NOAA TR NMFS SSRF-679

A UNITED STATES
DEPARTMENT OF
COMMERCE
PUBLICATION

NOAA Technical Report NMFS SSRF-679

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

Kinds and Abundance of Zooplankton Collected by the USCG Icebreaker *Glacier* in the Eastern Chukchi Sea, September-October 1970

BRUCE L. WING

SEATTLE, WA
August 1974

NOAA TECHNICAL REPORTS

National Marine Fisheries Service, Special Scientific Report—Fisheries Series

The major responsibilities of the National Marine Fisheries Service (NMFS) are to monitor and assess the abundance and geographic distribution of fishery resources, to understand and predict fluctuations in the quantity and distribution of these resources, and to establish levels for optimum use of the resources. NMFS is also charged with the development and implementation of policies for managing national fishing grounds, development and enforcement of domestic fisheries regulations, surveillance of foreign fishing off United States coastal waters, and the development and enforcement of international fishery agreements and policies. NMFS also assists the fishing industry through marketing service and economic analysis programs, and mortgage insurance and vessel construction subsidies. It collects, analyzes, and publishes statistics on various phases of the industry.

The Special Scientific Report—Fisheries series was established in 1949. The series carries reports on scientific investigations that document long-term continuing programs of NMFS, or intensive scientific reports on studies of restricted scope. The reports may deal with applied fishery problems. The series is also used as a medium for the publication of bibliographies of a specialized scientific nature.

NOAA Technical Reports NMFS SSRF are available free in limited numbers to governmental agencies, both Federal and State. They are also available in exchange for other scientific and technical publications in the marine sciences. Individual copies may be obtained (unless otherwise noted) from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, D.C. 20235. Recent SSRF's are:

619. Macrozooplankton and small nekton in the coastal waters off Vancouver Island (Canada) and Washington, spring and fall of 1963. By Donald S. Day. January 1971, iii + 94 pp., 19 figs., 13 tables.

620. The Trade Wind Zone Oceanography Pilot Study. Part IX: The sea-level wind field and wind stress values, July 1963 to June 1965. By Gunter R. Seckel. June 1970, iii + 66 pp., 5 figs.

621. Predation by sculpins on fall chinook salmon, *Oncorhynchus tshawytscha*, fry of hatchery origin. By Benjamin G. Patten. February 1971, iii + 14 pp., 6 figs., 9 tables.

622. Number and lengths, by season, of fishes caught with an otter trawl near Woods Hole, Massachusetts, September 1961 to December 1962. By F. E. Lux and F. E. Nichy. February 1971, iii + 15 pp., 3 figs., 19 tables.

623. Apparent abundance, distribution, and migrations of albacore, *Thunnus alalunga*, on the North Pacific longline grounds. By Brian J. Rothschild and Marian Y. Y. Yong. September 1970, v + 37 pp., 19 figs., 5 tables.

624. Influence of mechanical processing on the quality and yield of bay scallop meats. By N. B. Webb and F. B. [illegible]. April 1971, iii + [illegible] pp., 9 figs., [illegible] tables.

625. Distribution of salmon and related oceanographic features in the North Pacific Ocean, spring 1968. By Robert R. French, Richard G. Bakkala, Masanao Osako, and Jun Ito. March 1971, iii + 22 pp., [illegible] figs., 3 tables.

626. Commercial fishery and biology of the freshwater shrimp, *Macrobrachium*, in the Lower St. Paul River, Liberia, 1952-53. By George C. Miller. February 1971, iii + 13 pp., 8 figs., 7 tables.

627. Calico scallops of the Southeastern United States, 1959-69. By Robert Cummins, Jr. June 1971, iii + 22 pp., 23 figs., [illegible] tables.

628. Fur Seal Investigations, 1969. By NMFS, Marine Mammal Biological Laboratory. August 1971, 82 pp., 20 figs., 44 tables, 23 appendix A tables, 10 appendix B tables.

629. Analysis of the operations of seven Hawaiian skipjack tuna fishing vessels, June-August 1967. By Richard N. Uchida and Ray F. Sumida. March 1971, v + 25 pp., 14 figs., 21 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

630. Blue crab meat. I. Preservation by freezing. July 1971, iii + 13 pp., 5 figs., 2 tables. II. Effect of chemical treatments on acceptability. By Jurgen H. Strasser, Jean S. Lennon, and Frederick J. King. July 1971, iii + 12 pp., 1 fig., 9 tables.

631. Occurrence of thiaminase in some common aquatic animals of the United States and Canada. By R. A. Greig and R. H. Gnaedinger. July 1971, iii + 7 pp., 2 tables.

632. An annotated bibliography of attempts to rear the larvae of marine fishes in the laboratory. By Robert C. May. August 1971, iii + 24 pp., 1 appendix I table, 1 appendix II table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

633. Blueing of processed crab meat. II. Identification of some factors involved in the blue discoloration of canned crab meat *Callinectes sapidus*. By Melvin E. Waters. May 1971, iii + [illegible] pp., 1 fig., [illegible] tables.

634. Age composition, weight, length, and sex of herring, *Clupea pallasii*, used for reduction in Alaska, 1929-66. By Gerald M. Reid. July 1971, iii + 25 pp., 4 figs., 18 tables.

635. A bibliography of the blackfin tuna, *Thunnus atlanticus* (Lesson). By Grant L. Beardsley and David C. Simmons. August 1971, 10 pp. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

636. Oil pollution on Wake Island from the tanker *R. C. Stoner*. By Reginald M. Gooding. May 1971, iii + 12 pp., 8 figs., 2 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

637. Occurrence of larval, juvenile, and mature crabs in the vicinity of Beaufort Inlet, North Carolina. By Donnie L. Dudley and Mayo H. Judy. August 1971, iii + 10 pp., 1 fig., 5 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

638. Length-weight relations of haddock from commercial landings in New England, 1931-55. By Bradford E. Brown and Richard C. Hennemuth. August 1971, v + 13 pp., 16 figs., 6 tables, 10 appendix A tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

639. A hydrographic survey of the Galveston Bay system, Texas 1963-66. By E. J. Pullen, W. L. Trent, and G. B. Adams. October 1971, v + 13 pp., 15 figs., 12 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

640. Annotated bibliography on the fishing industry and biology of the blue crab, *Callinectes sapidus*. By Marlin E. Tagatz and Ann Bowman Hall. August 1971, 94 pp. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

641. Use of threadfin shad, *Dorosoma petenense*, as live bait during experimental pole-and-line fishing for skipjack tuna, *Katsuwonus pelamis*, in Hawaii. By Robert T. B. Iversen. August 1971, iii + 10 pp., 3 figs., 7 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

642. Atlantic menhaden *Brevoortia tyrannus* resource and fishery—analysis of decline. By Kenneth A. Henry. August 1971, v + 32 pp., 40 figs., 5 appendix figs., 3 tables, 2 appendix tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

643. Surface winds of the southeastern tropical Atlantic Ocean. By John M. Steigner and Merton C. Ingham. October 1971, iii + 20 pp., 17 figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

644. Inhibition of flesh browning and skin color fading in frozen fillets of yelloweye snapper (*Lutzanus vivanus*). By Harold C. Thompson, Jr., and Mary H. Thompson. February 1972, iii + 6 pp., 3 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

645. Traveling screen for removal of debris from rivers. By Daniel W. Bates, Ernest W. Murphey, and Martin G. Beam. October 1971, iii + 6 pp., 6 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

646. Dissolved nitrogen concentrations in the Columbia and Snake Rivers in 1970 and their effect on chinook salmon and steelhead trout. By Wesley J. Ebel. August 1971, iii + 7 pp., 2 figs., 6 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

647. Revised annotated list of parasites from sea mammals caught off the west coast of North America. By L. Margolis and M. D. Dailey. March 1972, iii + 23 pp. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Continued on inside back cover

U.S. DEPARTMENT OF COMMERCE
Frederick B. Dent, Secretary
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator
NATIONAL MARINE FISHERIES SERVICE
Robert W. Schoning, Director

NOAA Technical Report NMFS SSRF-679

Kinds and Abundance of Zooplankton Collected by the USCG Icebreaker *Glacier* in the Eastern Chukchi Sea, September-October 1970

BRUCE L. WING

SEATTLE, WA
August 1974

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

Figures

Tables

Kinds and Abundance of Zooplankton Collected by the USCG Icebreaker *Glacier* in the Eastern Chukchi Sea, September-October 1970

BRUCE L. WING[1]

ABSTRACT

Zooplankton samples were taken at 39 oceanographic stations in the eastern Chukchi Sea in September and October 1970. Sampling was done by vertical tows from near bottom to the surface with a 0.5-m diameter No. 0 (0.57 mm) mesh NorPac standard plankton net. Data are presented on the distribution and relative abundance of 63 categories of zooplankton at the onset of winter. Zooplankton abundance generally was lowest in waters with temperatures below 0°C; it did not appear to be associated with the distribution of salinity; and it tended to be inversely related to dissolved oxygen concentration. Comparison of zooplankton abundance in 1970 with published observations on the Chukchi Sea in 1947 shows probable seasonal variation of meroplankton abundance and yearly variation of holoplankton abundance.

INTRODUCTION

In September and October 1970, the U.S. Coast Guard icebreaker *Glacier* made the first of the Western Beaufort Sea Ecological Cruises (WEBSEC-70). The WEBSEC program is carried on principally by the Coast Guard, but several other Federal agencies and universities cooperate in obtaining the many types of data required for a complete ecological assessment of the Beaufort Sea. The work of WEBSEC-70 was actually done in the eastern Chukchi Sea because exceptionally heavy pack ice prevented work east of Barrow, Alaska.

I participated in the WEBSEC-70 cruise from 26 September to 17 October. During that time I took zooplankton samples at 39 of the 92 stations occupied by the *Glacier* (Fig. 1, Table 1). The area covered was between lat. 68°54'N-70°34'N and long. 162°24'W-168°56'W. My objective was to determine the kinds and abundance of zooplankton in the eastern Chukchi Sea at the onset of winter. Previously, with the exception of MacGinitie (1955), information on the zooplankton of the eastern Chukchi Sea was limited to the summer months of July and August (Johnson, 1936, 1953, 1956, 1958; Hand and Kan, 1961; English, 1966).

This paper lists the kinds and abundance of zooplankters collected in 1970. It then relates the zooplankton distribution to the distribution of temperature, salinity, and dissolved oxygen and compares my abundance data for 1970 with Johnson's (1953) data for the 1947 summer cruise of the USS *Nereus*.

[1]Auke Bay Fisheries Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 155, Auke Bay, AK 99821.

METHODS

My zooplankton sampling was limited to those stations at which the Coast Guard took hydrographic casts to measure physical and chemical characteristics of the water. Of the 92 stations occupied by the

Table 1.--Location, depth, date, time and number of species of zooplankton collected for 39 stations occupied by the USCG icebreaker Glacier, 26 September to 17 October 1970.

Station number	Long. W	Lat. N	Sampling depth	Date	Time[1/] (BST)	Number of species[2/]
8	69°45'	163°34'	17	26 September	2225	19
9	70°10'	166°03'	42	27 September	1545	15
11	70°19'	165°45'	41	28 September	0700	11
12[3/]	70°28'	165°15'	42	28 September	1520	11
15[3/]	70°18'	164°41'	40	29 September	1515	8
18	70°24'	164°09'	40	30 September	0715	13
19	70°22'	163°16'	28	30 September	1335	12
21	70°34'	163°16'	36	1 October	1425	15
23	70°23'	162°24'	20	2 October	1005	13
24	70°09'	162°57'	18	2 October	1620	10
26	70°11'	162°52'	16	3 October	0850	4
28[4/]	69°59'	163°17'	19	4 October	0710	13
29[4/]	70°01'	163°59'	28	4 October	1400	12
31	69°45'	163°34'	18	5 October	0720	9
33	69°47'	164°30'	30	6 October	0350	16
34	69°52'	165°37'	40	6 October	0745	14
35	69°59'	166°03'	43	6 October	1320	13
36	70°08'	167°11'	46	6 October	1640	13
39	69°51'	166°47'	49	7 October	0725	9
40	70°18'	166°57'	45	7 October	1225	22
43	70°30'	168°26'	44	8 October	0715	15
44	70°11'	168°56'	34	8 October	1215	15
49	69°48'	168°05'	45	9 October	0725	16
50	69°38'	167°44'	44	9 October	1420	16
54[4/]	69°24'	167°15'	42	10 October	0505	24
55[4/]	69°13'	166°52'	38	10 October	1230	29
60	68°57'	166°25'	35	11 October	1050	12
62	69°06'	166°02'	25	12 October	0740	13
63	69°14'	165°56'	32	12 October	1135	10
64	69°25'	166°29'	36	12 October	1455	23
69	69°50'	167°23'	44	13 October	0935	13
72	69°19'	165°11'	27	14 October	0910	7
73	69°33'	164°37'	24	14 October	1420	10
78	69°27'	165°38'	30	15 October	0840	11
85	69°13'	164°45'	20	16 October	0715	8
86	69°05'	165°05'	20	16 October	1100	6
87	69°04'	165°36'	20	16 October	1415	9
90	68°54'	166°40'	42	17 October	0705	12
91	68°54'	167°24'	44	17 October	1310	13

[1/]One pair of samples was taken at each station; the time of the start of the first sample is given.

