, spend the winter in fresh water. The distribution of the char in the sea varies with location, but a correlation with low salinity and moderate temperature is indicated. Evidence suggests that distances travelled from parent streams are generally small and a high degree of homing exists. Freshwater distribution of the char is limited to relatively short distances from the sea.

Char at Sylvia Grinnell were found to feed principally upon amphipod crustaceans, and other fish only contributed appreciably to their diets when they occurred in relatively large abundance. Observations from other locations also showed a preference for small fish when they were available. Intraspecific predation was found to be common in fresh water in both winter and summer but restricted to prey less than 20.0 cm fork length.

Two cestode parasites were found with wide ranges of incidence which might affect survival and reproduction. Diphyllobothrium was rarely found in anadromous char but was relatively common in land locked populations. Eubothrium was similarly found at a low level of incidence in the Sylvia Grinnell anadromous char stocks but high in the land locked populations. Coppermine River migratory char showed a high incidence of this parasite.

Two total annual mortality rates of 22.28% for the 17 to 20 year age classes and 54.66% for the 20 to 25 year age classes were found for the char of Sylvia Grinnell River in 1958. An annual fishing mortality rate of 9.42% and an annual natural mortality rate of 14.20% was derived for the 17 to 20 year age classes of these fish.

The population of char of Sylvia Grinnell River was found to consist of approximately 64,000 fish weighing 313,000 lb and to be capable of producing an annual sustained yield of 29,000 lb with an average fish weight of 4.8 lb. Maximum yield of char from the Sylvia Grinnell River was estimated to be 1.16 kg (2.6 lb) per acre. Higher rates of fishing mortality increase the weight of the catch up to a maximum of 50,000 lb but reduce the mean size of the fish caught.

Potential egg production is reduced by higher rates of exploitation of the char stocks. Potential egg production is reduced from 66 million to 9 million eggs with an increase in the annual fishing mortality rate from 5% to 45%.

A comparison of growth rates of char shows that considerable variation occurs throughout the circumpolar range. The only population of anadromous arctic char with a slower growth than that of Sylvia Grinnell River is that of Lake Hazen, Ellesmere Island. Among the fastest growing populations is that of Adlatok in southern Labrador. Comparison of growth of the anadromous char shows that very little variation in growth rate occurs after the fish have reached a fork length of 40.0 cm (Lake Hazen stock excluded) and that most of the variation in total growth is a result of conditions in the freshwater stage.

Growth rates reported from most char populations are inadequate for a rigorous comparison of growth asymptotes but on the present evidence it is indicated that migratory char throughout their entire range achieve approximately the same average maximum size.

J. G. Hunter

No. 3

Baffin Island

A survey of the arctic char stocks in Ward Inlet, Frobisher Bay by A. E. Peden and J. D. McEachern showed that relatively small numbers of char were present in the area. The streams and rivers draining into Ward Inlet were largely blocked by impassable falls which prevented utilization of headwater lakes by the anadromous char.

The south coast of Baffin Island from Dorset east to Shugba Bay contained fair numbers of char throughout the area, although in some cases populations were completely land locked.

Species of fishes collected from the two areas were:

1. Ward Inlet

    Salvelinus alpinus

    Pungitius pungitius

    Gasterosteus aculeatus

    Myoxocephalus scorpius

    M. scorpiodes

    Gymnocanthus tricuspis

    Gadus ogac

2. South coast of Baffin Island

    Salvelinus alpinus

    Pungitius pungitius

    Gasterosteus aculeatus

    Myoxocephalus scorpius

    M. scorpiodes

    Gadus ogac

    Boreogadus saida

J. G. Hunter

No. 4

Richmond Gulf

A survey of the fisheries of Richmond Gulf was carried out by Messrs J. H. Todd and R. Cruickshank during the summer.

Arctic char were found in streams on the west side and north end of Richmond Gulf only. Brook trout were the dominant salmonid species in all other streams. Brook trout, lake herring and whitefish were common in the saline waters while freshwater species such as lake trout, sucker and pike were caught in river mouths along the east coast shore. No statistics of catch from the area are available. However, a number of old Eskimo fishing campsites were located in the entrance to the Gulf indicating extensive fishing had been carried on.

Species of fish caught were:

Salvelinus alpinus

S. fontinalis

S. namaycush

Leucichthys artedi

Prosopium cylindraceum

Coregonus clupeaformis

Gadus ogac

Myoxocephalus quadricornis

M. scorpius

Cottus cognatus

Esox lucius

Catostomus catostomus

J. G. Hunter

No. 5

Population Estimates of Harp Seals

An estimate of numbers of breeding harp seals and young by aerial photographic survey was carried out in March, 1960. Results of this and of earlier surveys carried out in March of 1950, 1951 and 1959 have been given at length in a recent publication (Sergeant and Fisher, 1960, Circular No. 5 of the Arctic Unit). A summary of methods and results is given here.

Harp seals of the western North Atlantic whelp in two areas, the Front or ice east of Belle Isle and the Gulf of St. Lawrence. In each of these areas there may be one, two or three major groups of breeding seals with a few scattered outliers. One problem in an aerial estimate is therefore to find and survey, and to photograph sample strips from, all major groups. This objective, it is believed, was achieved in the two more recent surveys. However, in 1950 and 1951 estimates on the Front were achieved in only one out of two (1950) or three (1951) major groups, representing it was believed, about half the breeding population of the Front in each year. Since the population on the Front was believed to be about twice that breeding in the Gulf at this time, about two-thirds of the total population was believed to have been estimated directly on these earlier surveys.

A second problem in a survey of breeding seals is to census all the young. At first, not all are born. At all times, the small size of the young, their white colour, and their tendency to hide in the shadows of ice hummocks makes it unlikely that all can be surveyed; this is suggested by the fact that the density of young is never as great as that of the old seals in attendance. Two estimates are thus obtained, of adults and of young. The 1960 survey used faster shutter speeds and film than on earlier surveys, which gave better resolution of young seals in the photographs, and as a result probably allowed more of them to be detected; nevertheless, it is doubtful if these difficulties can be fully overcome.

A third problem is the nature of the adults in attendance. While the great majority are without doubt the breeding females, the adult males are known to enter the breeding groups to some extent when the young are nearly weaned, at which time mating begins to take place. However the high ratios of young to adults in some of the later counts, when all the young have been born, makes it unlikely that the number of males is great. Since the males enter the water more readily than the females, their relative numbers cannot be determined from shipboard. In the latest photographs, the majority of adults have left the young and may be lying on ice some distance from them with a greater tendency to enter the water; in these cases the estimate of adults may be less than that of young.

Results of all estimates are shown in Table I. The importance of the various factors discussed above is indicated for each count, and estimates regarded as the more complete or reliable are underlined. Taking the larger estimates for each period and area, we find a decrease over the nine-year period as follows:

--for the Gulf of St. Lawrence, from 350,000 adults and 215,000 young to 150,000 and 75,000 or more young, a drop of from 2½ to 3 times in both adults and young.

--for the Front, from 730,000 adults and 440,000 young (certainly an underestimate), to 215,000 adults and 160,000 young, a drop of at least three times.

Within the five-year period 1956 to 1960 prices of young harp seal pelts have increased about two and a half times, according to statistics of Nova Scotian landings and prices supplied by the Markets and Economics Service of the Department of Fisheries. Probably it is for this reason that catching effort by ships from both

Canada and Norway continues to increase at the present time. This increase is in spite of a decline in availability of seals which is shown by a decreased catch per unit of effort (See Table II, p. 8, Sergeant and Fisher, 1960). The harp seal normally whelps in concentrated groups or patches, and thus remains vulnerable to sealing as its numbers decrease. Smaller patches must be harder for ships to find in the immense ice-fields, but this factor is probably offset at the present time by improved knowledge of ice distribution and thickness obtained from Government surveys, by aerial surveys conducted by the industry in order to locate the seals, and by availability of ice-breakers to pull out sealing ships trapped in rafted ice. Under these conditions, and without imposition of effective controls, the stock of western Atlantic harp seals must be considered to be in grave danger of catastrophic decline in numbers within a very few years.

D. E. Sergeant

No. 6

Life Tables for Harp Seals of the Western North Atlantic

Introduction

In order to determine equilibrium yields of harp seals from populations of different magnitude it is necessary to construct life tables. Starting with a year-class of young of known magnitude, as determined

Table I. Results of aerial estimates of breeding harp seals, summarized. The firmer estimates are underlined.

A. Earlier estimates.

Area	Year	Adults	Young	Comments
GULF	1950	<u>347,600</u>	149,400+	Young under-estimated owing to early date of survey.
	1951	115,900+	<u>218,000</u>	Adults under-estimated in one group owing to late date of survey.
FRONT	1950	380,850+	215,700+	One group only out of two photographed, second group possibly as large as first.
	1951	323,625+	224,700+	One group only out of three photographed, second and third groups together possibly as large as first.
TOTAL SURVEYED	1950	727,450+	365,168+	
	1951	439,625+	224,700+	
TOTAL ESTIMATED	1950-1951	1,000,000	645,000	

B. Recent estimates.

Area	Year	Adults	Young	Comments
GULF	1959	<u>154,725</u>	70,245+	Young under-estimated owing to early date of survey.
	1960	89,390+	<u>77,319</u>	Adults under-estimated in one group owing to late date of survey.
FRONT	1959	176,121+	<u>116,494</u>	Adults under-estimated in one group owing to disturbance by ships.
	1960	<u>214,390</u>	<u>161,884</u>	Believed the most complete survey on the Front.
TOTAL	1959	330,846+	186,739+	
	1960	<u>303,780</u>	<u>239,203</u>	

from aerial survey, and using estimates of mortality rates and birth rates as determined from life-history studies (Fisher, 1954; Sergeant and Fisher, 1960), the fate of this year-class is followed through by repeated calculation until all members have died. If the sum of young ultimately produced by this year-class is equal to or exceeds its initial strength, then the population is maintaining itself or expanding; if the number of young produced is less, it is declining. By interpolating different levels of hunting mortality, the balanced state is determined by trial and error. In these calculations it is assumed, for simplicity in calculation, that the hunting mortality falls entirely on the newborn young. However estimates of total mortality of immatures and adults, being derived from a period when moderate catches of these groups were being made, allows for similar moderate catches.