[2/]Includes categories not identified to genus or species.

[3/]Part of samples lost.

[4/]Qualitative phytoplankton samples also taken at this station.

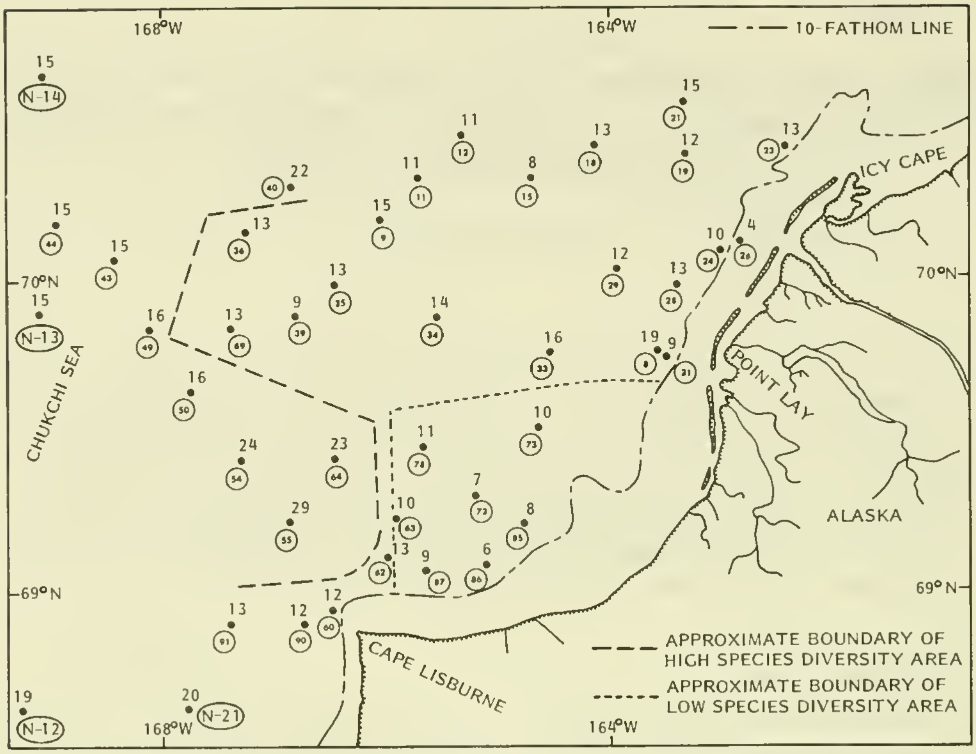

Figure 1.—Station locations (circled numbers) at which zooplankton samples were taken by the USCG icebreaker *Glacier* in 1970 and by the USS *Nereus* (prefix N) in 1947 and the number of species collected at each station (numbers without circles).

Glacier, 47 were for hydrographic casts; I was able to sample at 39 of those stations. At each station two samples were usually taken within 5 min of each other. All sampling was done with a 0.5-m diameter No. 0 (0.57 mm) mesh NorPac standard net. The net was lowered to 2 m from the bottom over depths of 18 to 51 m and was retrieved vertically at 40 m per min. The samples were preserved with 5% formaldehyde solution in plastic bags immediately after they were collected. Counts and identifications of zooplankters were done at the Auke Bay Fisheries Laboratory. No subsampling was required because the number of zooplankters in each sample was generally low (9-1,900). I did not make an extensive literature search for the most recent taxonomic revisions and was able to identify many of the larvae and even some of the adults only to phylum, class, or order (Table 2).

Biomass of the samples was not measured because weight measurements (wet or dry) and oxidation techniques would have made the specimen unfit for further taxonomic study; volumetric measurements were precluded by the large numbers and the large size variation of the hydromedusan *Aglantha digitale*.

I assumed a net efficiency of 100% and converted the catch data to numbers of zooplankton per 100 m^3 of water filtered. The coarse mesh (0.57 mm), short vertical tows, and absence of noticeable clogging by phytoplankton make the 100% assumption reasonable. The review of field and laboratory studies of the efficiencies of the plankton nets by Tranter and Smith (1968) indicates that the actual volume of water filtered by slowly pulled coarse mesh nets is no less than 95% of the theoretical.

The abundance of the eight most common zooplankters (*A. digitale, Clione limacina, Sagitta elegans, Acartia longiremis, Calanus finmarchicus, Centropages abdominalis, Eucalanus bungii, Pseudocalanus minutus*) and all calanoid copepods combined were examined for correlations with hydrographic conditions by comparing contour charts of levels of abundance of each species and total calanoid copepods with the contour plots of temperature, salinity, and dissolved oxygen from Ingham and Rutland (1972). Values of X^i ($X = 3, 4,$ or 6; $i = 1, 2, 3, \ldots m$) were used to assign levels of abundance of each group at each station. I contoured areas of absence and presence, and arbitrarily subdivided presence into five categories of abundance. Because a single scale of abundance could not be reasonably applied to all species, a separate scale based on maximum abundances recorded during the cruise was used for each species. To avoid subjective judgments, I used the power function to delimit abundance categories. This choice of power function was justified partially by the ease of computation and partially by the need to counter the effect of increasing variance with increasing means.

Table 2.--Numbers of zooplankters in the eastern Chukchi Sea, 26 September to 17 October 1970. Quantities are number per 100 m^3 of water filtered.

P indicates present but not counted. First and second sample at each station indicated by 1 and 2.

Zooplankter[1]	Number of stations at which found	Station number 8		9		11		12		15		18		19		21	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Aglantha digitale (O. F. Muller)	39	7,190	600	2,328	2,850	1,478	832	P	206	204	--	11,459	6,875	6,184	7,003	1,584	1,981
Melicertum octocostatum (M. Sars)	5	30	--	--	12	--	--	--	--	--	--	--	--	--	--	--	14
Obelia sp.	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aurelia aurita (Linneaus)[2]	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chrysaora melanaster Brandt[2]	2	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--
Cyanea capillata (Linneaus)[2]	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14
Ctenophora[3]	4	--	--	--	--	12	12	--	--	--	--	--	--	--	18	--	--
Nematoda	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bryozoa (cyphonautes)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (adults)	1	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (larvae)	31	60	--	73	36	--	--	--	--	13	--	--	--	36	18	28	14
Evadne nordmanni Loven	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Podon leuckarti G. O. Sars	4	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acartia longiremis (Lilljeborg)	26	60	--	--	12	--	12	--	24	13	--	--	--	36	18	--	28
Calanus finmarchicus (Gunnerus)	29	60	90	982	133	12	25	--	12	--	--	13	13	--	--	--	14
Calanus tonsus Brady	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Centropages abdominalis Sato	27	239	419	--	--	12	--	--	--	--	--	13	--	--	--	--	--
Derjuginia tolli (Linko)	5	--	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epilabodocera amphitrites (McMurrich)	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eucalanus bungii Giesbrecht	22	--	--	12	36	12	12	--	24	--	--	--	13	--	36	14	14
Eurytemora herdmani (Thompson & Scott)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metridia lucens Boeck	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Microcalanus sp.	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pseudocalanus minutus (Kroyer)	27	--	--	49	--	37	37	--	24	25	--	--	13	18	--	28	--
Tortanus discaudatus (Thompson & Scott)	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentified Calanoida (copepodites)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oithona helgolandica Claus	10	--	--	12	--	--	--	--	--	--	--	25	51	--	--	--	--
Copepoda-Harpacticoida	5	--	--	--	--	--	--	--	--	--	--	--	--	18	--	--	--
Copepoda (nauplii)	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Balanoids (nauplii)	25	90	--	--	--	--	--	--	--	--	--	25	13	--	--	--	--
Balanoids (cyprids)	10	--	--	--	--	--	--	--	24	--	--	--	--	--	18	14	--
Acanthomysis sp.	2	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mysis sp.	1	--	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cumacea	6	--	60	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epicaridea (cryptoniscids)	2	60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperia sp. (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperoche medusarum (Kroyer) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto libellula (Lichtenstein) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto pacifica Stebbing (juveniles)	6	--	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oedicerotidae (3-4 sp.)	6	90	150	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Phoxocephalidae	1	60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentified Gammaridea (3-4 sp.)	7	--	--	--	12	--	--	--	--	--	--	--	--	--	--	--	--
Thysanoessa inermis (Kroyer)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Thysanoessa raschii (M. Sars)	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	28
Thysanoessa sp. (larvae)	8	--	--	133	36	--	37	--	24	13	--	--	--	--	--	14	14
Pandalus goniurus Stimpson	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hippolytidae (zoeae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (zoeae)	6	--	--	--	--	25	--	--	--	--	--	--	--	18	--	--	--
Oxyrhyncha (megalopa)	20	30	30	24	49	37	12	--	--	--	--	64	51	--	18	--	--
Pagurus sp. (zoeae)	20	--	--	36	36	--	--	--	--	--	--	--	--	--	--	--	--
Pagurus sp. (glaucothoe)	12	--	--	--	--	--	--	--	12	--	--	--	--	--	--	--	--
Clione limacina (Phipps)	29	30	30	24	12	--	--	--	24	--	--	25	13	--	18	--	28
Spiratella helicina (Phipps)	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gastropoda (veligers)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lamellibranchia (veligers)	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sagitta elegans Verrill	30	60	120	146	73	118	50	P	121	25	--	13	13	--	--	57	28
Echinoidea (plutei)	16	--	--	24	24	12	--	--	--	13	--	25	51	73	146	57	85
Asteroidea (bipinnarias)	2	--	--	--	--	--	--	--	--	--	--	25	25	--	--	--	--
Fritillaria borealis Lohmann	16	--	--	--	--	--	--	--	--	76	--	204	229	673	655	42	127
Oikopleura vanhoeffeni Lohmann	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	28
Ascidacea (larvae)	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boreogadus saida (Lepechin) (juveniles)	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pleuronectes quadrituberculatus Pallas (larvae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Table 2.--Continued.

Zooplankter[1]	Number of stations at which found	23		24		26		28		29		31		33		34	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Aglantha digitale (O. F. Muller)	39	8,785	4,966	4,669	3,537	3,024	5,921	26,269	18,763	14,369	12,460	22,918	21,079	9,677	1,783	2,228	1,821
Melicertum octocostatum (M. Sars)	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Obelia sp.	4	--	--	--	--	--	--	P	P	--	--	--	--	--	--	--	--
Aurelia aurita (Linneaus)[2]	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chrysaora melanaster Brandt[2]	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyanea capillata (Linneaus)[2]	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ctenophora[3]	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13
Nematoda	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bryozoa (cyphonautes)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (adults)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (larvae)	31	76	25	--	28	--	32	2,680	1,608	127	164	28	57	68	51	25	25
Evadne nordmanni Loven	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Podon leuckarti G. O. Sars	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acartia longiremis (Lilljeborg)	26	25	76	28	--	--	64	--	54	--	--	--	--	16	--	--	--
Calanus finmarchicus (Gunnerus)	29	--	25	--	--	--	--	54	--	--	--	28	--	--	--	13	38
Calanus tonsus Brady	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Centropages abdominalis Sato	27	--	--	--	--	--	--	107	54	91	91	57	--	255	16	51	166
Derjuginia tolli (Linko)	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epilabidocera amphitrites (McMurrich)	8	--	--	--	--	--	--	--	--	--	18	--	--	--	--	--	--
Eucalanus bungii Giesbrecht	22	25	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--
Eurytemora herdmani (Thompson & Scott)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metridia lucens Boeck	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Microcalanus sp.	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pseudocalanus minutus (Kroyer)	27	25	--	28	--	--	--	--	27	18	--	--	--	--	--	--	--
Tortanus discaudatus (Thompson & Scott)	12	--	25	--	--	--	--	--	--	18	--	--	--	--	--	--	--
Unidentified Calanoida (copepodites)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oithona helgolandica Claus	10	--	--	--	--	--	--	751	509	--	--	--	--	--	--	--	13
Copepoda-Harpacticoida	5	--	--	--	--	--	--	27	--	--	--	--	--	--	--	--	--
Copepoda (nauplii)	4	--	--	--	--	--	--	P	P	P	P	--	--	--	--	--	--
Balanoids (nauplii)	25	--	--	--	--	--	--	80	54	18	18	141	--	272	102	--	38
Balanoids (cyprids)	10	25	--	--	--	--	--	27	--	--	--	--	--	--	--	--	--
Acanthomysis sp.	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mysis sp.	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cumacea	6	--	--	--	--	--	--	27	--	--	--	--	--	34	34	--	--
Epicaridea (cryptoniscids)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperia sp. (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperoche medusarum (Kroyer) (juveniles)	1	--	--	--	--	--	--	--	--	18	--	--	--	--	--	--	--
Parathemisto libellula (Lichtenstein) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto pacifica Stebbing (juveniles)	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13
Oedicerotidae (3-4 sp.)	6	--	--	--	--	--	--	--	--	--	--	--	--	119	68	--	--
Phoxocephalidae	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentified Gammaridea (3-4 sp.)	7	--	--	--	--	--	--	--	--	--	--	--	--	85	34	--	13
Thysanoessa inermis (Kroyer)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Thysanoessa raschii (M. Sars)	16	--	--	--	--	--	--	--	--	--	--	--	--	68	68	13	--
Thysanoessa sp. (larvae)	8	--	25	--	28	--	--	--	--	--	--	--	--	--	--	--	--
Pandalus goniurus Stimpson	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hippolytidae (zoeae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (zoeae)	6	51	--	--	28	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (megalopa)	20	--	76	85	85	--	--	--	--	--	55	--	28	85	68	38	140
Pagurus sp. (zoeae)	20	--	--	--	--	--	--	27	--	--	18	28	85	--	17	13	38
Pagurus sp. (glaucothoe)	12	--	--	28	--	32	--	--	--	--	--	--	--	--	34	13	--
Clione limacina (Phipps)	29	--	25	85	--	--	--	--	--	--	--	28	--	17	--	13	13
Spiratella helicina (Phipps)	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gastropoda (veligers)	1	--	--	--	--	--	--	P	P	--	--	--	--	--	--	--	--
Lamellibranchia (veligers)	7	--	--	--	--	--	--	P	P	P	P	--	--	--	--	--	--
Sagitta elegans Verrill	30	--	51	28	--	--	--	--	--	--	--	--	--	34	--	--	--
Echinoidea (plutei)	16	--	--	--	--	--	--	2,010	670	91	73	--	28	51	--	--	--
Asteroidea (bipinnarias)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fritillaria borealis Lohmann	16	509	357	85	57	--	32	590	384	55	146	--	--	17	--	--	--
Oikopleura vanhoeffeni Lohmann	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ascidacea (larvae)	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boreogadus saida (Lepechin) (juveniles)	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pleuronectes quadrituberculatus Pallas (larvae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Table 2.--Continued.

Zooplankter[1]	Number of stations at which found	Station number 35		36		39		40		43		44		49		50	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Aglantha digitale (O. F. Muller)	39	1,481	3,612	830	886	2,598	4,054	8,828	2,716	1,678	3,241	3,970	5,542	3,622	4,244	3,820	3,530
Melicertum octocostatum (M. Sars)	5	--	--	--	--	--	--	--	--	--	--	--	--	23	--	--	--
Obelia sp.	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aurelia aurita (Linneaus)[2]	2	--	--	--	--	--	10	--	--	12	--	--	--	--	--	--	--
Chrysaora melanaster Brandt[2]	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyanea capillata (Linneaus)[2]	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ctenophora[3]	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nematoda	1	--	--	--	--	--	--	34	--	--	--	--	--	--	--	--	--
Bryozoa (cyphonautes)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (adults)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (larvae)	31	24	83	11	11	--	--	91	45	35	12	--	15	11	34	93	139
Evadne nordmanni Loven	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Podon leuckarti G. O. Sars	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acartia longiremis (Lilljeborg)	26	--	--	--	--	--	--	11	45	35	--	75	15	23	--	12	23
Calanus finmarchicus (Gunnerus)	29	83	107	100	78	--	--	57	11	81	46	195	210	--	45	23	116
Calanus tonsus Brady	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Centropages abdominalis Sato	27	107	12	11	--	10	31	11	11	--	--	--	30	124	34	58	139
Derjuginia tolli (Linko)	5	--	--	--	--	--	--	23	34	--	--	--	--	--	--	--	--
Epilabodocera amphitrites (McMurrich)	8	--	--	--	--	--	10	--	--	--	--	--	--	--	--	23	58
Eucalanus bungii Giesbrecht	22	--	--	55	44	--	--	23	11	127	93	75	--	11	--	12	23
Eurytemora herdmani (Thompson & Scott)	1	--	--	--	--	--	--	--	11	--	--	--	--	--	--	--	--
Metridia lucens Boeck	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Microcalanus sp.	3	--	--	--	11	--	--	--	--	--	--	--	--	--	--	--	--
Pseudocalanus minutus (Kroyer)	27	--	--	--	--	--	--	11	23	--	12	30	90	23	--	12	--
Tortanus discaudatus (Thompson & Scott)	12	--	24	--	--	10	--	--	--	--	--	--	--	23	11	23	12
Unidentified Calanoida (copepodites)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oithona helgolandica Claus	10	--	--	--	--	--	--	23	11	35	--	15	--	--	--	--	--
Copepoda-Harpacticoida	5	--	--	--	--	--	--	11	11	--	--	--	--	--	--	--	--
Copepoda (nauplii)	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Balanoids (nauplii)	25	59	36	--	--	10	83	11	34	12	12	--	--	57	68	--	486
Balanoids (cyprids)	10	--	--	--	--	--	--	23	11	--	--	--	--	--	--	--	--
Acanthomysis sp.	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mysis sp.	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cumacea	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epicaridea (cryptoniscids)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperia sp. (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	11	--	--	--
Hyperoche medusarum (Kroyer) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto libellula (Lichtenstein) (juveniles)	1	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto pacifica Stebbing (juveniles)	6	--	--	--	--	--	--	--	--	--	--	--	--	11	--	--	--
Oediceroticae (3-4 sp.)	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Phoxocephalidae	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentified Gammaridea (3-4 sp.)	7	--	--	--	--	--	--	--	--	--	12	--	--	--	--	--	--
Thysanoessa inermis (Kroyer)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Thysanoessa raschii (M. Sars)	16	12	--	11	--	--	--	11	34	--	--	449	255	11	--	23	--
Thysanoessa sp. (larvae)	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pandalus goniurus Stimpson	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hippolytidae (zoeae)	1	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (zoeae)	6	--	--	--	--	--	--	--	--	23	12	--	15	--	--	--	--
Oxyrhyncha (megalopa)	20	--	47	11	11	31	187	34	34	150	208	105	15	--	--	12	--
Pagurus sp. (zoeae)	20	12	--	33	--	42	114	--	11	12	35	30	15	34	--	--	--
Pagurus sp. (glaucothoe)	12	12	--	--	--	--	--	--	--	--	--	--	--	11	--	--	--
Clione limacina (Phipps)	29	24	47	22	22	10	21	23	11	12	46	30	--	11	11	--	12
Spiratella helicina (Phipps)	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	93
Gastropoda (veligers)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lamellibranchia (veligers)	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sagitta elegans Verrill	30	--	12	33	100	--	--	45	68	58	93	30	45	11	79	637	1,146
Echinoidea (plutei)	16	--	--	--	11	--	--	113	11	--	--	15	60	--	--	--	--
Asteroidea (bipinnarias)	2	--	--	--	--	--	--	11	--	--	--	--	--	--	--	--	--
Fritillaria borealis Lohmann	16	--	--	11	--	--	--	1,754	170	35	58	300	45	--	--	--	--
Oikopleura vanhoeffeni Lohmann	5	--	--	--	--	--	--	11	--	--	--	--	--	--	--	--	35
Ascidacea (larvae)	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boreogadus saida (Lepechin) (juveniles)	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pleuronectes quadrituberculatus Pallas (larvae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Table 2.--Continued.

Zooplankter[1]	Number of stations at which found	Station number 54		55		60		62		63		64		69		72	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Aglantha digitale (O. F. Muller)	39	2,425	4,244	15,145	11,928	3,783	3,638	957	2,241	3,501	1,846	3,183	2,617	6,019	4,804	1,320	1,000
Melicertum octocostatum (M. Sars)	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Obelia sp.	4	--	121	54	13	--	--	--	--	--	--	--	--	--	--	--	--
Aurelia aurita (Linneaus)[2]	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chrysaora melanaster Brandt[2]	2	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyanea capillata (Linneaus)[2]	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ctenophora[3]	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nematoda	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bryozoa (cyphonautes)	1	--	--	P	P	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (adults)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (larvae)	31	12	146	1,514	630	--	--	--	--	48	48	14	--	35	--	38	19
Evadne nordmanni Loven	3	--	24	94	--	15	--	--	--	--	--	--	--	--	--	--	--
Podon leuckarti G. O. Sars	4	--	--	228	121	--	--	--	--	--	--	--	--	--	--	--	--
Acartia longiremis (Lilljeborg)	26	--	12	134	13	29	--	--	--	--	--	--	14	--	--	--	--
Calanus finmarchicus (Gunnerus)	29	1,031	2,959	1,649	1,086	3,201	1,397	41	--	--	--	141	552	--	12	--	--
Calanus tonsus Brady	1	--	--	--	--	--	--	--	--	--	--	--	28	--	--	--	--
Centropages abdominalis Sato	27	36	412	442	362	73	175	102	81	48	16	368	382	139	93	--	19
Derjuginia tolli (Linko)	5	--	--	--	--	--	--	--	20	--	--	--	--	--	--	--	--
Epilabodocera amphitrites (McMurrich)	8	--	--	13	--	--	--	--	--	--	--	14	14	12	--	--	--
Eucalanus bungii Giesbrecht	22	146	958	576	710	87	29	--	--	--	--	42	28	--	12	--	--
Eurytemora herdmani (Thompson & Scott)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metridia lucens Boeck	2	36	182	27	13	--	--	--	--	--	--	--	--	--	--	--	--
Microcalanus sp.	3	--	--	402	80	--	--	--	--	--	--	--	--	--	--	--	--
Pseudocalanus minutus (Kroyer)	27	85	558	536	322	146	73	--	--	--	--	--	14	--	--	--	19
Tortanus discaudatus (Thompson & Scott)	12	--	--	27	54	--	--	41	41	--	16	42	71	--	12	--	--
Unidentified Calanoida (copepodites)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19
Oithona helgolandica Claus	10	--	49	268	40	--	--	--	--	--	--	--	--	12	--	--	--
Copepoda-Harpacticoida	5	P	P	13	--	--	--	--	--	--	--	--	--	--	--	--	--
Copepoda (nauplii)	4	P	P	P	P	--	--	--	--	--	--	--	--	--	--	--	--
Balanoids (nauplii)	25	12	206	2,037	1,086	--	116	41	102	16	--	17	22	81	58	--	19
Balanoids (cyprids)	10	--	24	--	27	--	--	--	--	--	--	--	--	--	--	--	--
Acanthomysis sp.	2	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--
Mysis sp.	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cumacea	6	--	24	--	--	--	--	20	--	--	--	--	--	--	--	--	--
Epicaridea (cryptoniscids)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperia sp. (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperoche medusarum (Kroyer) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto libellula (Lichtenstein) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto pacifica Stebbing (juveniles)	6	--	24	13	--	--	--	--	--	--	--	--	3	--	--	--	--
Oedicerotidae (3-4 sp.)	6	12	--	13	--	--	--	--	20	--	--	3	--	--	--	--	--
Phoxocephalidae	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentified Gammaridea (3-4 sp.)	7	--	--	--	--	--	--	--	20	16	--	--	--	--	--	--	--
Thysanoessa inermis (Kroyer)	2	--	--	--	--	--	--	20	--	--	--	3	--	--	--	--	--
Thysanoessa raschii (M. Sars)	16	194	255	27	--	--	15	--	--	--	--	8	3	--	--	--	--
Thysanoessa sp. (larvae)	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pandalus goniurus Stimpson	1	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--
Hippolytidae (zoeae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (zoeae)	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (megalopa)	20	--	--	13	--	--	--	--	--	--	--	--	--	35	46	--	--
Pagurus sp. (zoeae)	20	24	12	13	27	--	15	--	--	--	16	3	3	--	--	--	--
Pagurus sp. (glaucothoe)	12	--	12	13	--	--	--	--	--	--	48	3	--	46	23	--	--
Clione limacina (Phipps)	29	12	12	13	27	--	--	41	20	16	605	8	--	--	--	19	--
Spiratella helicina (Phipps)	8	376	691	804	777	--	29	20	20	--	--	6	6	23	--	--	--
Gastropoda (veligers)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lamellibranchia (veligers)	7	P	P	P	P	--	--	41	20	16	--	3	--	--	--	--	--
Sagitta elegans Verrill	30	424	1,419	911	563	1,016	393	41	61	48	111	64	133	46	12	--	--
Echinoidea (plutei)	16	--	243	268	322	--	--	--	--	--	--	--	--	--	--	--	--
Asteroidea (bipinnarias)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fritillaria borealis Lohmann	16	--	36	--	13	--	--	--	--	--	--	--	--	--	--	--	--
Oikopleura vanhoeffeni Lohmann	5	--	--	27	--	--	--	--	--	--	--	--	--	--	--	--	--
Ascidacea (larvae)	3	--	24	27	--	--	--	--	--	--	--	3	--	--	--	--	--
Boreogadus saida (Lepechin) (juveniles)	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pleuronectes quadrituberculatus Pallas (larvae)	1	--	--	--	--	--	--	--	20	--	--	--	--	--	--	--	--

See footnotes at end of table.

Table 2.--Continued.