First, an estimate has been made of equilibrium yields appropriate for the 1950 period when the first aerial estimate of pups was made. This equilibrium yield will of course be less than the actual kill during the decade 1950-1960 which brought about a marked decline in numbers (See Appendix 5). It can also be assumed that this equilibrium will be somewhat higher than the kill of young through the 1920's and 1930's which was maintained apparently without harm to the herds. The estimated equilibrium kill of young will then lie somewhere between 130,000 and 240,000 young per annum, a useful first approximation.

Following calculation of equilibrium yield at the higher population level of 1950, calculation is easily made of an equilibrium yield from the present, reduced population by simple proportion, using the aerial survey estimate of young produced in the period 1959-1960.

Parameters used

The number of young seals born was estimated from aerial surveys. However in 1950 the estimate of 645,000 young produced was certainly an underestimate, owing to incomplete visibility of the young. Trial and error showed that life tables using this figure necessitated an impossibly low kill of young for equilibrium yield. The figure for young born was therefore increased rather arbitrarily to 750,000, 75% of the million or so adults estimated to occur at the breeding groups in 1950 (Sergeant and Fisher, 1960, p. 29).

The kill of young is known fairly precisely from catch statistics. Thus in 1950, the kill of young was about 177,000 for all ships and Canadian landsmen combined (Sergeant and Fisher, 1960, Table XIV). The annual kill of young in west Greenland is about 2,500 out of 12,500 according to analysis of age samples for 1953, and catch statistics for 1955 and 1956. The total kill of young in 1950 may therefore be taken as about

180,000. The hunting mortality of the young is then obtained by dividing the kill by the total number of young born.

The natural mortality of the young in their first year is unknown but is assumed to be at least equal to that of the immatures. The total mortality between ages 0 and 6 has been calculated to average 0.2, and it has been shown that this approximates the natural mortality since hunting mortality of these groups is small (See Table II). It is therefore assumed that the natural mortality of the young is 0.2. This is not a high figure, compared with estimates for young north Pacific fur seals of up to 0.6 (Kenyon and Scheffer, 1954) but the latter come from an excessively crowded population where the young are weakened by undernourishment or disease at birth.

The total mortality rate is then given by the formula $T = M + N - MN$ where T = total, M = hunting, and N = natural mortality.

The value for T for first-year seals in 1950 is then about 0.39. This was used as a starting point and was found to be close to the value for an equilibrium yield.

Total mortality rates for immatures and adults were obtained from samples taken in the period 1952 to 1956 (Sergeant and Fisher, 1960, Tables XI to XIII). During this period, catches of immatures and adults were moderate, running at about 65,000 annually. Using these figures then allows for an immature and adult catch of the same order, without necessitating elaborate calculation of hunting mortality of each year-group of immatures and adults. The figures obtained were: about 0.2 for immatures and 0.1 for young adults. The figure for immatures included young in their first year, the total mortality of which is considerably higher (0.39 above). Immature mortality rates must therefore be lower than 0.2, and are reduced progressively to attain the adult level of 0.1 at six years of age, as shown in the life table of Table II.

The greatest ages recorded in our age samples, totalling about 8,500 animals, were 35 and 37 years. Ages of 30 and over were recorded in most samples exceeding 250 animals. Thus in a life table for a population starting with 750,000 animals, an upper limiting age of 40 years is assumed. Adult mortality rates are gradually increased in old seals to bring about extinction of the year-class at that age.

The birth-rate is derived from three parameters; the sex ratio, the mean age at female sexual maturity, and the annual fertility of the females. The sex ratio is known from sexing of newborn pups to be close to 1:1 at birth (Fisher, 1954). It is assumed to remain at parity. The mean age at female sexual maturity is derived from data of Fisher's supplemented by unpublished data of the author's. The analysis, shown in Table I, shows the percentage of mature females in each age class.

Information on sterility of females comes from Fisher's data on females of mature age or older, not having an active corpus luteum in the ovary during the period of pregnancy. Of 69 females eight years old and up, 62 were pregnant. The percentage infertile is therefore about 10%. The mean fecundity in young females is therefore assumed to rise progressively to 90% and to remain at that level. Combining these data with those of Table I gives the following age-specific rates of pregnancy:

Age	Per cent pregnant	Age	Per cent pregnant
4	0.05	7	0.90
5	0.37	8 and up	1.0 - 0.1 = 0.90
6	0.76		

The sex ratio being 1:1 the birth rate for the whole of each age-class, males and females together, will be half the figure given above for the female age-class.

Data are now sufficient to calculate a life-table. It should be stressed that the least accurate parameter is believed to be the initial number of young born. This figure itself determines the value of the hunting mortality M, and hence the total mortality T, of the young.

Results

Table II starts with a population of 750,000 young seals and applies a kill of 180,000 young. The end result is a production of 796,587 young, showing that the kill is a little lower than the population could maintain. It may also be noted that the number of immatures in such a slowly increasing population would be just over one and a half million, of adults slightly more, giving a total population of about three and a quarter million just before the breeding season. Immediately after the breeding season, with addition of three-quarters of a million young there would be altogether four million animals. The kill of 180,000 young plus about 65,000 immatures and adults (included in their total mortality) gives a percentage kill of about 0.06 or 6%. Estimated kills of immatures and adults in 1950, calculated from age-samples and statistics, have been added into the life table in order to show the hunting mortality rates for each immature year-class and for the adults as a whole.

In this population the hunting mortality of young is 180,000/750,000 or 0.24. The number of young estimated from aerial survey in 1959-1960 was 239,000. If the same level of kill is applied to this initial population, an estimate of equilibrium yield at the present time is obtained of 239,000 x 0.24 or 57,360. However it may again be supposed that the number of young estimated from aerial survey is incomplete. The highest total of adults estimated in 1959-1960 was about 367,000 (Sergeant and Fisher, 1960, p. 29). Assuming the production of young to be of the same order an estimate of equilibrium yield of young is obtained of 88,000. Taking an estimate intermediate between these two figures it seems likely that the present catch of young should not exceed 75,000 in order that the population should build up in numbers once again.

If 75,000 young is 24% of pup production, the latter is 312,500. Assuming this stock to increase by 6.2% per annum, as in the life table of Table II, the actual increase by compound interest is shown in Table III, where it is assumed that the kill of young remains at 24% of production and the kill of adults and immatures is similarly controlled. Table III shows that under these conditions the present stock would return to the level of 1950 in between 15 and 16 years. Table III shows also the gradually increasing number of young that could be taken under such conditions. This number is the sum of both ships' and landsmen's kills.

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D. E. Sergeant.

Table I. Age at sexual maturity of female harp seals

Age in years	H.D.F. 1950-54 No.	Mature No.	Mature %	D.E.S. 1952-54 No.	Mature No.	Mature %	Combined totals No.	Mature No.	Mature %
1	4			3			7		
2	3			4	1	(25)	7	1	(25)
3	17			6			23		
4	18	1	6	3			21	1	4.76
5	20	8	40	7	2	35	27	10	37.0
6	10	9	90	11	7	64	21	16	76.3
7	22	20	90	9	8	89	31	28	90.3
8	11	11	100	6	6	100	17	17	100
9	13	13	100	8	8	100	21	21	100

Table II. A life table for a population of harp seals starting with 750,000 young, from which 180,000 young are removed by hunting. The sex ratio is taken to be 1:1.

Age (yrs)	Initial no.	Applied total mortality T	Kill C	Hunting mortality M	Natural Mortality N	Birth rate	Young born
0	750,000	0.39	180,000	0.24	0.20		
1	457,500	0.21	9,571	0.021	0.19		
2	361,425	0.18	4,899	0.014	0.17		
3	296,368	0.15	2,723	0.009	0.14		
4	251,913	0.13	2,032	0.008	0.12	0.025	6,298
5	219,164	0.10	1,712	0.008	0.09	0.185	40,545
6	197,248	0.10	32,500 overall	0.019 overall	0.09 overall	0.38	74,954
7	177,523	"				0.45	79,885
8	159,771	"				"	71,897
9	143,794	"				"	64,707
10	129,415	"				"	58,237
11	116,473	"				"	52,413
12	104,826	"				"	47,172
13	94,343	"				"	42,454
14	84,909	"				"	38,209
15	76,418	"				"	34,388
16	68,776	0.15				"	30,949

Table II (Continued). A life table for a population of harp seals, starting with 750,000 young. The birth rate remains constant at 0.45.

Age (yrs)	Initial no.	Applied total mortality T	Young born
17	58,460	0.15	26,307
18	49,691	"	22,361
19	42,237	"	19,007
20	35,901	"	16,155
21	30,516	"	13,732
22	25,939	"	11,673
23	22,049	0.2	9,922
24	17,639	"	7,938
25	14,111	"	6,350
26	11,289	"	5,080
27	9,031	"	4,064
28	7,225	0.25	3,251
29	5,419	"	2,439
30	4,064	"	1,829
31	3,048	"	1,372
32	2,286	0.3	1,029
33	1,570	"	707
34	1,099	0.3	495
35	766	0.4	349
36	465	"	209
37	279	0.5	126
38	139	0.7	63
39	42	0.9	19
40	4	0.9	2

Totals: young born:	796,587
immatures aged 1 to 5:	1,586,370
adults aged 6 and up :	1,696,775
whole population after breeding:	4,079,732
before breeding:	3,283,145

Table III. Recovery of present population of harp seals.