Zooplankter[1]	Number of stations at which found	Station number 73		78		85		86		87		90		91	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2
Aglantha digitale (O. F. Muller)	39	382	21	2,122	1,392	1,273	509	--	840	622	1,146	2,365	2,910	P	P
Melicertum octocostatum (M. Sars)	5	--	--	--	--	--	--	--	--	--	--	12	--	--	--
Obelia sp.	4	--	--	--	--	--	--	--	--	--	--	--	12	--	--
Aurelia aurita (Linneaus)[2]	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chrysaora melanaster Brandt[2]	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyanea capillata (Linneaus)[2]	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ctenophora[3]	4	21	--	--	--	--	--	--	--	--	--	--	--	--	--
Nematoda	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bryozoa (cyphonautes)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (adults)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polychaeta (larvae)	31	--	21	17	17	25	--	--	--	25	25	728	485	--	--
Evadne nordmanni Loven	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Podon leuckarti G. O. Sars	4	--	--	--	--	--	--	--	--	--	--	--	12	12	--
Acartia longiremis (Lilljeborg)	26	21	--	--	--	25	--	51	--	--	--	497	388	23	--
Calanus finmarchicus (Gunnerus)	29	85	318	--	51	127	25	25	25	--	--	606	303	405	370
Calanus tonsus Brady	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Centropages abdominalis Sato	27	--	--	17	--	--	--	--	--	--	25	36	61	197	81
Derjuginia tolli (Linko)	5	--	--	17	34	--	--	--	--	25	51	--	--	--	--
Epilabodocera amphitrites (McMurrich)	8	--	--	--	--	--	--	--	--	--	--	12	24	--	12
Eucalanus bungii Giesbrecht	22	21	--	17	--	--	--	--	--	--	--	--	--	--	12
Eurytemora herdmani (Thompson & Scott)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metridia lucens Boeck	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Microcalanus sp.	3	--	--	--	--	--	--	--	--	--	--	12	--	--	--
Pseudocalanus minutus (Kroyer)	27	21	--	17	34	102	--	25	--	--	51	49	12	--	--
Tortanus discaudatus (Thompson & Scott)	12	--	--	--	--	--	--	--	--	--	--	121	97	--	--
Unidentified Calanoida (copepodites)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oithona helgolandica Claus	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Copepoda-Harpacticoida	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Copepoda (nauplii)	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Balanoids (nauplii)	25	--	--	--	--	--	--	25	--	25	--	61	206	116	116
Balanoids (cyprids)	10	--	--	--	--	--	25	--	--	--	--	--	--	--	12
Acanthomysis sp.	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mysis sp.	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cumacea	6	--	--	--	--	--	--	--	--	--	--	12	--	--	--
Epicaridea (cryptoniscids)	2	--	--	--	--	--	--	--	--	--	--	12	--	--	--
Hyperia sp. (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyperoche medusarum (Kroyer) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto libellula (Lichtenstein) (juveniles)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parathemisto pacifica Stebbing (juveniles)	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oedicerotidae (3-4 sp.)	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Phoxocephalidae	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentified Gammaridea (3-4 sp.)	7	--	--	--	--	--	--	--	--	--	--	12	--	--	--
Thysanoessa inermis (Kroyer)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Thysanoessa raschii (M. Sars)	16	--	21	--	17	--	25	--	--	--	--	--	--	--	--
Thysanoessa sp. (larvae)	8	--	--	--	--	--	--	--	--	--	--	--	--	12	12
Pandalus goniurus Stimpson	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hippolytidae (zoeae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (zoeae)	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oxyrhyncha (megalopa)	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pagurus sp. (zoeae)	20	--	--	--	--	--	--	--	--	--	--	--	12	--	12
Pagurus sp. (glaucothoe)	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clione limacina (Phipps)	29	--	42	--	17	--	--	--	--	25	--	--	--	--	12
Spiratella helicina (Phipps)	8	--	--	--	--	--	--	--	--	--	--	--	--	12	--
Gastropoda (veligers)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lamellibranchia (veligers)	7	--	--	--	--	--	--	--	--	--	--	--	---	--	--
Sagitta elegans Verrill	30	85	64	119	238	229	102	102	255	178	102	388	182	--	--
Echinoidea (plutei)	16	--	--	--	--	--	--	--	--	--	--	24	49	--	--
Asteroidea (bipinnarias)	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fritillaria borealis Lohmann	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oikopleura vanhoeffeni Lohmann	5	--	--	51	--	--	--	--	--	--	--	--	--	--	--
Ascidacea (larvae)	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boreogadus saida (Lepechin) (juveniles)	7	--	--	--	--	--	--	--	--	--	25	--	--	--	--
Pleuronectes quadrituberculatus Pallas (larvae)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--

[1] *Staurophora mertensi* Brandt was frequently seen but not taken in any of the samples.

[2] Seen more often than taken in samples.

[3] All specimens too damaged for species identification.

ABUNDANCE AND DISTRIBUTION OF ZOOPLANKTON

Sixty-three categories of zooplankton, including separate larval stages for some species, were identified in the samples from the 39 stations (Table 2). Among the categories, 18 occurred at only one station each and 12 occurred at more than half of the stations (Table 2). The number of categories identified at each station varied from 6 at station 86 to 29 at station 55; the average number of species per station was 13 (Table 1, Fig. 1). In general, the stations with the greatest number of species were northwest of Cape Lisburne and those with the least were between Cape Lisburne and Point Lay.

The numbers of individuals in each category at each station varied greatly (Table 2). I calculated the average number for the two samples at each station for the purpose of comparing abundance of the categories. *Aglantha digitale* was the predominant zooplankter and the only one that occurred at all of the stations. The average number per 100 m^3 (i.e., the average of the two samples) among the stations ranged from 200 to 22,516. Calanoid copepods, the second most abundant zooplankters, ranged from 27 to 3,146 per 100 m^3. *Calanus finmarchicus* was the most abundant calanoid (up to 2,299 per 100 m^3) and also occurred the most frequently (29 stations). Larvae of polychaetes, barnacles, oxyrhynchid crabs, hermit crabs, and sea urchins in aggregate were more abundant than calanoid copepods at 18 stations. The large proportion of meroplankton to the total zooplankton is characteristic of the shallow areas of the eastern Chukchi Sea (Johnson, 1956).

Even though two samples were available from most stations, no rigorous statistical comparisons were made between samples or stations because of the low counts and the high frequency of zero counts in the samples. Frequently one sample of a pair would have a raw count four times or more the count of its mate. The extreme case was station 63 where one sample contained a single *Clione limacina* and its mate contained 38. The presence of one or more individuals of a species in one sample of a pair was often accompanied by the absence of individuals in the other sample. Extreme cases of absence and presence were 0 and 32 *Aglantha digitale* in the samples from station 86 and 0 and 20 plutei of Echinoidea in the samples from station 54.

RELATIONSHIPS BETWEEN ZOOPLANKTON AND CHARACTERISTICS OF WATER

The distribution and abundance of zooplankton are in part dependent on characteristics of the water before and at the time of sampling. In discussing the distribution and abundance of species within the area covered by the *Glacier*, it must be remembered that the survey was extended over a month; during this time marked chemical and physical changes in the water were caused by surface freezing, wind mixing, and the southward movement of the ice front (Ingham and Rutland, 1972). Despite the extended period, comparison of the contours of plankton abundance (Fig. 2 to 10) with contour plots of temperature, salinity, and dissolved oxygen (Fig. 11 to 13) are useful for an understanding of the area.

The similarity of the density distributions of zooplankters in the nine categories (Fig. 2 to 10) selected for comparison suggests that the abundance of all except *Acartia longiremis* (Fig. 5) were being influenced by a common set of environmental factors. The area appeared to be subdivided into three parts: a west area (stations 40-60, 64, 90, and 91), a north area (stations 8-39 and 69), and a south area (stations 62, 63, and 72-87). To test the reality of this subdivision, I computed means and variances for each area from the station means. The variances were high and increased as the means increased, which indicated that the data were not normally distributed and required transformation. Plots of variances and standard deviations against the means indicated that the square root transformation ($X' = \sqrt{X + 0.5}$) could be used. The original means and transformed data are given in Table 3.

The square root transformation did not fully normalize the data but did reduce variances enough for me to test for differences of means and variances among the three areas. To test for equality of transformed means (Table 4), I used either a t-test assuming equal variance or a t'-test assuming unequal variance (Ostle, 1963). The choice of whether to use the t-test or the t'-test depended on the results of an F-test for equality of variances (Ostle, 1963) (Table 5). The 0.05 level of significance was used in all cases to accept or reject the assumptions of equal means or variances. Although they were not always statistically different, the higher variances were usually associated with the higher means. Because the north and south areas appeared to have equivalent means but differing variances in several cases, I combined the north and south areas into an east area for further testing against the west area (Tables 4 and 5).

Aglantha digitale (Fig. 2) was least dense in the south area and had significantly higher variance in the north area than in either the west or south areas. *Sagitta elegans* (Fig. 3) had significantly different mean densities in all three areas; the west was highest and the north lowest.

Clione limacina (Fig. 4) was the only species in which no statistical difference among means was found. The variance about the mean was highest in the south area because of the exceptionally high count of juveniles at station 63. Deleting station 63 from the statistics left the north area separable from the other areas by reason of higher variance (Table 5).

The mean density of *Acartia longiremis* in the south area was significantly lower than in the west area but not lower than in the north area. The variance for the

Table 3.--Means, transformed means, and standard deviation and 0.95 confidence limits of transformed means of the density of zooplankters in three areas[1] of the eastern Chukchi Sea, September-October 1970.

Zooplankter, area, and number of stations (in parentheses)	Mean (number per 100 m^3)[2]	Transformed mean ($\overline{\sqrt{X + 0.5}}$)	Standard deviation of $\sqrt{X + 0.5}$	0.95 confidence limits of transformed mean	
				Lower limit	Upper limit
Aglantha digitale					
West (18)	4,492	64.32	19.85	50.12	78.52
North (20)	6,577	71.21	39.82	52.57	89.85
South (8)	1,218	33.12	11.76	23.29	42.96
Sagitta elegans					
West (10)	424	18.24	10.07	11.04	25.45
North (20)	32	4.49	3.58	2.81	6.17
South (8)	100	9.26	4.10	5.83	12.68
Clione limacina					
West (11)	12	3.28	1.53	2.25	4.30
North (20)	14	3.30	1.93	2.40	4.21
South (8)	48	4.82	5.38	0.32	9.32
South (7)[3]	15	3.78	0.96	2.89	4.67
Acartia longiremis					
West (11)	60	5.97	5.24	2.28	9.67
North (20)	13	2.98	2.18	1.96	4.00
South (8)	6	1.92	1.75	0.45	3.39
Calanus finmarchicus					
West (11)	646	20.73	15.44	10.36	31.11
North (20)	47	4.52	5.31	2.03	7.01
South (8)	43	4.95	4.68	1.04	8.86
Centropages abdominalis					
West (11)	130	9.90	6.01	5.87	13.94
North (20)	48	4.98	5.04	2.62	7.34
South (8)	19	3.35	3.03	0.81	5.88
South (7)[4]	9	2.47	1.87	0.74	4.19
Eucalanus bungii					
West (11)	129	8.07	8.40	2.43	13.72
North (20)	9	2.37	1.97	1.45	3.29
South (8)	1	1.02	0.90	0.27	1.77
Pseudocalanus minutus)					
West (11)	90	7.22	6.50	2.85	11.59
North (20)	9	2.47	1.96	1.55	3.37
South (8)	16	3.55	2.19	1.73	5.39
Total calanoids					
West (11)	1,109	28.68	17.77	16.74	40.62
North (20)	131	10.39	4.97	8.06	12.72
South (8)	98	9.40	3.47	6.49	12.30

[1] West area includes stations 40 to 60, 64, 90, and 91; north area stations 8 to 39 and 69; and south area stations 62, 63, and 72 to 87.

[2] Rounded to the nearest whole number.

[3] Excluding station 63.

[4] Excluding station 62.

Table 4.--Values of t from tests for equality of transformed means ($\bar{X}' = \sqrt{X + 0.5}$) of density of zooplankters in four areas of the eastern Chukchi Sea, September-October 1970.

Zooplankter	Areas compared: West-South	West-North	West-East[1]	North-South
Aglantha digitale	3.915*	0.632	0.185	3.876*
Sagitta elegans	2.569*	4.187*	3.706*	3.051*
Clione limacina	0.789	0.037	0.578	0.778
C. limacina (excluding station 63)	0.771	--	0.262	0.842
Acartia longiremis	2.378*	1.807	2.021	1.227
Calanus finmarchicus	3.196*	3.376*	3.387*	0.200
Centropages abdominalis	3.114*	2.432*	3.033*	0.851
C. abdominalis (excluding station 62)	3.826*	--	3.122*	1.891
Eucalanus bungii	2.761*	2.217	2.380*	2.489*
Pseudocalanus minutus	1.737	2.366*	2.222*	0.368
Total calanoids	3.508*	3.342*	3.423*	0.514

[1] East equals north and south areas combined.

*t or t' equals difference of means significant at P = 0.05.

Table 5.--Values of F from tests for equality of variances using transformed data ($X' = \sqrt{X + 0.5}$) for density of zooplankters in four areas of the eastern Chukchi Sea, September-October 1970.

Zooplankter	Areas compared: West-South	West-North	West-East[1]	North-South
Aglantha digitale	2.85	4.02**	3.475**	11.47***
Sagitta elegans	6.03***	7.89***	5.78***	1.31
Clione limacina	12.44***	1.60	4.56***	7.78***
C. limacina (excluding station 63)	2.52	--	4.68***	4.02*
Acartia longiremis	8.95***	5.81***	6.296**	1.54
Calanus finmarchicus	10.90***	8.44***	9.315***	1.29
Centropages abdominalis	3.93*	1.42	1.735	2.76
C. abdominalis (excluding station 62)	10.36***	--	1.752	7.28***
Eucalanus bungii	87.99***	18.26***	21.302***	4.82**
Pseudocalanus minutus	8.80***	10.98***	10.051***	1.25
Total calanoids	26.20***	12.80***	15.256***	2.05

[1] East equals north and south areas combined.

*P = 0.05.

**P = 0.025.

***P = 0.010.

north and south areas separately and combined were significantly lower than for the west area, although the mean of the two areas (11 per 100 m³ for 28 stations) did not differ significantly from the mean for the west area (60 per 100 m³ for 11 stations). The density contours of *A. longiremis* (Fig. 5) tend to run more strongly north-south than the contours for the other species. Although the west-north and west-east differences of means were not statistically significant, the differences are probably real.

The mean densities and variances of *Calanus finmarchicus* and *Centropages abdominalis* were significantly higher in the west area than in the north and south areas. The separation of north and south areas was not statistically significant for either *C.*

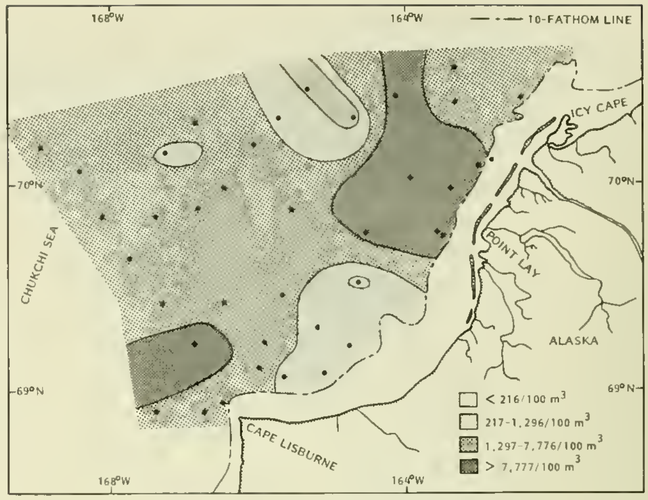

Figure 2.—Abundance of the hydromedusan *Aglantha digitale* contoured in powers of 6 per 100 m³.

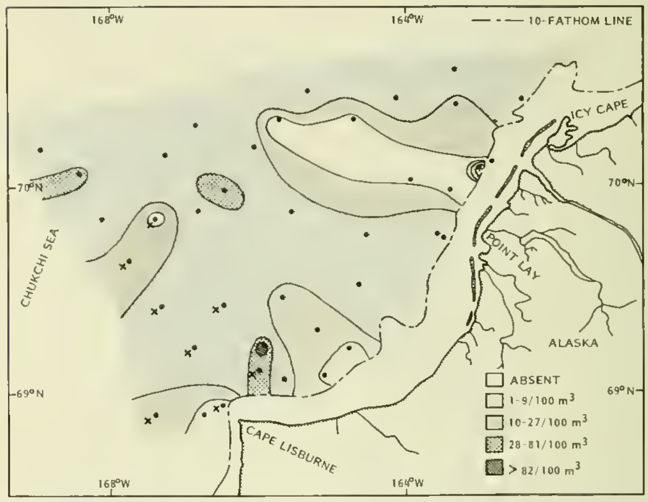

Figure 3.—Abundance of chaetognath *Sagitta elegans* contoured in powers of 3 per 100 m³.

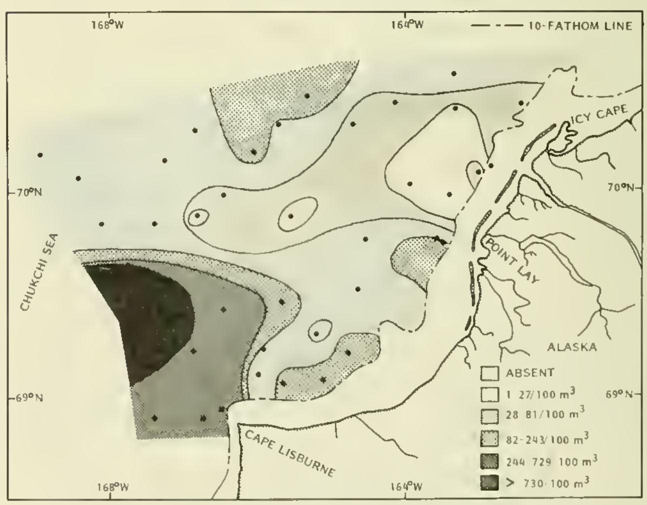

Figure 4.—Abundance of pteropod *Clione limacina* contoured in powers of 3 per 100 m³. Presence of *Spiratella limacina* indicated by X.

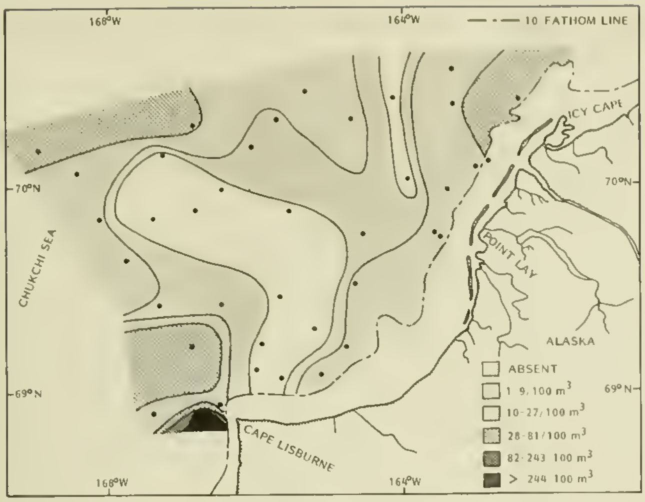

Figure 5.—Abundance of the copepod *Acartia longiremis* contoured in powers of 3 per 100 m³.

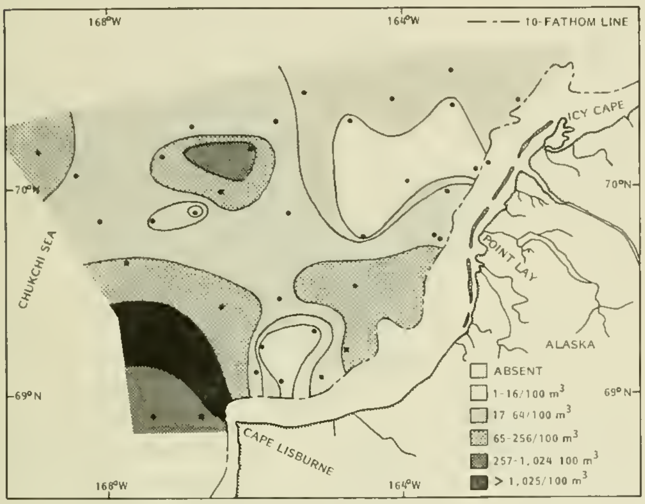

Figure 6.—Abundance of the copepod *Calanus finmarchicus* contoured in powers of 4 per 100 m³.

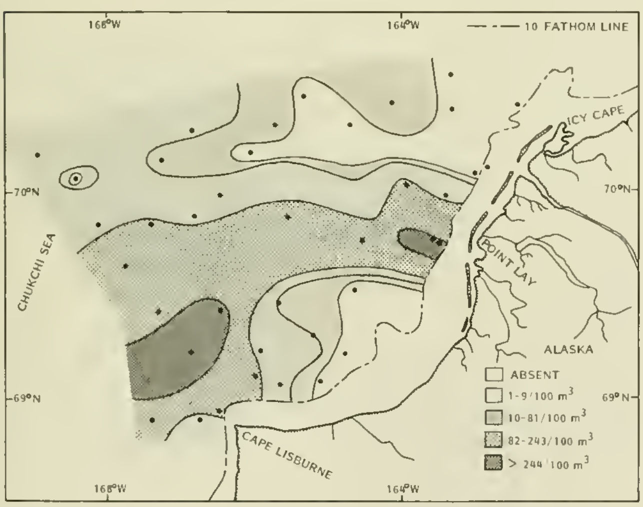

Figure 7.—Abundance of the copepod *Centropages abdominalis* contoured in powers of 3 per 100 m³.

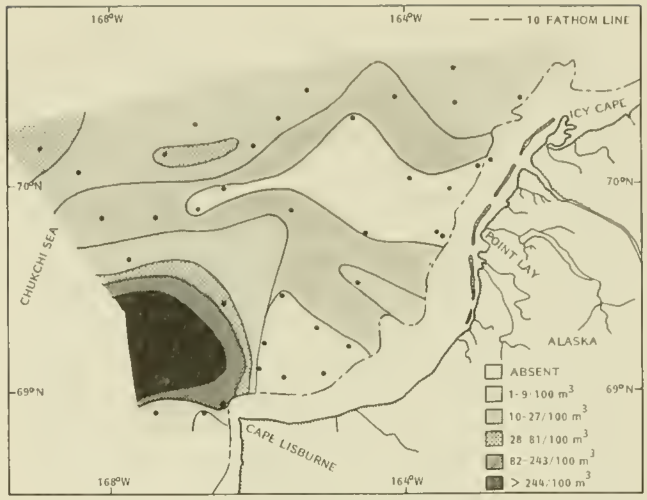

Figure 8.—Abundance of the copepod *Eucalanus bungii* contoured in powers of 3 per 100 m³.

Figure 9.—Abundance of the copepod *Pseudocalanus minutus* contoured in powers of 3 per 100 m³.

finmarchicus or *C. abdominalis*, but the density contours (Fig. 6, 7) show that the portions of each area having zero counts were separated by a band of moderate density along the probable boundary of the north and south areas. *Eucalanus bungii* (Fig. 8) had a similar density distribution, in which statistically significant differences were found between means of the south area and the west and north areas but not between the west and north areas. However, the difference in the mean for *E. bungii* in the west and north areas is quite large ($t' = 2.217$ vs. $t'_{0.975} = 2.224$), and the difference of variance is significant ($F = 18.26$ vs. $F_{0.9995} = 8.14$). *Pseudocalanus minutus* varied from the other calanoid copepods in that the higher mean density for the west area (90 per 100 m³) was not statistically different from that for the south area (16 per 100 m³) but did differ from that for the north area (9 per 100 m³). The density contours of *P. minutus* (Fig. 9) show a broad area of absences and low abundance in the lower half of the north area, compared with a very narrow band of absences or low abundance on the western margin of the south area.

Contouring and testing the density of all calanoid copepods as one group obscures much detail but does indicate major patterns (Fig. 10). The west area was statistically separable from the north and south areas because of the high abundance in the lower half of the west area. The north and south areas were not statistically separable and were characterized by generally few calanoids. Lowest abundances in the north area were in the northeast sequences of stations, considerably off center from the areas of lowest abundance for the individual species contoured. In the south area, the four stations of lowest total calanoid densities (stations 63, 72, 86, and 87) were the same stations contributing to the low mean densities of *Acartia longiremis*, *Calanus finmarchicus*, and *Eucalanus bungii*.

In general, the west area had significantly higher mean concentrations of zooplankters than the combined north and south areas except for *Aglantha digitale* and *Clione limacina*. Although not statistically separable, the difference between west and east concentrations of *Acartia longiremis* (Fig. 5) is probably real.

The north area had statistically higher mean densities of *Aglantha digitale* and *Eucalanus bungii* and lower mean density of *Sagitta elegans*. After deleting the exceptionally high count of *Centropages abdominalis* at station 62, the density of *C. abdominalis* was also statistically higher in the north than in the south area. Variances of *A. digitale*, *C. abdominalis*, and *E. bungii* were statistically higher in the north area than in the south area, as was the variance of *Clione limacina* after deletion of exceptionally high values from station 63. Although the differences were not always statistically significant, the north area had generally higher means and variances than the south area.

Figure 10.—Abundance of calanoid copepods (all species) contoured in powers of 4 per 100 m³.