Year	Production of young	Per cent increase	Yield at 0.24 of production
1	312,500	6.2	75,000
2	331,875		79,650
3	352,451		84,588
4	374,303		89,833
5	397,510		95,402
6	422,156		101,317
7	448,329		107,599
8	476,125		114,270
9	505,645		121,355
10	536,999		128,879
11	570,287		136,869
12	605,645		145,355
13	643,195		154,366
14	683,073		163,938
15	725,424		174,101
16	770,400		184,896

No. 7

Age Composition of Harp Seals

Sampling has continued of migrant harp seals taken by net at La Tabatière on the north shore of the Gulf of St. Lawrence. Nine years' samples have now been analyzed, from 1952 to 1961, with 1959 omitted since unfavourable ice conditions greatly reduced catch. The results of age determinations of samples taken in January 1960 and 1961 are shown in Figure 1. Because they delay their southward migration, the younger immatures are not fully represented in samples from this source until attaining an age of three or four years. Catches of young harp seals by all agencies are shown for recent years on the same graph; complete data are not available before 1949.

In the past, highest catches of young harp seals have been followed fairly consistently in the samples by lowest survival of the corresponding year-class. Similarly, in the 1961 sample, though less clearly in that of 1960, the very high catch of about 340,000 young harp seals in 1956 is seen to be followed by a poor representation of the 1956 year-class.

In contrast, Figure 1 shows that unusually low catches of young for the present period, about 150,000 young harp seals taken in both 1957 and 1958, have been followed by unusually good survival of the corresponding year-classes. In both samples, the 1957 year-class is dominant, with the 1958 class approaching it in the 1961 sample as that year-class becomes fully represented in the catch.

Females of the strongly surviving 1957 year-class will begin to give birth to their first young at four years of age (See Appendix 6), that is, in the current year 1961. Reduction of the kill of breeding females by suitable protection, if applied in the near future, would therefore have a considerable effect in allowing recovery of stocks and higher production of young.

For the preparation of tooth samples for age determination I am indebted to Mr. Brian Beck.

D. E. Sergeant

No. 8

Harbour Seal

The age analysis of harbour seals killed for the bounty in the Maritime Provinces in 1959 (See Annual Report 1959-60, Figure 7a) has been used as a basis for construction of the life table shown in Table I. In attempting to assess the population by such a method, certain assumptions have to be made which inevitably lack supporting data. However as a first approximation to a population estimate, the life table is considered to be satisfactory.

According to Ricker (1958) a catch curve may be used to calculate mortality rates, provided the sample is

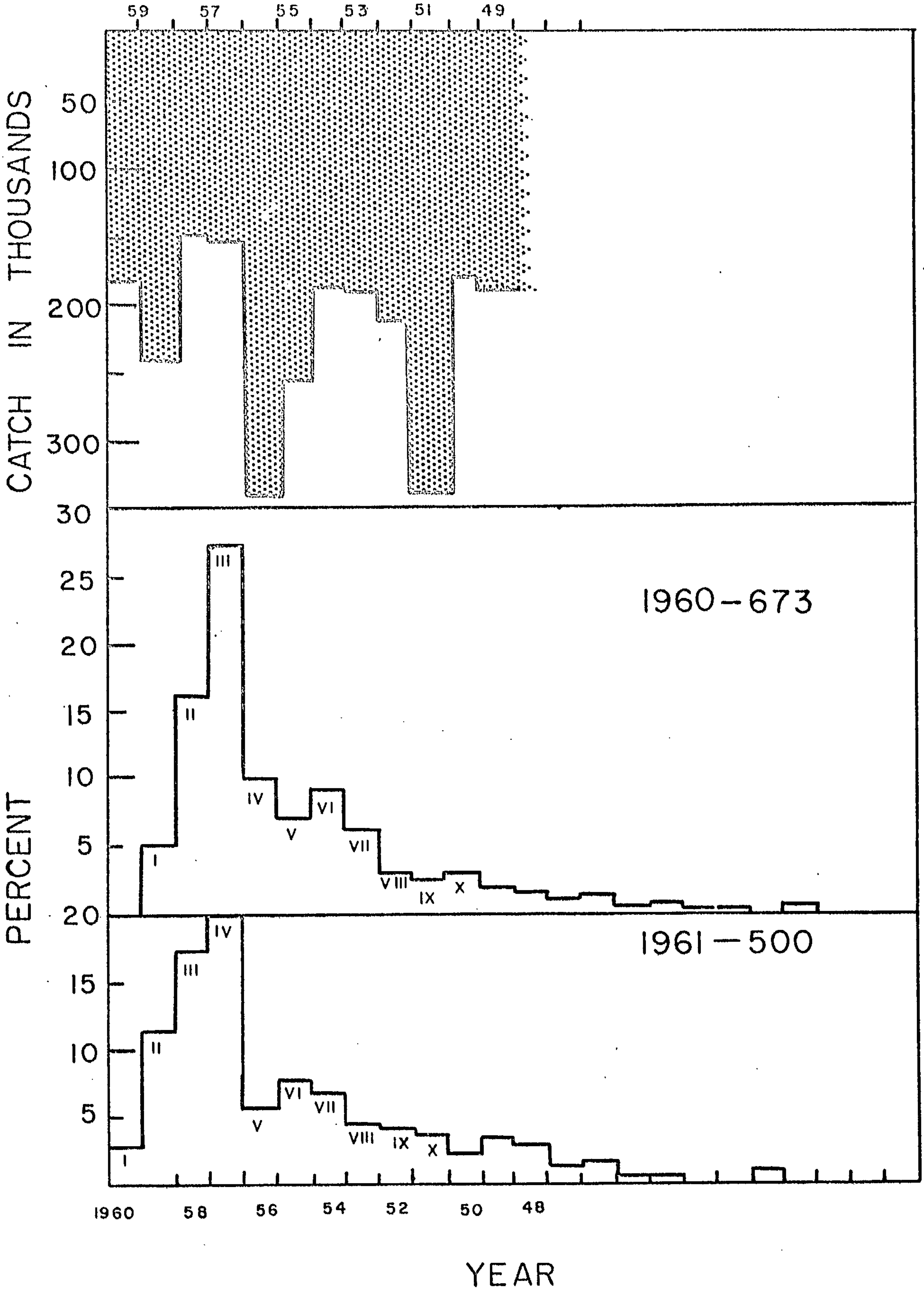

Figure 1. Lower: Age samples of migrant harp seals taken at LaTabatière in January 1960 and 1961. Year classes are shown by Roman numerals. Upper: Yearly catch of young harp seals by all agencies from 1949 to 1960.

random. Since pups are mostly killed in the first few weeks after birth when they would suffer high natural and hunting mortality, the proportion of this first age group in the population is highly over-represented in the sample. This effect probably declines quickly amongst the immature age groups, and adult seals must suffer no differential mortality in this way.

The catch curve shown in Figure 1 was obtained by smoothing the age frequency analysis by a running average of three. Total mortality rates were determined from tangents to this curve and entered in the life table. These were considered to be representative of the adult age groups 8 to 22 years and were entered as true total mortalities (A). The immature seals were considered to be slightly over-represented owing to their comparative inexperience, and the mortality rates for ages 1 to 7 were adjusted to allow for this. Assumed mortality rates of seals in the age groups over 22 years were increased rapidly to account for the few specimens of older harbour seals taken.

The mortality rates so determined allow us to work out the population of immature and adult seals resulting from an initial cohort of known size, but reproductive rates must be considered in order to view the population as a balanced whole. Harbour seal females may first become mature at three years of age, but few will become impregnated at this time. In keeping with the reproductive capacity in other phocids, the full reproductive rate is assumed not to occur until several years after first maturity is possible. If we also assume that the sex ratio of adults is unity, the total pup production may be worked out. By adjusting the value of the cohort of one year olds, a figure of pup production can be arrived at which will balance the table and provide values for both hunting and natural mortalities, and a total mortality for the pups.

It is as well to reaffirm here that what the life table shows is a balanced population, and the figure arrived at for total pup kill is the maximum exploitation such a population could stand and remain in balance. When the effect of the real and very much higher pup kill on this balanced population is considered it can be shown that a rapid reduction in total numbers will occur over the next ten-year period. This suggests that the marked reduction in annual kill of pups which has already occurred since the bounty was increased in 1950 (See Annual Report 1959-60, Figure 6) represents a true decline in the total population.

A. W. Mansfield

No. 9

The Netting of Sea Mammals

In the months of August and September, 1960,

Table I. Life table for a balanced population of harbour seals from the Maritime Provinces. (All numerical values have been increased 10 times for ease in calculating. Thus the total Maritime population is approximately 5,000 seals.)

Total no. of animals	Age in years	Total mortality per cent A	Catch curve mortality	Hunting Kill	M	N	Total no. of animals killed	Per cent females pregnant	Pup production
10,000	0	30	--	--*	.10	.22	3,000	0	
7,000	1	23	28	340	.08	.16	1,610	0	
5,390	2	20	25	243	.08	.13	1,078	0	
4,312	3	18	23	182	.07	.12	776	16	345
3,536	4	17	21	140	.06	.12	601	56	990
2,935	5	16	20	108	.06	.11	470	80	1,174
2,465	6	16	19	86	.06	.11	394	90	1,109
2,071	7	15	17	73	.06	.11	311	90	932
1,760	8	15	15	62	.05	.11	264	90	792
1,496	9	15	15	52	.05	.11	224	90	673
1,272	10	14	15	45	.04	.10	178	90	572
1,094	11	13	14	38	.04	.10	142	90	492
952	12	13	13	33	.03	.10	124	90	428
828	13	13	13	28	.03	.10	108	90	373
720	14	13	13	25	.03	.10	94	90	324
626	15	13	13	21	.03	.10	81	90	282
545	16	13	13	18	.03	.10	71	90	245
474	17	13	13	16	.03	.10	62	90	213
412	18	13	13	14	.03	.10	54	90	185
358	19	13	13	12	.03	.10	47	90	161
311	20	13	13	10	.03	.10	40	90	140
271	21	13	13	9	.03	.10	35	90	122
236	22	13	13	8	.03	.10	31	90	106
205	23	15	--	7	.03	.12	31	90	92
174	24	18	--	6	.03	.15	31	85	75
143	25	25	--	5	.03	.23	36	80	57
107	26	33	--	4	.04	.30	35	75	41
72	27	40	--	3	.04	.37	29	70	25
43	28	50	--	2	.05	.48	22	65	14
21	29	60	--	1	.05	.58	13	60	6
8	30	75	--	1	.13	.71	6	55	2
49,837									9,970

* The figure of 4,800 for the catch of pups has not been included since the hunting kill is heavily biased towards this age group.