Temperature

The contours of temperature (Fig. 11) resemble those of zooplankton abundance. The area enclosed by the 0°C contours between Cape Lisburne and Point Lay most closely approximates the area of lowest zooplankton diversity (Fig. 1) as well as areas of low abundance for *Aglantha*, *Clione*, *Centropages*, *Eucalanus*, *Pseudocalanus*, and total calanoid copepods (Fig. 2, 4, 7, 8, 9, 10). To the north, temperatures rise to over 3°C and then drop, forming a series of contours that parallel changes in abundance of these same five zooplankters, plus *Sagitta*, total calanoid copepods, and perhaps *Calanus*. The area northwest of Cape Lisburne generally has wider contour spacing of temperatures from 1° to 3°C and generally higher abundance of zooplankton. If temperature is the major physical factor controlling zooplankton abundance, areas with temperatures below 0°C or with strong horizontal gradients probably had a history of conditions (either too cold or unstable) that prevented development of large populations. The areas of broad temperature contours probably represent more stable conditions that would allow denser populations of zooplankton to develop.

Salinity

The distribution of zooplankton did not appear to be associated with salinity. The salinity contours (Fig. 12) did not correspond well with the zooplankton contours, particularly in the 10 m and bottom contours. Thus, although the nearshore stations were less saline than the offshore stations, these differences were not associated with differences in zooplankton abundance.

Dissolved Oxygen

The horizontal contours of dissolved oxygen concentration (Fig. 13), especially at the surface and 10-m depths, may be more indicative of recent physical processes and lowering temperatures than biological processes. Although there appears to be an inverse relationship between zooplankton abundance and oxygen concentration, comparison of zooplankton abundance with percent saturation of dissolved oxygen (Fig. 14) and theoretical oxygen depletion yielded no significant relationships. The cold-water area between Cape Lisburne and Point Lay had low zooplankton abundance and high oxygen concentrations. The stations northwest of Cape Lisburne had warmer waters, more zooplankton, and generally less oxygen. West of Point Lay, nearshore stations (where lowered salinity or increased wave action may have effected greater oxygen solution) had higher oxygen concentrations, whereas offshore stations had lower oxygen concentrations and moderately high populations of *Aglantha*

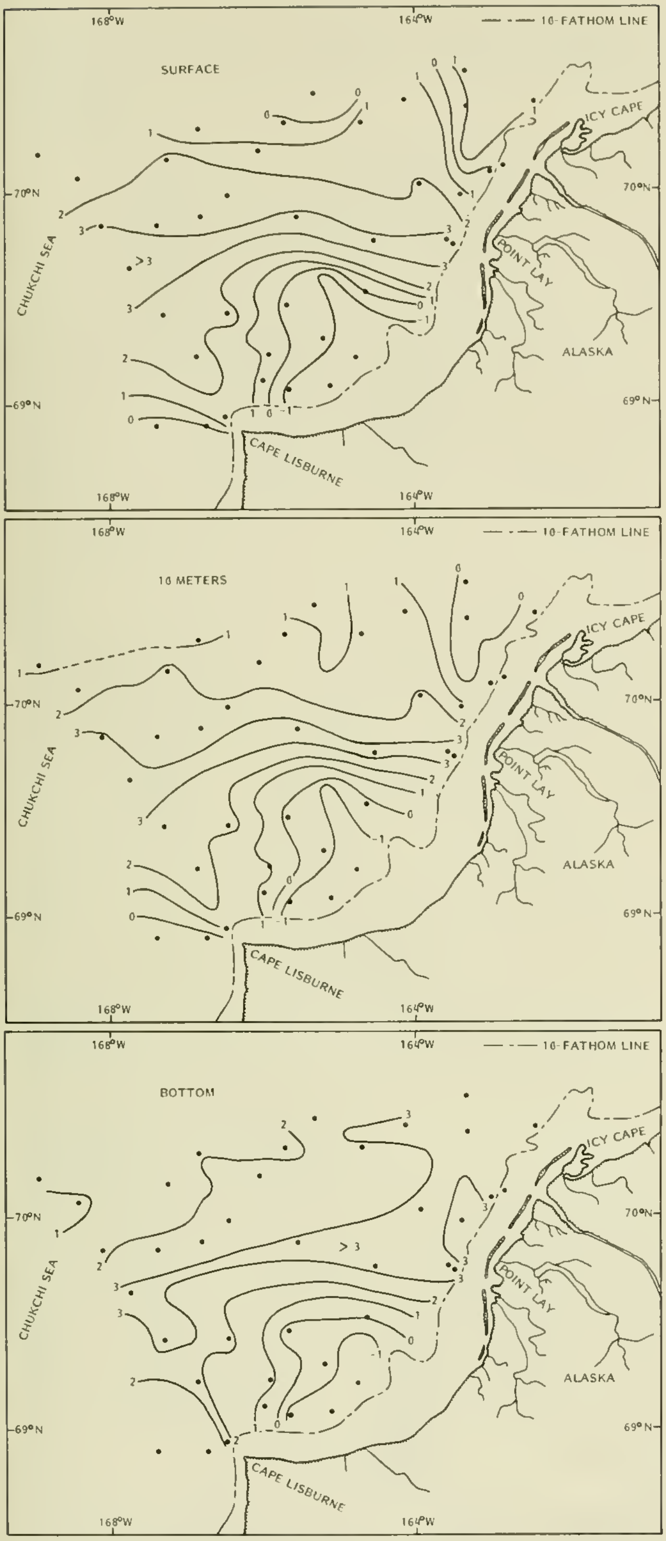

Figure 11.—Sea temperature distributions at surface, 10 m, and bottom, eastern Chukchi Sea off Cape Lisburne-Icy Cape, 25 September to 17 October 1970. Redrawn from Ingham and Rutland (1972).

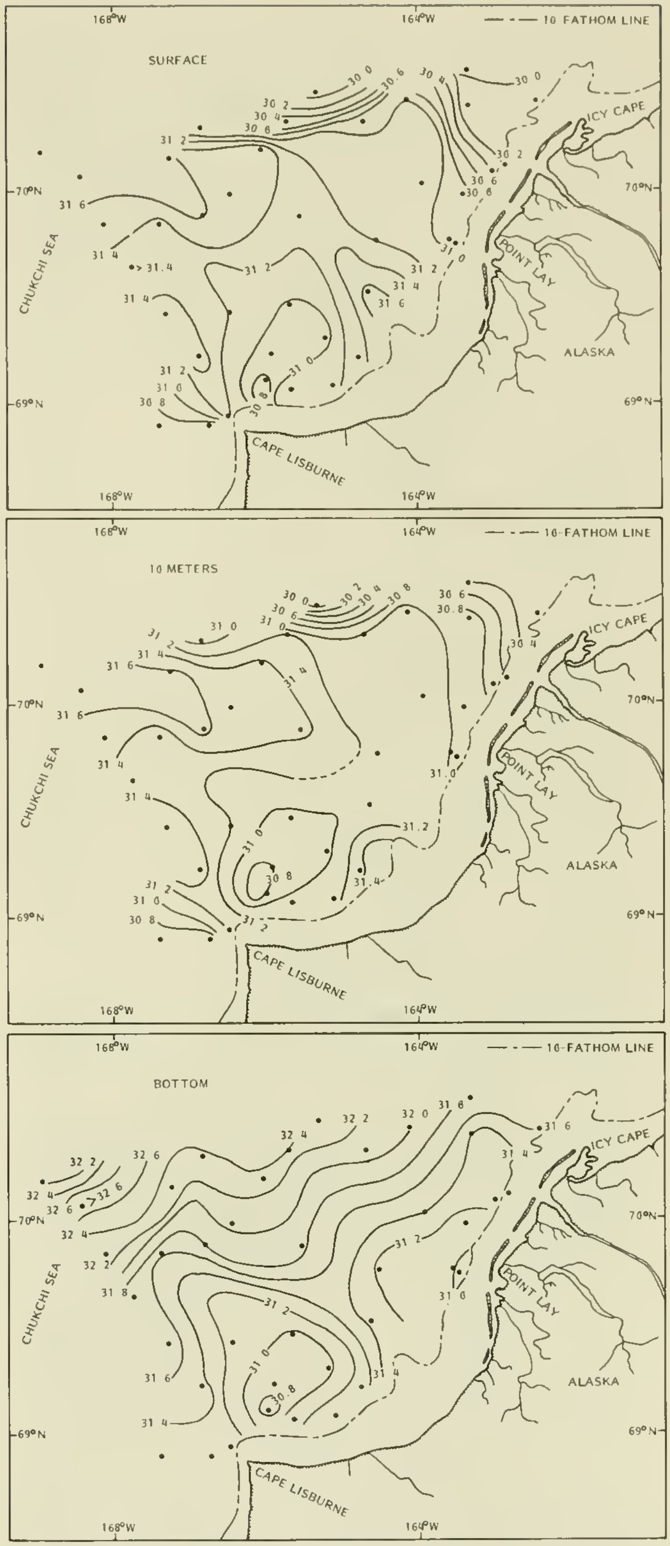

Figure 12.—Salinity distributions at surface, 10 m, and bottom, eastern Chukchi Sea off Cape Lisburne-Icy Cape, 25 September to 17 October 1970. Redrawn from Ingham and Rutland (1972).

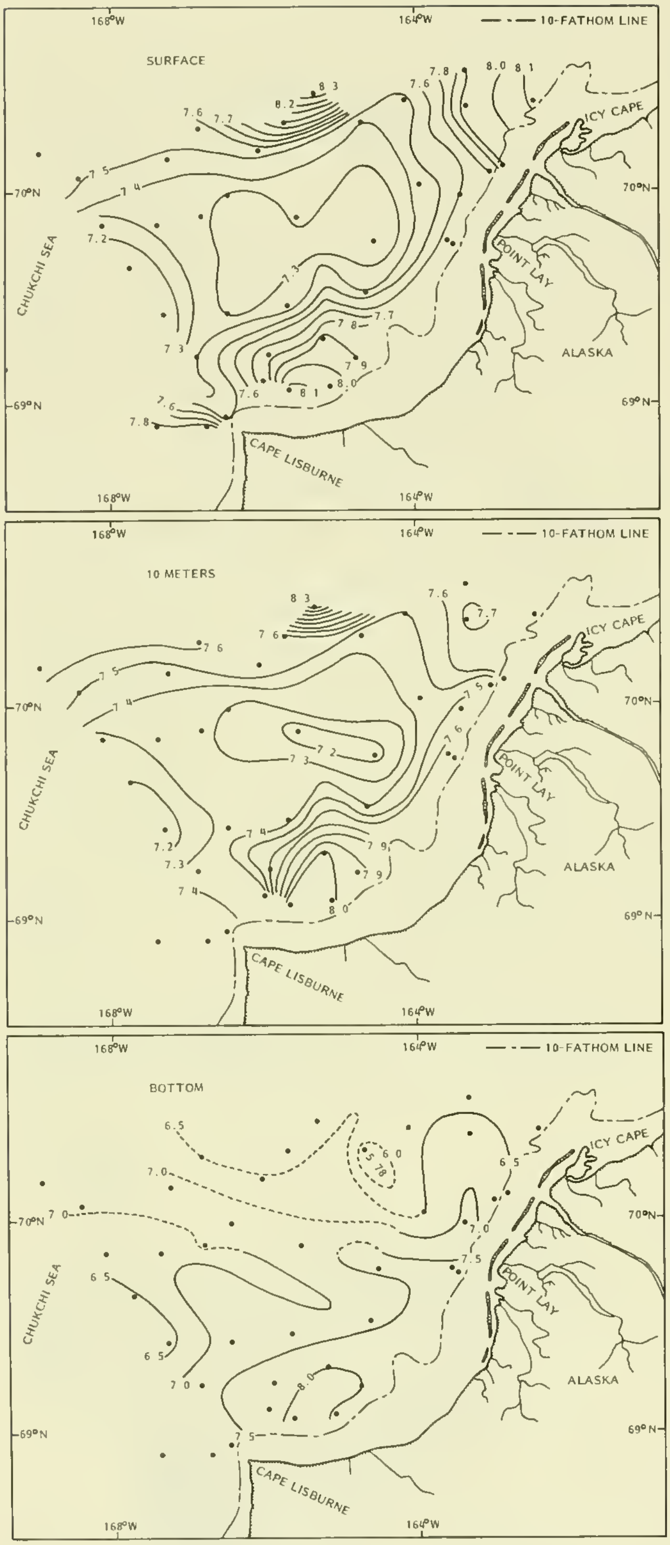

Figure 13.—Dissolved oxygen distributions at surface, 10 m, and near bottom, eastern Chukchi Sea off Cape Lisburne-Icy Cape, 25 September to 17 October 1970. Redrawn from Ingham and Rutland (1972).

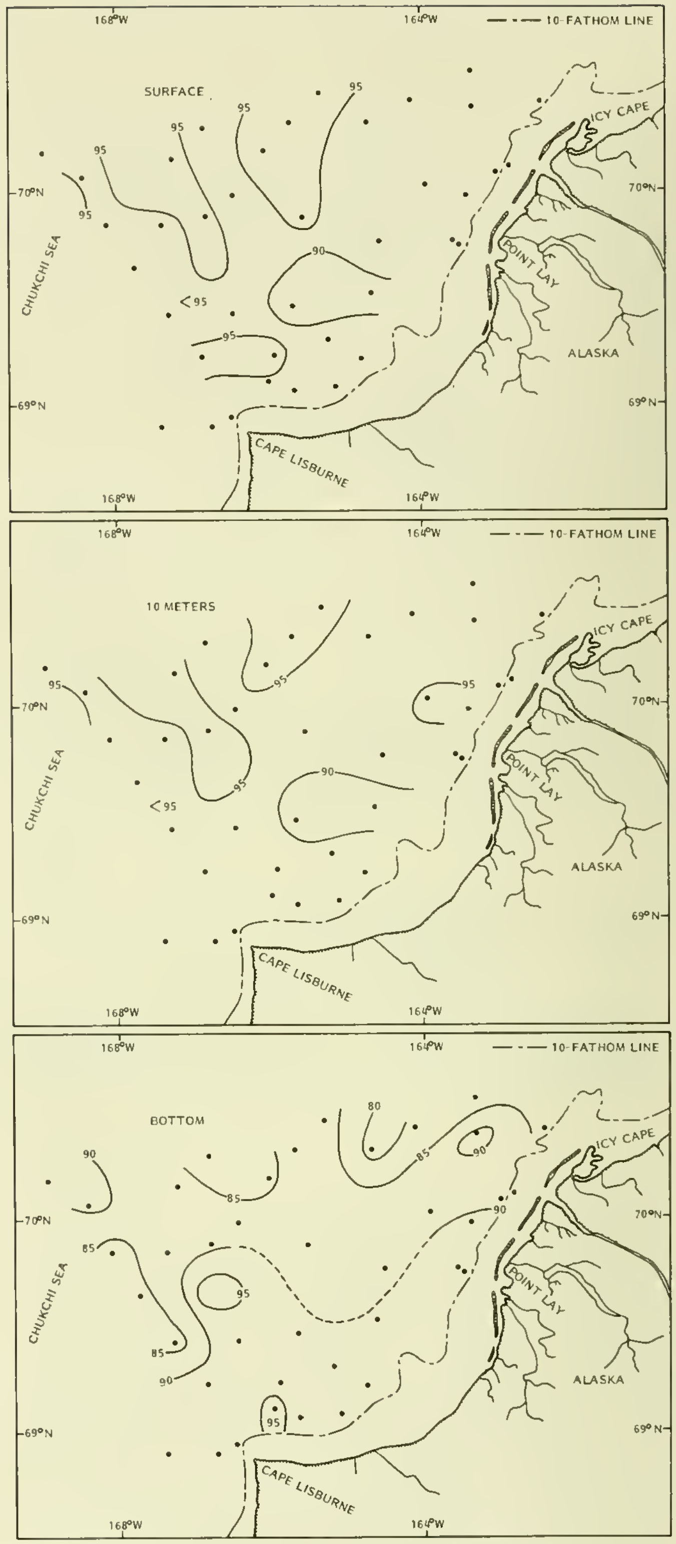

Figure 14.—Contours of percent saturation of dissolved oxygen at surface, 10 m, and near bottom, eastern Chukchi Sea, Cape Lisburne-Icy Cape, 28 September to 17 October 1970. Redrawn from Ingham and Rutland (1972).

and calanoid copepods. Stations west of Icy Cape had alternating areas of low and high oxygen concentration and corresponding areas of high and low zooplankton abundance respectively.

COMPARISON OF ABUNDANCE AND DISTRIBUTION OF ZOOPLANKTON IN 1970 AND 1947

The eastern Chukchi Sea fauna is a continuation of the fauna of the eastern Bering Sea (Johnson, 1953, 1956; Johnson and Brinton, 1963). Of the 32 kinds of zooplankters from the eastern Chukchi Sea identified to species, only the copepod *Derjuginia tolli* has not been previously recorded in the eastern Bering Sea; it appears to be restricted to the polar seas (Brodskii, 1950; Johnson, 1963).

In this section I compare the results of sampling by the *Glacier* in the fall of 1970 with the results of sampling by the *Nereus* in the summer of 1947. Others have studied zooplankton in the Chukchi Sea, but the *Nereus* cruise was the only one that collected data in the same area and used similar sampling techniques as the *Glacier*. Because an east-west change in zooplankton composition and abundance has been demonstrated (Johnson, 1936, 1953; English, 1966), I compare my data with Johnson's only for the most approximate of the two sets of stations—*Nereus* stations 12, 13, 14, and 21; and *Glacier* stations 43, 44, 49, and 90 (Fig. 1, Table 6). The comparative data in Table 6 are drawn from Table 1 of Johnson (1953) and my Table 2 in this paper. The data from both sources were adjusted to number of zooplankters per 100 m^3. The differences between the zooplankton catches of the two cruises may have been due to differences in the years of sampling, the season, or the size of the mesh in the sampling net used. Also, because most of the *Glacier* stations were inshore of the *Nereus* stations, they were shallower and less saline.

Johnson (1953) did not list Hydromedusae in any of his samples, but the hydromedusan *Aglantha digitale* was the predominant zooplankter in my samples and occurred both as juveniles and adults. MacGinitie (1955) and Hand and Kan (1961) found this species to occur consistently off Point Barrow, and Hand and Kan noted large yearly variation in its abundance. Considering the ubiquity of the distribution of *A. digitale* in 1970 (Fig. 2), I believe it likely that 1947 was a year of low abundance and 1970 one of very high abundance.

Polychaete larvae were more numerous in 1947 than in 1970. Among all of the stations sampled in 1970, the counts at only two approached the magnitude of Johnson's counts. The 1947 samples were taken with a finer meshed net, which would account for part of the difference, and also they were taken earlier in the year. Many of the larvae I examined were approaching a size and state at which they settle to the bottom.

When present, in the 1947 cruise cladocerans (*Evadne* sp. and *Podon* sp.) were observed in high numbers and in the 1970 cruise in low numbers. The abundance of marine cladocerans varies seasonally, with peaks in spring and summer (Gieskes, 1971); so that the low numbers obtained on the *Glacier* cruise could have been due to the time of year.

Calanoid copepods dominated the zooplankton in 1947 but not in 1970. Except for *Acartia longiremis* and *Pseudocalanus minutus* most species of calanoid copepods were about as abundant in 1947 as in 1970. *Acartia longiremis* was much more abundant in the 1947 samples, possibly because this species, like the cladocerans, has peak abundance in the summer. *Pseudocalanus minutus* was more abundant in the summer of 1947 than the fall of 1970 even though this species probably overwinters as copepodites (Fontaine, 1955) and should have a relatively high population in the early fall. Thus, I think the large difference in abundance of *P. minutus* between 1947 and 1970 reflects a difference between years rather than seasons. The high numbers of calanoid nauplii and the cyclopoid *Oithona* sp. in the summer of 1947 versus very few in the fall of 1970 appears to be a seasonal effect. Because of their small size, copepod nauplii and *Oithona* were never sampled adequately by the nets I used; however, few copepod nauplii and *Oithona* were found in qualitative phytoplankton samples taken with finer nets at four stations. No egg-bearing calanoids were found in the 1970 samples.

Barnacle larvae were more uniformly distributed than cladocerans in both years and were more numerous in the summer of 1947 than the fall of 1970. Early summer populations of barnacle larvae may be composed of several species. Three species of *Balanus* (MacGinitie, 1955) and one of *Chthamalus* (Southward and Southward, 1967) may contribute larvae to the area. Some species of *Balanus* release only a single spring or early summer brood, whereas *Chthamalus* in the Chukchi Sea may release more than one brood per summer (Southward and Southward, 1967). Although large yearly variations in abundance of barnacle larvae probably occur, I believe the differences between the 1947 and 1970 samples represent seasonal more than yearly differences.

Amphipods and euphausids were probably not adequately represented in either the 1947 or 1970 samples because of their ability to avoid the nets used. Without knowledge of the identity of the amphipods taken in 1947, I can only note that amphipods were about as abundant in 1947 as in 1970. Only larval stages of unidentified euphausids were reported for the 1947 samples, and juveniles of *Thysanoessa inermis* and *T. raschii* predominated in the 1970 samples, as one would expect in the later season.

Crab larvae were more abundant in the fall of 1970 than the summer of 1947. Advanced zoeae and megalopa of an oxyrhynchid crab (probably *Hyas coarctatus*) were more numerous than equivalent stages of hermit crabs (*Pagurus* sp.) At many stations oxyrhynchid and *Pagurus* larvae were about as abundant as many of the calanoid copepods (Table 2).

The pteropods *Clione limacina* and *Spiratella helicina* were found in the southeastern Chukchi Sea in 1970 but not in 1947. Yearly variation in abundance of both species may be large—Johnson (1953) did not find pteropods in the southeastern Chukchi Sea in 1947, but MacGinitie (1955) reports that *S. helicina* were abundant at Point Barrow that same summer. *Spiratella* spp. are the only known prey of *C. limacina* (Lalli, 1970). However, the frequent occurrence of *C. limacina* in the absence of *Spiratella* (my Fig. 4; MacGinitie, 1955, Table 7) suggests that *Clione* does have alternative prey.

Lamellibranch veligers were numerous in Johnson's samples in the summer of 1947 but rarely occurred in my samples in the fall of 1970. The small size of the veligers precluded quantitative sampling by the nets used in 1970, but I believe the difference is principally due to the lateness of the season in which I sampled. I found lamellibranch veligers at only 7 of 39 stations, and then only in low abundance; Johnson encountered lamellibranch veligers at 19 of 21 stations in the Bering and Chukchi Seas, usually in high abundance.

Sagitta elegans is the only chaetognath recorded from the Chukchi Sea (Dawson, 1971). The stations compared in Table 6 had greater numbers of *S. elegans* in 1947 than 1970, but complete data from both years show a wide variation in catch (my Table 2; Johnson, 1953, Table 1). Where there is a thousandfold difference between stations, a twofold or threefold difference between years (Table 6) does not seem significant.

Echinoderm larvae, like polychaete larvae, copepod nauplii, *Oithona* sp., and lamellibranch veligers, were probably underestimated in 1970, relative to estimates in 1947, because my net was coarser than that used aboard the *Nereus*. However, I think the major cause of the difference between the 1947 and 1970 counts is seasonal because most echinoderm larvae have a pelagic life of less than 8 weeks (Thorson, 1961) and would have settled out of the plankton before late September or October. If my hypothesis is correct, this in combination with MacGinitie's (1955) data indicates a very short spawning period for most Chukchi Sea echinoderms with planktonic larvae; the peak spawning period is in July or August and most larvae settle before September or October.

Like echinoderm larvae, adult larvaceans (appendicularians) may also be seasonal in abundance. This seasonality may explain why larvaceans were about 1,000 times more abundant in the 1947 summer samples than in my 1970 fall samples. Neither Johnson (1953) nor MacGinitie (1955) mention *Fritillaria borealis* in their samples, but it dominated the larvaceans in my samples. I found the larger *Oikopleura vanhoeffeni* only occasionally in 1970. Unfortunately, Johnson (1953) does not identify the larvaceans found in the *Nereus* samples, although a *Fritillaria* sp. and an *Oikopleura* sp. were recorded by Johnson (1936) from samples taken by the U.S. Coast Guard cutter *Chelan* in 1934 at stations west of Nome, Alaska.

I believe the strong seasonal nature of Arctic productivity accounts for most of the differences found in comparing my 1970 fall data with Johnson's 1947 summer data, especially those larval forms which were much more abundant in 1947. Large yearly variations probably account for the greater abundance of some larger and longer lived zooplankters in 1970. Although a coarser net was used in 1970 than 1947, I feel that net selectivity played a role secondary to the seasonal and yearly differences.

SUMMARY

1. Zooplankton samples were collected at 39 stations in the eastern Chukchi Sea between 26 September and 17 October 1970.

2. Sixty-three categories of zooplankton were encountered; between 6 and 29 categories occurred at the individual stations.

3. The hydromedusan *Aglantha digitale* was the predominant zooplankter, both in numbers and biomass. Calanoid copepods were the second most abundant zooplankters, although meroplankters equaled or exceeded copepods in numbers at one-half of the stations.

4. Contour plots of zooplankton abundance indicate that three environments were sampled: 1) an area of high abundance and diversity northwest of Cape Lisburne, 2) an area of low abundance and diversity between Cape Lisburne and Point Lay, and 3) an area of rapid north-south variation but generally low abundance extending west along the 70°N parallel.

5. Waters with temperatues below 0°C tended to have lower zooplankton abundance than adjacent warmer waters. In areas where the temperatures changed rapidly from 1° to 3°C horizontally, the abundance of many species changed along the gradient in a parallel fashion. Broad temperature contours in the area northwest of Cape Lisburne indicated some stability, which would be conducive to the development of large zooplankton populations.

6. Nearly no assocation was evident between zooplankton abundance and salinity.

7. A tendency was noted for an inverse relation between zooplankton abundance and dissolved oxygen concentration of the water.

8. A comparison of the 1970 data with data for 1947 demonstrated several differences—some appeared to be differences between years and others seemed to be differences due to time of year. Apparent between-year differences were greater numbers of *Aglantha*, *Clione*, and crab larvae, and lesser numbers of *Pseudocalanus* in 1970 than in 1947. Differences thought to be due to season were lesser numbers of cladocerans, *Acartia*, *Oithona*, larvaceans, and most

Table 6.--Numbers of selected zooplankters taken at four stations by the USS Nereus in 1947 and at four comparable stations by the USCG icebreaker Glacier in 1970 (WE8SEC-70), southeastern Chukchi Sea (adjusted to number per 100 m^3).