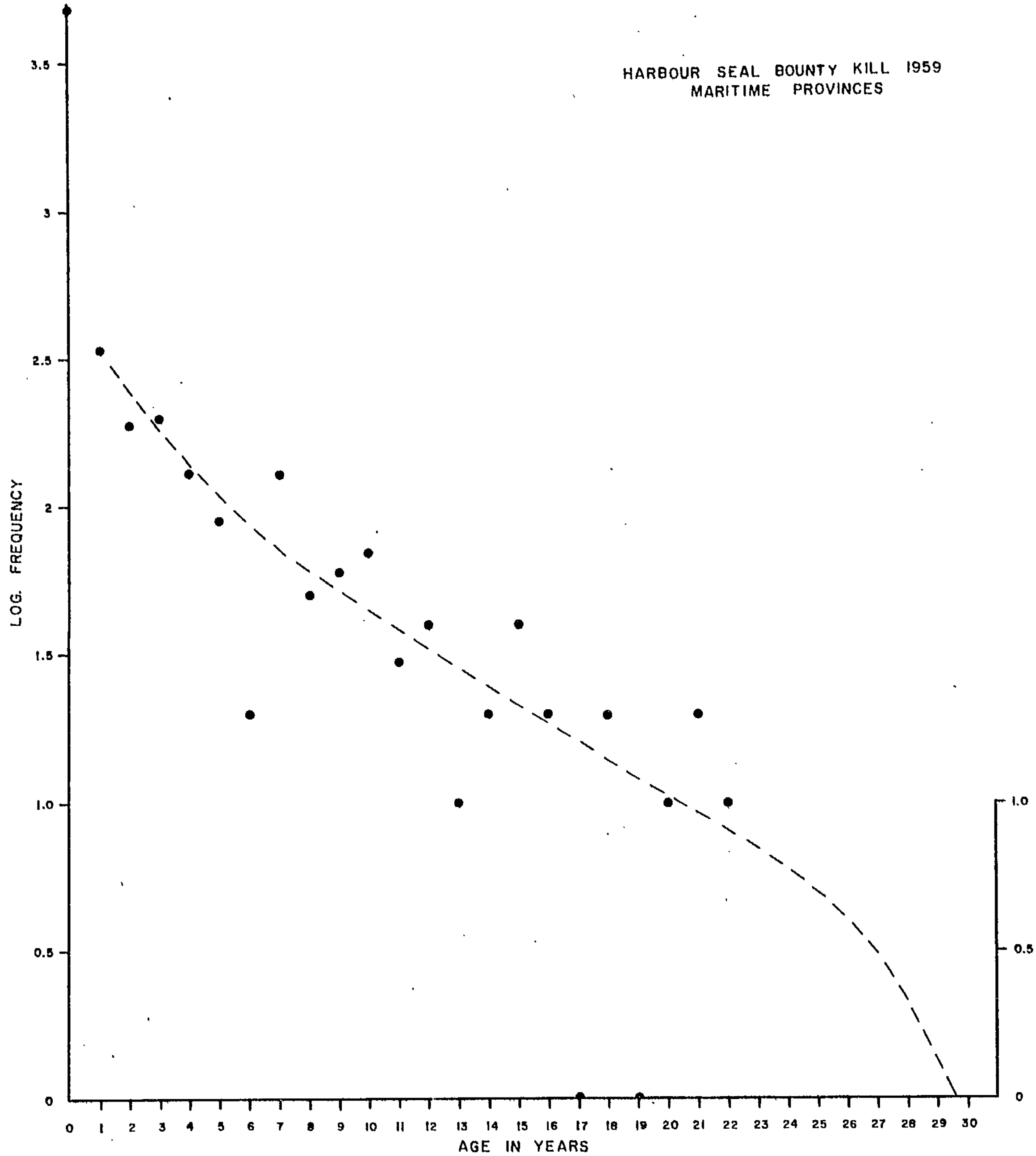

Figure 1. Catch curve of harbour seals killed for the bounty in the Maritime Provinces, 1959.

M.V. Calanus was used as the floating base of operations for a program of netting sea mammals in the Belcher Islands. These islands are well supplied with seals and white whales, but the prevalence of bad weather in the open water season gives little opportunity for hunting. Also, low surface salinities result in a substantial loss of seals by sinking. Nylon nets of 14 and 18 inch mesh, 150 feet long by 24 meshes deep were used, and from the results it has been calculated that each well set net would produce about 2,700 pounds of meat between mid July and mid October. This compares favourably with the 4,900 pounds of edible meat (38 ringed seals, 20 bearded seals and 3 white whales) that a powered hunting canoe would produce in the same period. Netting thus appears to be of considerable advantage to the personal economy of the Eskimos, especially since it does not interfere with other hunting activities.

A. W. Mansfield and I. A. McLaren

No. 10

The Grey Seal

The extent to which the grey seal Halichoerus grypus acts as a vector in spreading infective larvae of the cod-worm Porrocaecum (Phoconema) decipiens is still uncertain. The high incidence of infection of cod taken in the southwestern Gulf of St. Lawrence (Scott and Martin, 1959) suggests that the grey seal may be a more important vector than the harbour seal Phoca vitulina, since few of the latter are taken for the bounty kill in that area. Besides its possible effect on the cod in the Gulf of St. Lawrence, the grey seal is also a predator of salmon, particularly in the Miramichi estuary. Here again, its effect is uncertain, but a concession is granted to the local fishermen, allowing them to claim bounties on grey seals shot within the estuary, though elsewhere in the Maritimes a bounty on grey seals does not apply.

Since the seals in the Miramichi estuary appear to be summer residents, it will be important to know their seasonal movements and also the size and potential increase of the population if any plan of control is to be effected. With these ideas in mind, we began a preliminary investigation of breeding biology and a branding program at Amet Island in Northumberland Strait in January, 1961 (See Figure 1). Field studies carried out from the St. Andrews station in 1953 and 1954 showed the feasibility of marking large numbers of pups by means of tail tags, but some more permanent means of marking seemed now desirable. Experience of one member of the party (B. Beck) on marking elephant seals at Signy Island in the South Orkneys suggested hot-iron branding to be the most suitable method.

Heavy ice conditions in Northumberland Strait prevented access to Amet Island by small boat, and an R.C.A.F. helicopter was used as no commercial aircraft were available in the Maritimes. Unfortunately the ice also stopped the majority of pregnant seals from reaching the shallows about the island and when we arrived on 18 January only 14 pups, 9 adult females and 2 adult males were present. Thirteen of the pups were very fat, ranging in weight from 67 to 105 lb (average 90 lb) and most were fully weaned. Grey seal pups of similar weight from the Farne Islands (Coulson and Hickling, 1960) are between 10 and 16 days old when still suckling, though a steady decline in weight occurs after weaning. The remaining pup was recently born and weighed 33 lb. It was deserted by its mother the day after our arrival and died of starvation on the sixth day, when it weighed 26 lb.

The white pup coats were unusual in being marked with blotches and spots of a light greyish-fawn colour. On one pup, the markings resulted from the dark mottlings of the first hair coat showing through the natal fur, but on the others the hairs were definitely coloured. On all but one of the larger "whitecoats" the face was quite dark, though little moulting had occurred elsewhere. The new-born pup was also dark-faced, a condition in sharp contrast to the white-faced pups from the British Isles. Only one male pup was present and was readily distinguishable by its large muzzle. The one fully moulted female pup observed had a sparser coat of short silver hair, overlain by a close pattern of small blue-black patches.

To facilitate recognition of individual pups, each was daubed on the back with spots of aircraft cellulose paint (Pittsburgh Paints, Spec. no. 1096; red and yellow), the colours remaining clearly visible for six days.

Branding was tried using a cattle type branding iron surmounted with an open letter "O" of 3/8" iron, 4" in diameter. This was heated to red heat with a two-pint capacity gasoline blowtorch, the flame being shielded by a four-gallon drum. The blowtorch was unsatisfactory in high winds, and the system has been redesigned to make use of bottled gas supplying a two or three jet burner. The heated iron was not too effective in branding the "whitecoats" since the charred natal hair prevented the skin from being properly cauterized, and a crisp mark was not obtained. However the fully moulted pup was efficiently branded, which strongly suggests that we should either clip the hair of pups before branding them, or reserve branding for moulted seals. Both methods have been carried out successfully on grey seal pups in the Orkney Islands by the British Nature Conservancy (E. A. Smith, personal communication). With the open type of brand used, sepsis is probably minimal, though more extended work is needed to confirm this.

Throughout our six-day stay at Amet Island the weather remained very cold and all the open water froze over. The adult males and females, which had all taken to the water within a few days of our arrival, disappeared and were not seen again. After returning from Amet Island we surveyed the consolidated ice along the coast eastwards to the Strait of Canso and then north along the west Cape

Breton shore to Port Hood. At Troy on the west Cape Breton shore we examined the frozen carcasses of a group of grey seals killed by local residents. There were 5 adult males, 13 adult females and 11 pups as well as 8 living pups. They had evidently drifted close in shore on ice floes and then been trapped as the remaining open water froze over. Most had had the jaws removed, though we explained to several men whom we met that there was no bounty on these seals.

At Malignant Cove, west of Cape George, we saw 3 adult females and 5 pups, and local residents stated that there had been several big black seals (adult males) as well as others of the same kind now on the ice. These had all left a few days previously.

At Moydart Point a few miles further along the coast to the west we counted through binoculars at least 40 adult seals of both sexes within a mile of shore, as well as numerous pups. The nearest group of 6 adult females and three adult males were killed for specimens.

The behaviour of the grey seal, as shown in these small groups is interesting because it differs markedly from the behaviour of grey seals in the British Isles. There, breeding occurs on land and a loose social organization of parturient females and considerably fewer dominant males is formed. In Canada, ice-breeding is the predominant habit, and a much closer ratio between breeding males and females is apparent. Family units of an adult male together with a female and pup are common suggesting that monogamy may be frequent. The similarity between this behaviour and that of the hooded seal Cystophora cristata is striking, though there is no suggestion that the two species are closely related.

There is a marked sexual difference both in size and colouration of grey seals. The males attain a maximum average length of 94" while females reach only 81". The female coat is dusky grey dorsally shading quickly into silver on the belly. The background is overlaid by a pattern of large black spots and splotches which are more continuous dorsally, and usually sparse or absent ventrally. In older females the black patches may coalesce and come to resemble the male colouration. Old males are uniformly dark when viewed from a distance, but at close hand the overall brownish-black colour is overlaid by a faint light grey pattern of spots and reticulations. The neck skin is thick and thrown into slight folds, but the broad elongated nose is the dominant male sexual characteristic.

The adult male specimens taken on 27 January at Moydart Point were all in rut. They had strong musky odours and the testes were actively producing sperm; the epididymides were packed with sperm in two of the specimens examined.

The six adult females were lactating and all accompanied by pups. Examination of ovaries showed that each pair contained a regressing corpus luteum of pregnancy in one ovary as well as numerous ripening follicles, usually in the opposite ovary. Comparative volumes of corpora lutea ranged from 837 to 2,588 mm^3 while volumes of the largest follicle in each ovary pair ranged from 1,206 to 3,214 mm^3. The largest follicle was accompanied by the smallest corpus luteum, indicating both a rapid decline in size of corpus luteum as well as a rapid increase in follicle size immediately after birth. The largest follicle was found in a female with a prolapsed and highly tumescent vestibular sphincter, an almost sure sign of oestrus. This imminence of ovulation was further suggested by copulatory behaviour in one of the adult pairs examined.

Ages of the females ranged from 5 to 39 years (based on rings in the cementum, a method recently validated by Hewer (1960)). The five-year-old was primiparous, since no corpora albicantia indicating former pregnancies were found. Eight possible corpora albicantia were found in the ovaries of the oldest female suggesting that the older scars may disappear in time.

From female specimens obtained in the period 1950-1955, only one of which was accompanied by aging data; an average body length of 67" to 71" was found in those attaining maturity. From the growth curves illustrated in the 1959-1960 Annual Report (P. 32) this corresponds to an age range of 4 to 5 years. Significantly the single aged specimen was 4 years old and in her first pregnancy. Full breeding maturity is probably not reached until 7 or 8 years, after which the reproductive potential is maximal.

This is suggested by the fact that no mature females without pups were seen in the groups examined.

We have less certain information for the males, but 1955 data indicate an age at sexual maturity of six years. It is significant that the adult males are younger on average than the females (17 years and 20 years), a difference which may partly result from sexual fighting amongst the males with increased mortality.

A. W. Mansfield, H. D. Fisher and B. Beck

No. 11

Catches of Squid and Pilot Whales in Newfoundland

Statistics compiled by the Department of Fisheries in St. John's, Newfoundland, show that catches of squid *Illex illecebrosus* (LeSueur) continue to rise from a low point reached in 1958 (Figure 1). Catches in 1960 totalled 11×10^6 lb, approaching the previous peak of 17×10^6 lb attained in 1956. Fluctuations in squid catches have been known for many years and the previous low point was reached in 1948 and 1949 (W. Templeman and A. M. Fleming: Ann. Proc. ICNAF, 1952-1953, P. 83), but figures for squid landings were not kept before 1952.

Statistics of catches of pilot whales *Globicephala melaena* (Traill) are available since the start of the industrial fishery in 1948. It may be seen from Figure 1 that, following a poor start in 1948-1949, catches rose reaching a peak in 1956, then fell to a minimum in 1958,

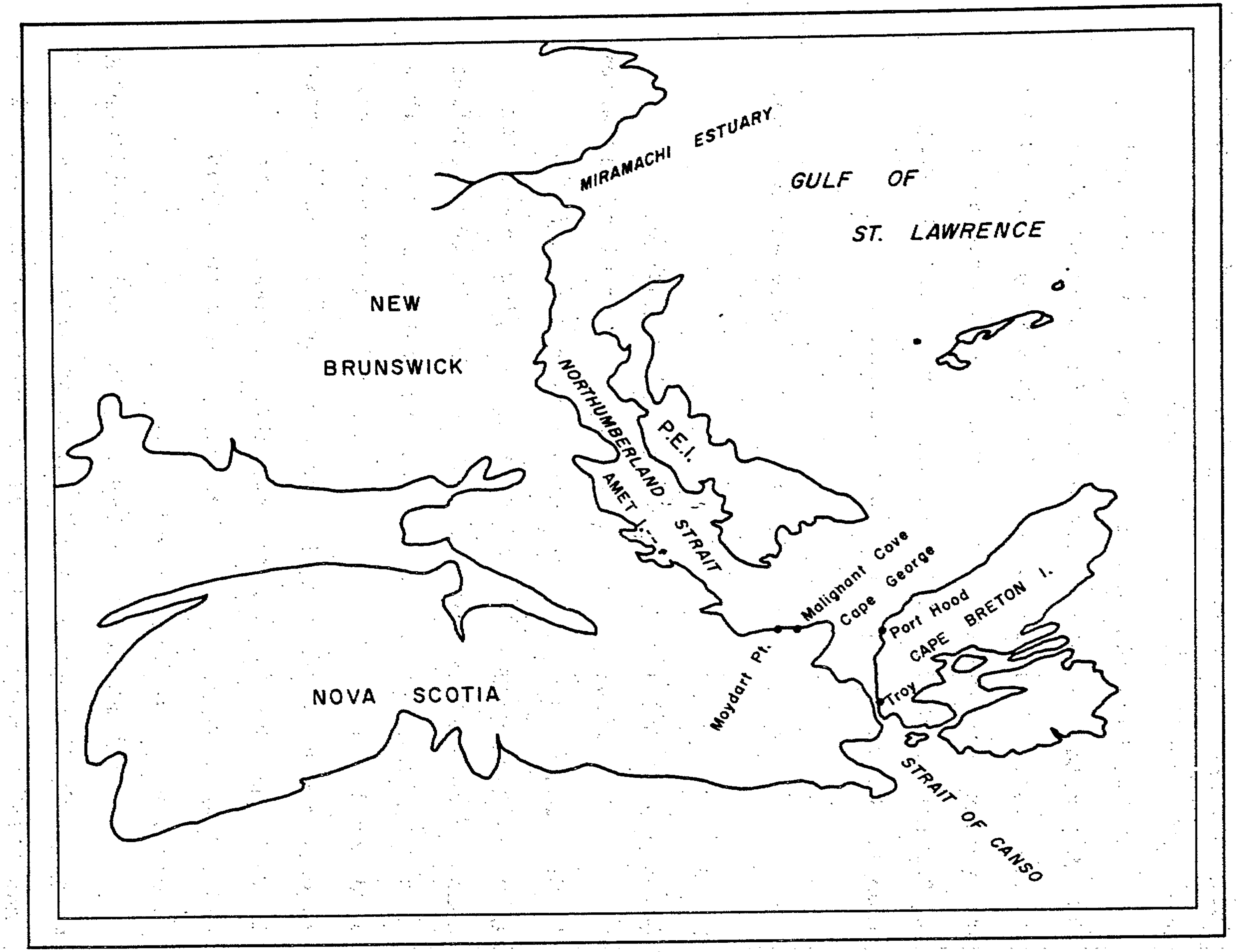
MIRAMACHI ESTUARY
GULF OF
ST. LAWRENCE
NEW
BRUNSWICK
NORTHUMBERLAND
STRAIT
P.E.I.
AMET I.
Malignant Cove
Cape George
Moydart Pt.
Port Hood
CAPE BRETON I.
Troy
NOVA SCOTIA
STRAIT OF CANSO

Figure 1

thus paralleling squid catches up to this time. However, at present pilot whale catches have not risen to the extent that squid catches would lead one to expect, having totalled less than 2,000 in 1960.

Since a very large number of pilot whales have been removed from their stock, and the species has a very slow rate of increase, the question must arise: to what extent does the decline in catch inshore reflect depletion of the herds?

Observations made in 1960 suggest that depletion may not account for all of the observed decline. Pilot whale catches in 1960 fell off earlier than usual following good catches in September. At the same time, pilot whales were reported on the Banks by Norwegian fishing skippers, as reported by Captain Iver Iversen. In November, the writer on board C.N.A.V. Sackville met with pilot whales on three crossings of the Laurentian Channel and southwest Grand Bank (Figure 1 of Appendix 12). All three sightings occurred over the Continental Slope between 100 and 1,000 fathoms. It is noteworthy that two additional sightings, made in July, 1959, from C.G.S. A. T. Cameron on the eastern edge of the Grand Bank, came from similar depths, and in one of these instances current slicks had suggested convergent mixing with, presumably, high organic production. Possibly the Slope in this region is an area providing abundant food for squid.

It is possible to argue on theoretical grounds that inshore catches will remain low, although in the absence of research facilities offshore, the only check on such a hypothesis will be the future trend of catches. The movements of both squid and pilot whales into the coast in late summer has in the past been a very striking feature, indeed the basis for the fishery for both organisms. The concentration of squid inshore can perhaps be explained by supposing a high level of predation by squid on its food organisms, which include euphausiids and small fish (H. J. Squires, 1957; J. Fish. Res. Bd. Canada 14(5): 693-728). Similarly the migration of pilot whales in such large numbers into the coast suggests a high level of predation by them on squid, necessitating much searching until the rich coastal stocks of squid are found. However, with a significant reduction of numbers of pilot whales, the level of their predation on squid would be much reduced, they would in many seasons find sufficient squid offshore, and their numbers inshore would fall while those of squid remained high. Indeed, with the removal of much predation by pilot whales the numbers of squid inshore might be expected to rise. On this hypothesis, the positive correlation which has existed in the past would tend to break down, as it appears to have done recently.

Should offshore catching of pilot whales be justified by present day economics, a good catching field would appear to be the margins of the Newfoundland Banks, from at least St. Pierre Bank eastward and northward to

Flemish Cap, where pilot whales are reported in all months. This region would also be the most profitable for further research from shipboard on the ecology and numbers of pilot whales.

The writer wishes to express thanks to Mr. C. R. Molson and staff of the Markets and Economics Service of the Department of Fisheries for furnishing the statistics quoted in this Appendix.

D. E. Sergeant

No. 12

Whale Sightings and Biomass of Zooplankton in the Northwest Atlantic

In two cruises (S-53) in 1960 of C.N.A.V. Sackville, lasting from October 7 to November 7 and from November 14 to December 7, crossings were made of the Continental Shelf and Slope and the deep water from between Bermuda and Cape Hatteras northward to Cabot Strait and the southwest edge of the Grand Bank. This wide coverage allowed an attempt at synoptic study of zooplankton biomass and its relation to density of whales sighted.

At hydrographic stations, vertical hauls were made from 200 m (or bottom) to surface with a monofilament nylon net of diameter 50 cm and mesh diameter 333 microns (equivalent to a No. 3 silk net). One to two hours daily were spent watching for whales, and additional sightings were made by the officers and men on watch, whenever weather

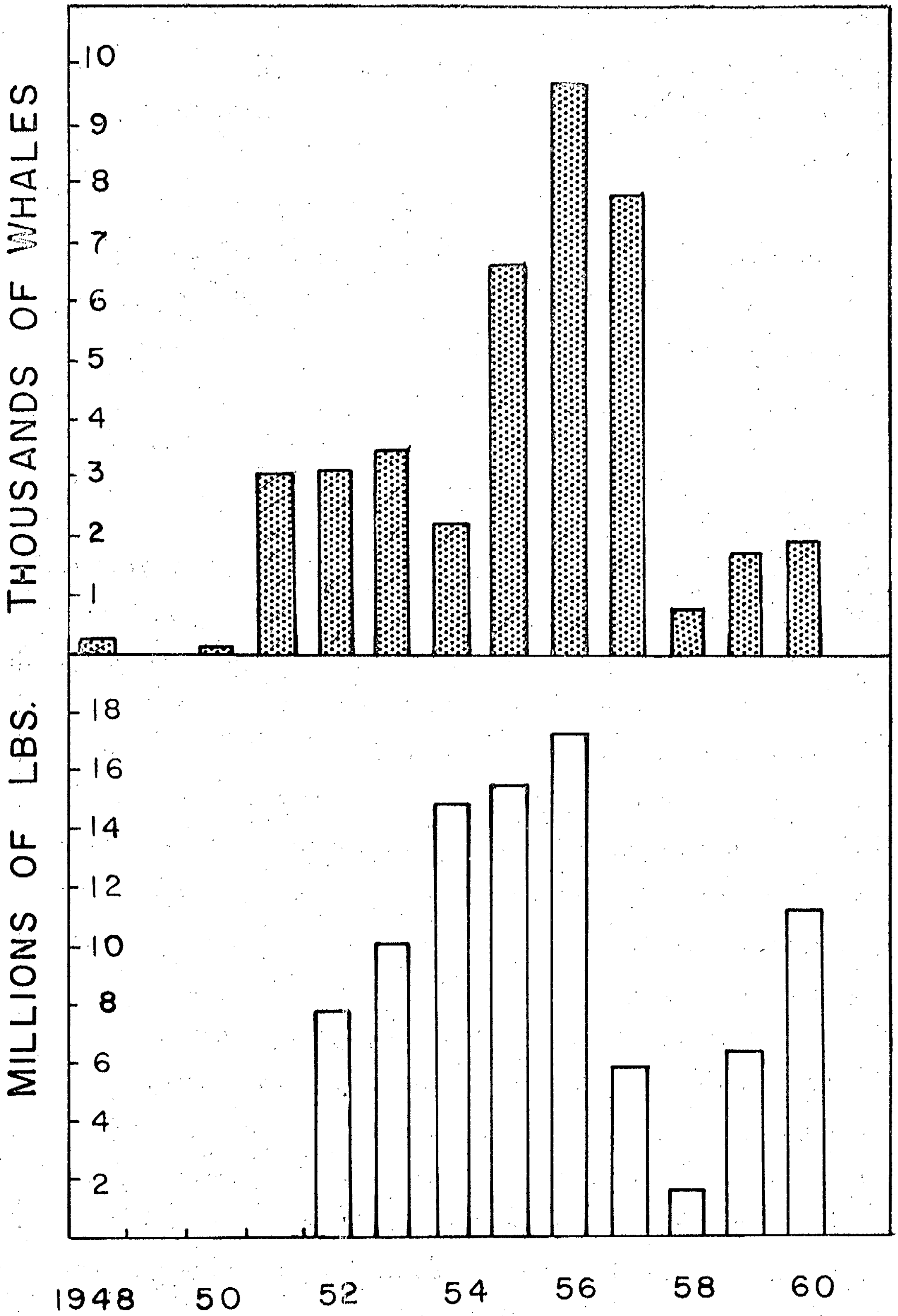

Figure 1. Catches of squid (lower) and of pilot whales (upper) in Newfoundland in recent years.

permitted. It is believed that sightings of the larger whales were possible with winds up to about 25 knots, although doubtless the percentage sighted fell off with increasing wind strength. The two sets of observations are correlated in Figure 1.

Standing crop of zooplankton is expressed as wet weight per cubic metre. This includes salps, ctenophores and the larger medusae which did not however exceed 20% of total wet weight. Since the net was not metred, its efficiency is assumed to be 100%, which is certainly not the case, so that the estimates of standing crop will be too high. Correction was made for wire angle. Hauls within the Continental Shelf in depths less than 200 m have been considered as reaching to 200 m in calculating volume hauled; in other words, it is assumed that the mass of the plankton is concentrated in the top layers. It was unfortunately not possible to use a closing net on this cruise.

In the Gulf of Maine, horizontal-oblique tows were made at 10, 5 and 0 metres by personnel of the St. Andrews Biological Station using a 1-metre woven nylon net of mesh size equivalent to a No. 0 silk net. This net was later loaned to the writer and from comparable tows between the two nets a conversion factor has been applied in order roughly to express plankton density in the Gulf of Maine in terms of hauls with the 50 cm net.

Average wet weight of zooplankton in the upper

200 m ranged from 50 to 600 mg per m^3 in coastal waters to 25 to 50 mg or slightly higher in the Slope and Gulf Stream waters off New England and Nova Scotia, but only around 5 mg per m^3 in Gulf Stream water between Cape Hatteras and Bermuda. There was a slight increase around Bermuda itself. Observations were deficient in the intervening waters as the result of storminess, except for a short line off the Maryland Peninsula which gave a moderate value (87 mg per m^3 in coastal water) and low values again over the deep water. Notably high levels were found off Nantucket, in the central Gulf of Maine, off southwest Nova Scotia and close to the southwest Grand Bank, with the suggestion of increasing values towards the eastern part of the Grand Bank, which was not, however, surveyed. Kusmorskaya (1960) gives spring values for this region and eastward across to Europe using very similar techniques, and shows highest levels (greater than 300 mg per m^3) over the Grand Bank. There appear to be no earlier plankton studies in the Nova Scotian Shelf region since those of the Canadian Fisheries Expedition described by Huntsman (1919), which are not directly comparable.

No whales were sighted in Gulf Stream waters. The only whales seen in mid-State coastal waters were two schools of bottle-nose dolphin Tursiops, a benthic feeding species, close to Cape Hatteras. Sightings of large rorquals began south of Nantucket, and fin whales were numerous in the Gulf of Maine, north of Georges Bank. A few dolphins only were seen off Nova Scotia, but sightings of humpback whales, pilot whales and dolphins *Lagenorhynchus* and *Delphinus* were made on the edges of the Laurentian Channel and southwest Grand Bank.

Previous authors (Hjort and Ruud, 1929; Hardy and Gunther, 1935) have noted a positive correlation between the abundance of whales and of the macroplankton particularly euphausiids, in west Greenland and Antarctic waters respectively. The relation between rorqual abundance and that of the macroplankton may at times be indirect, the whales feeding on fish; in the Gulf of Maine good catches of herring larvae near the sightings of whales, as reported by the St. Andrews Biological Station, suggest that the fin whales were feeding on spawning herring. The pilot whales, again, feed on squid, but these are known to feed on euphausiids (Squires, 1957). Thus a knowledge of zooplankton biomass may serve to indicate the expected abundance of whales at any given time.

Attempts were made to catch *Illex* squid using a 6-ft Isaacs-Kidd pelagic trawl at speeds up to 6 knots (above which, in a swell, the fail-safe mechanism of the frame tended to collapse), at various depths in the region of the Continental Slope where the presence of pilot whales suggested their presence. While fragments of pelagic squid were taken, no *Illex* were. Fishermen report squid taken in commercial trawl (drag) nets in late autumn on the edges of the Newfoundland and Nova Scotian Banks, after they have left inshore waters. Possibly the squid are later to be found at or close to the Continental Slope itself. Larger, faster pelagic trawl gear, and deep bottom trawling gear should be used in any further attempt to take squid off-shore. The Isaacs-Kidd net with ½-in bait liner took large amphipods and euphausiids and small deep sea fish; the crustaceans were considerably larger than the largest taken in either the 1 m or 50 cm plankton nets.

The writer records his thanks to the Atlantic Oceanographic Group for the opportunity to travel on C.N.A.V. Sackville and to her officers and crew for assistance; to Mr. H. J. Squires of the St. John's Biological Station and to Mr. S. N. Tibbo of the St. Andrews Biological Station for the loan of nets, and to Mr. Tibbo for permission to use data collected by his herring research group; to Mr. Brian Beck for his assistance with the work at sea.

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D. E. Sergeant

No. 13

Invertebrate Investigations in the Western Arctic

During the course of fisheries investigations from the M.V. *Salvelinus* in 1960, plankton and benthos samples were collected. Preliminary notes on these are given here.

Invertebrate collections are quantitatively and qualitatively rich, and contain much new information for zoogeography. Identification of most groups of western arctic material has reached only a preliminary stage.

Herschel Island area zooplankton

The following species have been recorded to date:

Medusae

Sarsia princeps

Aglantha digitale

Halitholus cirratus

Euphysa flammea

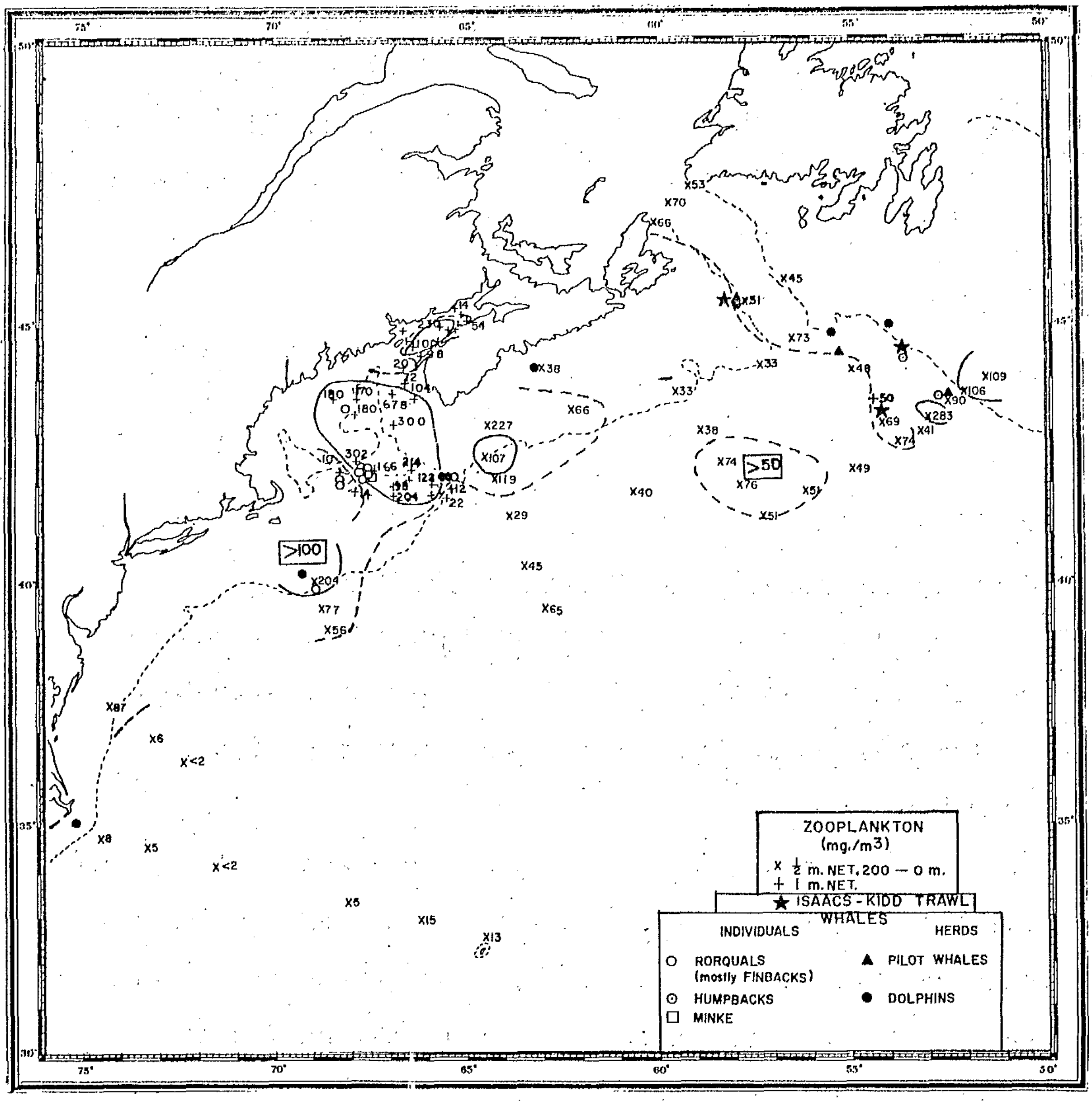

Figure 1. Sackville cruises S-53, October to December, 1960. Standing crop of zooplankton and distribution of whales.

Anthozoa

several species (unidentified)

Nematoda

2 species (unidentified)

Chaetognatha

1 species (unidentified)

Priapuloidea

1 species (unidentified)

Asteroidea

Ophiuroidea

Gorgonocephalus arcticus

Echinoidea

1 species (unidentified)

Holothuroidea

1 species (unidentified)

Crinoidea

Heliometra glacialis

Gastropoda

7 species (unidentified)

Pelecypoda

12 species (unidentified)

Polychaeta

several species (unidentified)

Copepoda

Calanus glacialis

3 other species (unidentified)

Mysidacea

3 species (unidentified)

Isopoda

Mesidothea entomon

Mesidothea sabini

Amphipoda

Anonyx nugax

Pseudalibrotus glacialis

Pseudalibrotus nanseni

Stegocephalopsis ampulla

Stegocephalus inflatus

Haploops tubicola

Ampelisca eschrichti

Rhachotropis aculeata

Acanthozone cuspidata

Gammaracanthus loricatus

Gammarus setosus

Weyprechtia heuglini

8 species not identified

Euphausiacea

2 species (unidentified)

Decapoda

Sabinea septemcarinata

Eualus gaimardi

Eualus gaimardi belcheri

5 species not identified

Isopoda

Two circumpolar species, Mesidothea entomon and M. sabini were found in particular abundance in the western arctic. Mesidothea entomon, by far the more prevalent, comprised from 25% to 90% by weight of benthos samples (including all species of fish). Quantitative hauls indicate that this species in certain areas exists to the extent of 5,500 pounds for every square mile of sea bottom.

Female specimens of Mesidothea entomon mature at a length of from 50 to 79 mm. Males, on the other hand, mature between 65 and 95 mm. In both sexes, reproduction is followed by mortality. The species was observed swimming at the surface and was collected at depths of 24 fathoms. Corresponding temperatures ranged from -1.32° to 10.00°C. Definite inshore migration takes place for purposes of reproduction which occurs throughout the arctic summer. Larger specimens, particularly males, inhabit deep water. The biomass of isopods living in areas of mud bottom is much greater than for areas of gravel or stones.

Experiments on growth rate, behaviour, respiration and salinity tolerances were carried out in the field. These observations, accompanied by a statistical treatment of the population, will appear in a future report. The morphology and internal anatomy with species reference to sexual development have been given careful attention.

Amphipoda

Twenty species of Amphipoda, twelve of which have been identified, were taken in the western arctic during 1960.

Haploops tubicola, Pseudalibrotus glacialis and P. nanseni were taken from bottom hauls in Pauline Cove, Herschel Island. These species were found at depths less than six fathoms from areas of mud bottom. Because of the Mackenzie influence these individuals are subject to a great variation in temperature and salinity conditions. Several species--Anonyx nugax, Stegocephalus inflatus, Ampelisca eschrichti and Acanthozone cuspidata were taken from one station conducted at 50 to 75 fathoms. At 50 fathoms, a temperature of -1.5°C prevailed; the gravel bottom yielded a very rich haul of invertebrates.

Stegocephalopsis ampulla was taken at 50 fathoms and also at 24 fathoms from mud bottom. Three species--Rhachotropis aculeata, Gammaracanthus loricatus and Gammarus setosus were taken in comparatively large numbers from nearly all stations along the Yukon coast. Another species, Weyprechtia heuglini was found in medium abundance at nearly every station.

J. R. Bray

No. 14

Zooplankton of Foxe Basin, 1955-1957

Study of zooplankton collections from 100 stations in Foxe Basin and adjacent waters has been completed. A mean value of about 50 mg/m^3 of zooplankton was computed for the basin. Zooplankton species numbered 48, dominated numerically by amphipods (12), copepods (10) and medusae (9). Chief biomass contributors were the copepods, primarily Pseudocalanus minutus, Calanus glacialis and C. hyperboreus. From plankton distribution, Foxe Basin appears to be a region of opposed arctic and subarctic elements, the former entering from the north and dominating most of the north and central parts of the region, the latter entering from the south and influencing mainly the southernmost part of the basin and to a lesser degree the eastern portion. Local conditions appear to exert a noticeable influence on the state of the zooplankton, both quantitative and qualitative. Chief among these are ice cover and extreme shallowness of the eastern part of the basin which, with associated turbidity of these waters, exerts an inhibiting effect on zooplankton production and limits the occurrence of several species. Variations in zooplankton production from year to year are related to the duration of sea ice cover.

E. H. Grainger.

No. 15

Calanus glacialis and C. finmarchicus in the Canadian Arctic-Subarctic

Using copepod collections from the M.V. Calanus, H.M.C.S. Labrador and other sources in the arctic-subarctic waters of Canada, a study on the Calanus glacialis-C. finmarchicus problem was made. It was shown that C. glacialis

Jaschnov, described originally from north Russian seas, exists in northern North America, and that _C. finmarchicus_, formerly recorded as one of the major copepods there, appears to be totally absent from the true arctic waters of the region. Size difference permits separation of the two species in nearly all instances. In addition, however, the two species may be separated on morphological grounds, most readily on fifth leg structure.

While _C. glacialis_ appears to exist without _C. finmarchicus_ in the Arctic Ocean and throughout the islands of the Canadian arctic archipelago, that is in arctic water, both species occur together in Hudson Strait and along the east coast of the continent from north Baffin Bay southward to at least the Gulf of Maine, in subarctic water. Over this range there is a gradual shift in dominance from _glacialis_ to _finmarchicus_ from arctic to Atlantic areas. Within unmixed Atlantic water of the Labrador Sea and offshore from the Atlantic provinces, only _C. finmarchicus_ has been found. It is suggested therefore that the two species may occupy a useful role as indicators, _glacialis_ alone of arctic, both together of subarctic and _finmarchicus_ alone of Atlantic water.

Work is being continued on attempts to distinguish between the two species in young copepodite stages, and to compare life cycles of the two species in areas of common occurrence.

E. H. Grainger

No. 16

Polar Continental Shelf Project, 1960

During June and July of 1960, biological oceanographic observations were made in the vicinity of Isachsen, N.W.T., in conjunction with the Polar Continental Shelf Project. The area worked is high arctic in character, adjacent to the Arctic Ocean. Shallow, near-shore waters only were sampled during the summer melting period. Somewhat specialized conditions were encountered therefore, differing from the Arctic Ocean in the degree of influence from surface ice melting and land drainage.

Water temperatures were low. Although at the surface they were slightly higher than 0°C throughout the sampling period, at 5 metres they did not exceed -0.5° and at 20 metres and deeper they were constantly about -1.6°C. A slight increase was detected in in situ oxygen between 29 June and 2 July, after which time a slow decline was noted. Highest values (more than 10 ml/l) were found at 5 metres, lowest (less than 8 ml/l) at 30 metres, the greatest depth sampled. Inorganic phosphate, consistently zero at the surface and never more than 1 μg at/l in deeper water, was highest at 30 metres. Little seasonal change was detected in the upper layers but a slight gradual decrease was found at 20 and 30 metres. Inorganic nitrate, sampled only twice (15 and 21 July), was lowest at 5 metres and less than 0.4 μg at/l throughout the upper 10 metres, around 3 μg at/l at 20 metres and between 4 and 6 μg at/l at 30 metres.

The few estimates made of primary production (from dark-light bottle oxygen experiments) showed a low rate of production, at its greatest about 2 mg C/m^3 at 5 metres on July 3 only, generally much less than 1 mg during the remainder of the period. A phytoplankton peak, small and of short duration, coincided with the maximum production value. Zooplankton was found in small quantity, dominated by copepods (*Oithona*, *Oncaea*, *Calanus*). Detailed analyses of quantity and specific composition of the zooplankton have not yet been done.

E. H. Grainger

No. 17

Asteroidea of Northern Canada

Work was continued during the year on the sea stars of northern Canada, with identification of 1960 collections from Hudson Bay and the Herschel Island region. To date, 23 species have been recorded between Alaska and southern Labrador.

A collection of about 320 sea stars collected by the *Blue Dolphin* expeditions of 1949 to 1952 to the Labrador coast has been studied. There are 11 species included, only 3 of which were known formerly from the region. The following are new Labrador records: *Ctenodiscus crispatus*, *Poraniomorpha tumida tuberculata*, *Pteraster militaris*, *P. pulvillus*, *Henricia eschrichti*, *H. scabrior*, *Stephanasterias albula* and *Urasterias lincki*. A report on the collection is in preparation.

E. H. Grainger

No. 18

Calanus Invertebrate Collections

Studies on the chaetognaths and the euphausids of the *Calanus* collections are nearing completion. The remaining bivalve molluscs collected to date were identified during the year. Cephalopod and amphineuran molluscs have been sent to the National Museum of Canada for study. Arrangements for work on the remaining decapod crustaceans and on the gastropod molluscs are being made with outside specialists.

E. H. Grainger

No. 19

Phytoplankton Studies

Quantitative and net samples of phytoplankton were collected in the vicinity of Isachsen, N.W.T., as part of the Polar Continental Shelf Project of the Department of Mines and Technical Surveys. The special advantage of field work was the discovery of many pelliculate dinoflagellates which must be studied *in vivo*.

The neritic brackish phytoplankton of the

Isachsen area, slightly to the south of the Arctic Ocean in the Canadian Archipelago, shows a bimodal annual cycle. The spring maximum in this cycle was formed by pennate diatoms mostly (Nitzschia pungens, N. lineola and N. seriata) with one peak on July 2 and a second on July 9, after which they declined. The summer succession of Centriceae was formed mainly by Chaetoceros ceratosporum, which also had two peaks, the first on July 9, and the second on July 13. All cells by this later date had formed cysts and their life cycle was completed. Lesser cycles included a unimodal succession of the freshwater flagellates with a peak on July 2 and a unimodal dinoflagellate cycle with a peak on July 22.

The Isachsen cycle, with 48 diatoms, 33 dinoflagellates and 20 flagellates, formed larger populations than in the offshore waters of the Arctic Ocean. The spring awakening and increase in quantity of the phytoplankton starts near mid May and appears to be completed by the end of August. Phytoplankton of the Isachsen area consists of many brackish diatoms which form large populations, but because of their small size and volume of protoplasm they represent only low nutritional values. Their populations were large and ungrazed by zooplankton because of the presence of many needle-shaped pennate diatoms and cysts covered with heavy spined membranes which possibly are hard to swallow because of their shape and hard to digest because of their membrane. It was found that even the finest net collection near Isachsen looks like distilled water, since main forms like _Nitzschia_, measuring from 50 to 76 μ by 2.5 μ escape through the finest net meshes. The tiny _Chaetoceros_, Chlorophyceae and Coccolithineae were mostly absent in the net samples. Quantitative dynamics of such organisms can be studied by using the sedimentation method. All previous results require revision if nets only were used for phytoplankton estimation.

Three weeks were spent at the St. Andrews Station. The poisonous _Goniaulax tamarensis_ was studied, along with other species of the genus. _G. tamarensis_ was found to be abundant in net plankton samples taken in previous years.

The pelliculate diatoms were studied in the vicinity of St. Andrews. This group is surprisingly rare in the area and the main bulk of primary food there is formed by the diatoms and the thecate dinoflagellates. A total of 22 of pelliculate dinoflagellates was found, a new genus and some new species new for taxonomy were described.

The main laboratory work was focussed upon quantitative and qualitative aspects of the phytoplankton standing crop in Foxe Basin contrasted against hydrographic conditions. Fifty phytoplankton stations were occupied by H.M.C.S. _Labrador_ in 1956 and by M.V. _Calanus_ in 1955-56. Quantitative samples were taken from a standard depth. An attempt was made to determine spring, summer, autumn and winter phases, and the sequence of their successions in different bodies of water at the stations dispersed over Foxe Basin. The fact that pennate groups are exclusively arctic and are favoured by ice conditions, allows us to contrast these conditions against summer or open water Centriceae. Such a quantitative analysis permits interpolation of the balance between both ecological groups of diatoms, and appears to be instructive for an understanding of the main limiting life factor. This is low temperature and its complex effect as a factor influencing light and salinity versus photosynthesis. At the present moment, it is possible to show that the higher level of the phytoplankton standing crop along the east coast of Foxe Basin from Fury and Hecla to the southernmost plankton station at southern Foxe Basin could be related to the current, carrying to the south great populations of diatoms with ice floes into more optimal areas where light and water mixing invigorates their growth. The late maxima of the diatoms within northernmost Foxe Basin and the dominance of pennate diatoms in August is associated with the delaying influence of ice, particularly severe in that region.

A. S. Bursa

No. 20

Ogac Lake Studies

The available observations on hydrography have been analyzed. Although more specialized studies of this unique system are called for, the basic features of bathymetry, tidal inflow, the salinity cycle, thermal regime, and oxygen cycle have been established. The amounts, salinities and temperatures of the tidal inflows during the summer season were observed or predicted, and the salinity cycle balanced roughly for the year. The thermal regime has proved especially curious. The great vertical stability of the lake combined with the clarity of the water permits radiation to be the source of heating as deep as 30 or more metres. Marked temperature inversions, resulting from the entry of cold tidal water of intermediate density in autumn, are preserved throughout the following summer, and have, among other effects, striking influence on the vertical distribution of plankton.

The plankton has been largely counted and measured. Reproductive and production cycles have been clarified, and demonstrate the inadequacy of standing crop as a measure of secondary and tertiary productivity. Although the ultimate aim of the work will be to measure energy exchanges throughout this rather simple and slow-moving ecosystem, there is much of biological interest at a lower level of integration. The life-histories of the four dominant species, the copepods Oithona and Pseudocalanus, the chaetognath Sagitta and the hydromedusan Aglantha, have been worked out with detail unobtainable in the several marine studies of these species. Precise information on their trophic relations, intrinsic reproductive limits, depth relations, and interactions were gained. There is marked niche diversification of the species, and when the boundaries of the niches of Aglantha and Sagitta are forced to coincide in the lower basin for bathymetric and hydrographic reasons, Aglantha is apparently excluded by competition.

The material stresses the necessity of year-round, post-larval competition between holoplanktonic herbivores, and suggests that the poverty of species in the holoplankton may not reflect immaturity of the fauna in geologic time as much as real saturation of the rather limited opportunities for niche diversification.

A start has been made in the analysis of the benthos. One quite unprecidented observation to date is that veliger larvae, probably of Saxicava, spend almost a year in the meroplankton. Obviously productivity studies of the benthos, which supports much of the initial growth at least of the resident Gadus morhua, will be simplified in this slow-moving system.

I. A. McLaren