	Nereus stations--July-August 1947				Glacier stations[1/]--September-October 1970				Difference attributable
Zooplankter	12	13	14	21	43	44	49	90	to[2/]
Aglantha digitale	--	--	--	--	2,460	4,756	3,933	2,638	Y
Polychaeta (larvae)	--	13	8,037	2,507	23	7	23	607	S & N
Evadne nordmanni	--	--	--	2,507	--	--	--	--	S
Podon leuckarti	--	--	--	2,507	--	--	--	6	S
Acartia longiremis	66	2,016	13	80	17	45	11	442	S
Calanus finmarchicus	981	106	93	385	64	202	23	454	None
Centropages abdominalis	--	--	--	--	--	15	79	49	None
Epilabodocera amphitrites	--	--	--	40	--	--	--	--	None
Eucalanus bungii	--	--	--	106	110	37	--	--	None
Microcalanus sp.	--	--	--	--	--	--	--	6	None
Pseudocalanus minutus	9,998	1,007	20,199	31,287	--	60	--	30	Y
Tortanus discaudatus	13	--	--	13	--	--	--	109	--
Calanoida (nauplii)	10,780	1,511	26,260	--	--	--	--	--	S & N
Oithona sp.	7,690	3,130	6,061	37,547	17	7	--	--	S & N
Balanoids (nauplii)	13	--	9,629	10,013	12	62	--	134	S
Balanoids (cyprids)	13	133	93	2,507	--	--	--	--	S
Amphipods	13	27	13	--	6	--	11	6	None
Euphausids	--	--	--	--	--	352	6	--	S
Euphausids (larvae)	--	--	--	27	--	--	--	--	S
Crab larvae	--	13	13	--	196	68	--	--	Y
Pagurus sp. (larvae)	--	--	--	--	23	22	23	--	Y
Clione limacina	--	--	--	--	26	15	11	--	Y
Lamellibranchia (veligers)	6,152	13	2,016	45,054	--	--	--	--	S & N
Sagitta elegans	438	106	159	584	--	37	45	285	None
Echinoidea (plutei)	3,845	--	--	28,780	--	37	--	36	S & N
Ophiuroidea (plutei)	2,307	--	--	17,520	--	--	--	--	S & N
Asteroidea (bipinnarias)	--	--	--	2,506	--	--	--	--	S & N
Larvaceans	6,152	4,748	28,236	13,766	--	172	--	--	S & N

1/ Average of two samples.

2/ Major attribution of difference between 1947 and 1970 values:

S = difference between seasons
Y = difference between years
N = difference in net selectivity.

planktonic larvae in the fall of 1970 than in the summer of 1947.

ACKNOWLEDGMENTS

The author is indebted to the U.S. Coast Guard for the opportunity to participate in the WEBSEC studies. Appreciation is extended to Captain Robarge and the officers and crew of the *Glacier* for their interest and assistance in sampling. Particular thanks must be given to those of the marine science department for their willingness to brave the wind and cold in order for the scientists to obtain data from an area and time period not normally covered by arctic investigations. Oceanographic data discussed in this report were supplied by cruise leader Merton Ingham of the Coast Guard Oceanographic Unit.

LITERATURE CITED

BRODSKII, K. A.
1950. Veslonogie rachki *Calanoida* dal'nevostochnikh morei SSSR i poliarnogo basseina (Calanoida of the Far Eastern Seas and the polar basin of the USSR). Zool. Inst., Akad. Nauk SSSR, No. 35, 441 p. [Translated by Israel Program Sci. Transl., 1967, 440 p; avail. U.S. Dep. Commer., Clearinghouse Sci. Publ., Springfield, Va., as TT 67-51200.]

DAWSON, J. K.
1971. Species of Arctic Ocean chaetognaths. *In* H. A. Kobayashi (editor), Taxonomic guides to Arctic zooplankton (III), p. 3-21. Univ. South. Calif., Dep. Biol. Sci., Tech. Rep. 4.

ENGLISH, T. S.
1966. Net plankton volumes in the Chukchi Sea. *In* N. J. Wilimovsky and J. N. Wolfe (editors), Environment of the Cape Thompson region, Alaska, p. 809-815. U.S. Atomic Energy Comm., Wash., D.C.

FONTAINE, M.
1955. The planktonic copepods (Calanoida, Cyclopoida, Monstrilloida) of Ungava Bay, with special reference to the biology of *Pseudocalanus minutus* and *Calanus finmarchicus*. J. Fish. Res. Board Can. 12:858-898.

GIESKES, W. W. C.
1971. Ecology of the Cladocera of the North Atlantic and the North Sea 1960-1967. Neth. J. Sea Res. 5:342-376.

HAND, C., and L. B. KAN.
1961. The Medusae of the Chukchi and Beaufort seas of the Arctic Ocean including the description of a new species of *Eucodonium* (Hydrozoa: Authomedusae). Arctic Inst. North Am., Tech. Pap. 6, 23 p.

INGHAM, M. C., and B. A. RUTLAND.
1972. Physical oceanography of the eastern Chukchi Sea off Cape Lisburne-Icy Cape. *In* WEBSEC-70, an ecological survey in the eastern Chukchi Sea, p. 1-86. U.S. Coast Guard, Oceanogr. Rep. 50. Wash., D.C.

JOHNSON, M. W.
1936. The production and distribution of zooplankton in the surface waters of Bering Sea and Bering Strait, with special reference to copepods, echinoderms, mollusks and annelids. *In* Report of oceanographic cruise U.S. Coast Guard cutter *Chelan* 1934, Part II, p. 45-84. U.S. Coast Guard, Wash., D.C.
1953. Studies on plankton of the Bering and Chukchi Seas and adjacent areas. 7th Pac. Sci. Congr. Proc., Vol. 4, Zool., p. 480-500.
1956. The plankton of the Beaufort and Chukchi sea areas of the Arctic and its relation to the hydrography. Arctic Inst. North Am., Tech. Pap. 1, 32 p.
1958. Observations on inshore plankton collected during summer 1957 at Point Barrow, Alaska. J. Mar. Res. 17:272-281.
1963. Zooplankton collections from the high polar basin with special reference to the Copepoda. Limnol. Oceanogr. 8:89-102.

JOHNSON, M. W., and E. BRINTON.
1963. Biological species, water-masses and currents. *In* M. N. Hill (editor), The Sea. Ideas and observations on progress in the study of the seas, Vol. 2, p. 381-414. John Wiley & Sons, N.Y.

LALLI, C. M.
1970. Structure and function of the buccal apparatus of *Clione limacina* (Phipps) with a review of feeding in gymnosomatous pteropods. J. Exp. Mar. Biol. Ecol. 4:101-118.

MACGINITIE, G. E.
1955. Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. Smithson. Misc. Collect. 128(9):1-201.

OSTLE, B.
1963. Statistics in research. 2d ed. Iowa State Univ. Press, Ames, 585 p.

SOUTHWARD, A. J., and E. C. SOUTHWARD.
1967. On the biology of an intertidal chthamalid (Crustacea, Cirripedia) from the Chukchi Sea. Arctic 20:8-20.

THORSON, G.
1961. Length of pelagic larval life in marine bottom invertebrates as related to larval transport by ocean currents. *In* M. Sears (editor), Oceanography, p. 455-474. Am. Assoc. Adv. Sci., Publ. 67, Wash., D.C.

TRANTER, D. J., and P. E. SMITH.
1968. Filtration performance. *In* D. J. Tranter (editor), Reviews on zooplankton sampling methods, p. 27-56. UNESCO (U.N. Educ. Sci. Cult. Organ.) Monogr. Oceanogr. Methodol. 2, Part 1.

★ U. S. GOVERNMENT PRINTING OFFICE: 1974—697-306

648 Weight loss of pond raised channel catfish (*Ictalurus punctatus*) during holding in processing plant vats. By Donald C. Greenland and Robert L. Gill. December 1971, iii + 7 pp., 3 figs., 2 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

649 Distribution of forage of skipjack tuna (*Euthynnus pelamis*) in the eastern tropical Pacific. By Maurice Blackburn and Michael Laurs. January 1972, iii + 16 pp., 7 figs., 3 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

650 Effects of some antioxidants and EDTA on the development of rancidity in Spanish mackerel (*Scomberomorus maculatus*) during frozen storage. By Robert N. Farragut. February 1972, iv + 12 pp., 6 figs., 12 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

651 The effect of premortem stress, holding temperatures, and freezing on the biochemistry and quality of skipjack tuna. By Ladell Crawford. April 1972, iii + 23 pp., 3 figs., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

653 The use of electricity in conjunction with a 12.5-meter (Headrope) Gulf-of-Mexico shrimp trawl in Lake Michigan. By James E. Ellis. March 1972, iv + 10 pp., 11 figs., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

654 An electric detector system for recovering internally tagged menhaden, genus *Brevoortia*. By R. O. Parker, Jr. February 1972, iii + 7 pp., 3 figs., 1 appendix table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

655 Immobilization of fingerling salmon and trout by decompression. By Doyle F. Sutherland. March 1972, iii + 7 pp., 3 figs., 2 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

656 The calico scallop, *Argopecten gibbus*. By Donald M. Allen and T. J. Costello. May 1972, iii + 19 pp., 9 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

657 Making fish protein concentrates by enzymatic hydrolysis. A status report on research and some processes and products studied by NMFS. By Malcolm B. Hale. November 1972, v + 32 pp., 15 figs., 17 tables, 1 appendix table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

658 List of fishes of Alaska and adjacent waters with a guide to some of their literature. By Jay C. Quast and Elizabeth L. Hall. July 1972, iv + 47 pp. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

659 The Southeast Fisheries Center bionumeric code. Part I: Fishes. By Harvey R. Bullis, Jr., Richard B. Roe, and Judith C. Gatlin. July 1972, xl + 95 pp., 2 figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

660 A freshwater fish electro-motivator (FFEM)-its characteristics and operation. By James E. Ellis and Charles C. Hoopes. November 1972, iii + 11 pp., 9 figs.

661 A review of the literature on the development of skipjack tuna fisheries in the central and western Pacific Ocean. By Frank J. Hester and Tamio Otsu. January 1973, iii + 13 pp., 1 fig. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

662 Seasonal distribution of tunas and billfishes in the Atlantic. By John P. Wise and Charles W. Davis. January 1973, iv + 24 pp., 13 figs., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

663 Fish larvae collected from the northeastern Pacific Ocean and Puget Sound during April and May 1967. By Kenneth D. Waldron. December 1972, iii + 16 pp., 2 figs., 1 table, 4 appendix tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

664 Tagging and tag-recovery experiments with Atlantic menhaden, *Brevoortia tyrannus*. By Richard L. Kroger and Robert L. Dryfoos. December 1972, iv + 11 pp., 4 figs., [illegible] tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

665 Larval fish survey of Humbolt Bay, California. By Maxwell B. Eldridge and Charles F. Bryan. December 1972, iii + 8 pp., 8 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

666 Distribution and relative abundance of fishes in Newport River, North Carolina. By William R. Turner and George N. Johnson. September 1973, iv + 23 pp., 1 fig., [illegible] tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

667 An analysis of the commercial lobster (*Homarus americanus*) fishery along the coast of Maine, August 1966 through December 1970. By James C. Thomas. June 1973, v + 57 pp., 18 figs., 11 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

668 An annotated bibliography of the cunner, *Tautogolabrus adspersus* (Walbaum). By Fredric M. Serchuk and David W. Frame. May 1973, ii + 43 pp. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

669 Subpoint prediction for direct readout meteorological satellites. By L. E. Eber. August 1973, iii + 7 pp., 2 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

670 Unharvested fishes in the U.S. commercial fishery of western Lake Erie in 1969. By Harry D. Van Meter. July 1973, iii + 11 pp., 6 figs., 6 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

671 Coastal upwelling indices, west coast of North America, 1946-71. By Andrew Bakun. June 1973, iv + 103 pp., 6 figs., 3 tables, 45 appendix figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

672 Seasonal occurrence of young Gulf menhaden and other fishes in a northwestern Florida estuary. By Marlin E. Tagatz and E. Peter H. Wilkins. August 1973, iii + 14 pp., 1 fig., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

673 Abundance and distribution of inshore benthic fauna off southwestern Long Island, N.Y. By Frank W. Steimle, Jr. and Richard B. Stone. December 1973, iii + 50 pp., 2 figs., 5 appendix tables.

674 Lake Erie bottom trawl explorations, 1962-66. By Edgar W. Bowman. January 1974, iv + 21 pp., 9 figs., 1 table, 7 appendix tables.

UNITED STATES
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SCIENTIFIC PUBLICATIONS STAFF
ROOM 450
1107 N E 45TH ST
SEATTLE, WA 98105

OFFICIAL BUSINESS

FOURTH CLASS

POSTAGE AND FEES PAID
U S DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL