Zooplankton and Ichthyoplankton Data Collected from the Chukchi and Beaufort Seas during the R/V *Mirai* Cruise, September 2002

W. Walkusz, J.E. Paulić, M.H. Papst, S. Kwasniewski, S. Chiba
and R. E. Crawford

Fisheries and Oceans Canada
Central and Arctic Region
Winnipeg, Manitoba R3T 2N6

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by

W. Walkusz[1,2], J.E. Paulić[1], M.H. Papst[1], S. Kwasniewski[2], S. Chiba[3] and R.E. Crawford[4]

[1]Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg, MB
R3T 2N6
E-mail: Wojciech.Walkusz@dfo-mpo.gc.ca

[2]Institute of Oceanology, Polish Academy of Sciences,
55 Powstancow Warszawy, Sopot 81-712, Poland

[3]Frontier Research Center for Global Change/JAMSTEC,
3173-25 Showa-machi, Kanazawa-ku, Yokohama, Kanagawa 236-0001, Japan

[4]Prince William Sound Science Center,
P.O. Box 705, Cordova, Alaska 99574

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ABSTRACT

Walkusz, W., J.E. Paulić, M.H. Papst, S. Kwasniewski, S. Chiba and R.E. Crawford. 2008. Zooplankton and Ichthyoplankton Data Collected from the Chukchi and Beaufort Seas during the R/V *Mirai* Cruise, September 2002. Can. Data Rep. Fish. Aquat. Sci. 1211: ii + 34 p.

Zooplankton and ichthyoplankton were collected from the Chukchi and Beaufort Seas (69 - 75º N and 127 - 165º W) during the fall 2002 R/V *Mirai* cruise. Samples were taken at 33 stations using a 330 µm Bongo net. In general, the coastal stations were warmer and less saline than farther from shore and peaks in fluorescence were near 25 m depth. The distribution of zooplankton was patchy, both in the Chukchi and Beaufort Seas, and was dominated by copepods. The greatest biomass of zooplankton was in the Chukchi Sea at station CS-03 (132.9 mg·m^{-3}; wet mass) while, the maximum biomass collected in the Beaufort Sea was at station MSE-01 (98.7 mg·m^{-3}; wet mass). A total of 93 fish larvae were captured of which four taxa were identified: Arctic cod (*Boreogadus saida*), slender eelblenny (*Anisarchus medius*), gelatinous snailfish (*Liparis fabricii*) and the kelp snailfish (*Liparis tunicatus*). Arctic cod *(Boreogadus saida)* were the most abundant and widely distributed larvae (n = 74 and 51 % of stations) with an average standard length of 30.1 mm (range 17.0 - 49.0 mm). Food items were found in all Arctic cod stomachs and the most abundant taxon identified was *Pseudocalanus spp*.

Key words: zooplankton, ichthyoplankton, Chukchi Sea, Beaufort Sea, Arctic cod, slender eelblenny, snailfish, copepods, *Pseudocalanus*.

RESUMÉ

Walkusz, W., J.E. Paulić, M.H. Papst, S. Kwasniewski, S. Chiba et R.E. Crawford. 2008. Données sur le zooplancton et l'ichthyoplancton recueillies des mers des Tchouktches et de Beaufort durant la campagne à bord du navire de recherche *Mirai*, en septembre 2002. Rapp. stat. can. sci. halieut. aquat. 1211: ii, 34 p.

On a récolté du zooplancton et de l'ichthyoplancton dans les mers des Tchouktches et de Beaufort (69 - 75º N et 127 - 165º O) durant la campagne de l'automne 2002 à bord du navire de recherche *Mirai*. Des échantillons ont été prélevés à 33 stations à l'aide d'un filet de type Bongo de 330 µm. En général, les stations côtières étaient plus chaudes et moins salines que celles situées plus loin du rivage et les crêtes de fluorescence avaient une profondeur de près de 25 mètres. La répartition du zooplancton était éparse, tant dans la mer des Tchouktches que dans la mer de Beaufort, et les copépodes dominaient. La plus grande biomasse de zooplancton se trouvait dans la mer des Tchouktches à la station CS-03 (132,9 $mg·m^{-3}$; masse humide), tandis que la biomasse maximale récoltée dans la mer de Beaufort se trouvait à la station MSE-01 (98,7 $mg·m^{-3}$; masse humide). Un total de 93 larves de poissons a été capturé, duquel on a repéré quatre taxons : la morue arctique (*Boreogadus saida*), la lompénie de Fabricius (*Anisarchus medius*), la limace gélatineuse (*Liparis fabricii*) et la limace des laminaires (*Liparis tunicatus*). La morue arctique *(Boreogadus saida)* a représenté la larve la plus abondante et celle ayant la distribution la plus étendue (n = 74 et 51 % des stations), avec une longueur standard moyenne de 30,1 mm (plage de 17,0 à 49,0 mm). On a trouvé des aliments dans tous les estomacs des morues arctiques et le taxon le plus abondant repéré était le *Pseudocalanus spp*.

Mots clés : zooplancton, ichthyoplancton, mer des Tchouktches, mer de Beaufort, morue arctique, lompénie de Fabricius, limace gélatineuse, copépodes, *Pseudocalanus*.

INTRODUCTION

In general the Chukchi Sea is regarded as more productive than the Canadian Beaufort Shelf (including the Beaufort Sea) due to increased nutrient loading originating from the waters of the deep Bering Sea, which are transported through the Bering Strait (Sakshaug and Walsh, 2000; Smetacek and Nicol, 2005). Although the Chukchi Sea makes up a significant part of the Arctic Ocean its pelagic realm is poorly understood. There are only a few technical reports from the 1950s – 1970s (e.g. Johnson, 1956; Wing, 1974) and the papers only partly describe the composition, distribution and abundance of the Chukchi Sea zooplankton. Other information from this area on zooplankton composition and biomass can be found in Springer et al. (1989), Thibault et al. (1999), Hopcroft (2005) and Plourde et al. (2005).

The Beaufort Sea lies on the continental shelf in the Canadian western Arctic. The Shelf is relatively narrow, approximately 120 km wide and 530 km in length, bounded by the Amundsen Gulf to the east and the Mackenzie Trough to the west (Carmack & Macdonald 2002). This area is under strong influence from the Mackenzie River outflow, which plays a crucial role in the area's hydrology, circulation and geochemistry (Macdonald 2000; Macdonald et al., 2004; O'Brien et al, 2006). Local hydrological conditions in the Beaufort Sea are characterized by strong seasonal and inter-annual variability which also influence sea ice extent within the Mackenzie and Kugmallit estuaries. Zooplankton collections from the Beaufort Sea have been well described in terms of composition and spatial distribution. Works completed by Grainger (1974, 1975), Grainger and Grohe (1975) and Shih and Laubitz (1978) have led to the overall description of this ecological formation. However, it appears to be poorly investigated since the last major studies completed in 1984-1988. They were driven by the Northern Oil and Gas Action Program (NOGAP), which resulted in a series of reports on zooplankton composition and biomass collected across the entire Beaufort Sea Shelf (Hopky et al. 1994a,b,c,d; Hopcroft et al. 2005).

Many of the ichthyoplankton collections from the Chukchi Sea have focused on walleye pollock (*Theragra chalcogramma*) life history (Napp et al. 2000), while others were more focused on the Alaskan Beaufort Sea adult Arctic cod (*Boreogadus saida*) populations (Craig 1984; Moulton & Tarbox 1987; Jarvela & Thorsteinson 1999). In 1986, Bradstreet et al. published a report which summarized Arctic cod catches for the Arctic and included data from the Chukchi and Beaufort Seas. The last major survey of ichthyoplankton in the Canadian Beaufort Sea came from the NOGAP program conducted in 1984-1988. The results of these survey years are reported in Chiperzak *et al*. 2003a,b,c for the Shelf and Hopky *et al.* 1994d for Tuktoyaktuk Harbour. In all studies conducted Arctic cod was found to be the most widely distributed larval fish species indicating its ecological significance to western North American Arctic ecosystems.

This report presents data on the occurrence and distribution of zooplankton and ichthyoplankton collected from the Chukchi and Beaufort Seas during the fall season. Samples were collected during the 2002 cruise on the research vessel R/V *Mirai* (Appendix 1) as part of a multi-disciplinary study of physical and biological interactions in the Chukchi and Beaufort Sea regions. The purpose of this data report is to describe the results of zooplankton and ichthyoplankton collections completed during the cruise.

MATERIALS AND METHODS

Study area

The Beaufort and Chukchi Seas are located within the Arctic Ocean in areas lying beyond the north-western extent of North America (Figure 1). The survey area extends approximately 1300 km, from west of Point Barrow (165° N) to Cape Dalhousie (127° N). Sampling stations were located along the continental shelf within the Chukchi Sea (12 stations) and the Beaufort Sea (21 stations) (Figure 1; Table 1). Stations sampled in the Chukchi Sea were offshore in waters greater than 50 m, except one station, CS-01 (50 m), which was located within the coastal waters west of Point Barrow (Figure 1; Table 1). Of the 21 stations in the Beaufort Sea, 11 were offshore and ten were in less than 50 m of water depth (Figure 1; Table 1).

The western Arctic Ocean is a poorly understood complex hydrographic system. The region is influenced by Pacific and Atlantic waters which mix and influence zooplankton and ichthyoplankton distributions. The waters in this region are primarily influenced by 1) local and global circulation systems; 2) inter-annual ice variability; 3) local wind conditions and; 4) output of warm sediment-rich Mackenzie River plume waters. The area is temporarily covered with ice during the winter and spring, and the coverage has been found to be highly variable from year to year. Variability in ice cover is due in part to the local wind conditions and the general climatic variability (Tremblay & Mysak, 1998; O'Brien et al., 2006). The combination of these physical forces can initiate both up- and down-welling events in the water column and influence the extent of the plume waters in the Beaufort Sea.

Data collection

Zooplankton and ichthyoplankton were collected using a Bongo net with 330 µm mesh size, towed obliquely between the surface and 180 m at a ship speed of 2 to 3 knots at stations with depths greater than 100 m (Table 1; Appendix 2). At shallow stations (< 100 m) the net was towed obliquely from the surface to the depth of station but not deeper than 15 m above the sea floor. Both nets were equipped with flowmeters (General Oceanics Inc. - Model 2030 Series with standard rotor) to estimate the volume of water filtered. Oceanographic conditions were determined by the ship's CTD (conductivity, temperature, fluorescence and depth) system prior to each Bongo tow. An echogram (Lowrance X-15B, 192 KHz, single 9° beam) was also examined prior to each tow to determine the presence of fish in the water column and their vertical distribution.

Laboratory processing

Zooplankton

All zooplankton samples were preserved in 5 % formaldehyde solution in seawater and shipped to the Freshwater Institute, Winnipeg, Manitoba for biomass assessment and identification. Prior to identification, samples were rinsed with freshwater and split for biomass and taxonomical identification with a 1 L Folsom splitter. Whatman filter paper was placed on the low vacuum apparatus and water was filtered through the paper and weighed. The paper was placed back on the apparatus and the sample was filtered through and then weighed using a Mettler PM2500 scale to the nearest 0.1 mg. Through back calculations the total sample mass (biomass) was obtained.

The taxonomical identification of zooplankton was conducted at the Institute of Oceanology – Polish Academy of Sciences in Sopot, Poland. Sorting and identification of the zooplankton was carried out according to the procedures given in Harris et al. (2000). A micropipette was used to obtain subsamples from the entire sample, which was earlier cleaned of dirt, detritus and macrozooplankton and placed in a beaker in a known water volume. All organisms were identified to the lowest possible taxonomic level. To determine species of the genus *Calanus,* methods proposed by Kwasniewski et al. (2003) were applied. The prosome lengths, as well as morphological features were assessed to distinguish between the three/four *Calanus* species (*C. finmarchicus/marshallae* complex, *C. glacialis* and *C. hyperboreus*) present in the study area. Since distinguishing the taxonomic difference between *C. finmarchicus* and *C. marshallae* is difficult to discern, the smallest individuals of *Calanus* were assumed to be from the *C. marshallae*/*C. finmarchicus* complex.

Ichthyoplankton

All larval and post-larval fish were removed from the fresh zooplankton net catch and preserved in non-aqueous ethyl alcohol. The standard lengths of all fish were measured to the nearest millimeter and a portion of the caudal fin from 64 *Boreogadus saida* (Arctic cod) specimens were dissected for further genetic analysis.

All larval fish were then shipped to the Freshwater Institute, Winnipeg, Manitoba for identification and stomach content analysis. The stomachs of all Arctic cod were removed and contents were identified and enumerated. All undigested food items were identified to the lowest possible level.

RESULTS

Zooplankton

Zooplankton biomass ranged from 0.1-132.9 mg·m^{-3}. The distribution of zooplankton biomass was patchy (Table 2; Figure 2). Overall, the highest values of biomass were noted at station CS-03 (132.9 mg·m^{-3}; wet weight) while station NWR-04 had the lowest biomass (0.1 mg·m^{-3}). In the Beaufort Sea the highest biomass was found at station MSE-01 (98.7 mg·m^{-3}) while the KC-08W and MCJ-Z was the lowest (0.1 mg·m^{-3}). The Beaufort Sea mean value of biomass per station was found to be lower than stations in the Chukchi Sea (30.6 and 45.1 mg·m^{-3}, respectively).

A total of 63 taxa of zooplankton were identified, among which 43 were identified to species level and 5 to genus level (Table 3). Copepods were the most numerous group of organisms at all stations. In most cases two taxa of Copepods, namely *Pseudocalanus* spp. and *Calanus glacialis*, occurred in the highest abundance. In the Chukchi Sea *Pseudocalanus* reached 80 ind.·m^{-3} at CS-03 and 63 ind.·m^{-3} at NSC-06 with copepodite stage CIV and adult females being the most abundant at each station, respectively. *Calanus glacialis* was found abundant at the same stations as *Pseudocalanus* with 40 and 41 ind.·m^{-3} at CS-03 and NSC-06, respectively. At station CS-03 *C. glacialis* stages CIII and CIV prevailed while at NSC-06 CII were predominant. In the Beaufort Sea, *Pseudocalanus* was abundant at stations MSE-02 and CBAT-15 with 75 and 56 ind.·m^{-3}, respectively. Stages CIV and CV dominated these stations. High abundances of *C. glacialis* in the Beaufort Sea were recorded at MSE-01, KC-08 and CBAT-12 with 201, 106 and 103 ind.·m^{-3}, respectively. Stages CIII and CIV prevailed at these localities.

In the Beaufort Sea, (MSE-01) *C. finmarchicus/marshallae* reached 30 ind.·m^{-3} with stage CIII being the most abundant. In the Chukchi Sea this species complex was barely present with the highest abundance of only 3 ind.·m^{-3} at CS-03.

Ichthyoplankton

A total of 93 larval fish were captured in the Chukchi and Beaufort Sea. Four species from three families were identified. A total of 37 larvae were collected from the Chukchi Sea and 56 from the Beaufort Sea (Table 4).

Gadidae

The Family Gadidae was represented by the species *Boreogadus saida* (Arctic cod), and made up 79.6 % (n = 74) of the total catch (Table 4). The station with the greatest abundance of cod larvae was HC-01 in the Chukchi Sea (n = 20) and MCZ-09 in the Beaufort Sea (n = 15) (Figure 4). This species was also the most widely distributed one, appearing in 51.5 % (n = 17) of the stations sampled (Table 4). The average standard length of 51 *Boreogadus saida* (majority from the Beaufort Sea) was 30.1 mm (range 17.0 – 49.0 mm, Table 5; Figure 3). Most of the Arctic cod collected during the survey were likely in the post flexion stage of their life based on the guide in Moser et al. (1984).

Stichaeidae

The Family Stichaeidae was represented by the species *Anisarchus medius* (Slender eelblenny). This was the second most frequently captured species (11.8 %; n = 11) and was only captured in the Chukchi Sea at station HC-01 (Figure 5). The average standard length was 39.6 mm (range 34.0 – 46.0 mm, Table 5; Figure 5).

Cyclopteridae

The Family Cyclopteridae was represented by two species *Liparis fabricii* (Gelatinous snailfish) and *Liparis tunicatus* (Kelp snailfish). The family made up a total of 8.6 % of the total catch (n = 8) with a frequency of occurrence of 15.2 % (n = 5) (Table 4). *Liparis fabricii* was found in both the Chukchi (n = 3) and Beaufort Seas (n = 4) (Table 4) and the average standard length was 24.1 mm (range 13.0 – 31.0 mm, Table 5; Figure 6). One individual of *Liparis tunicatus* was found in the Beaufort Sea at station CBAT-15, with a standard length of 38.0 mm (Table 5).

Stomach Contents

Forty four Arctic cod stomach contents were analyzed. All contained food items. The average number of food items was 98 (range 2 - 460) (Table 6). On average the most numerous food item was *Pseudocalanus* spp. followed by Copepoda nauplii, Copepoda eggs and *C. glacialis*.

Environmental Variables

Salinity, temperature and fluorescence were measured at each station. Data from the cruise are available on-line at www.jamstec.go.jp/mirai/. For this report all three environmental variables measured are presented in Figures 7-10 for the Beaufort and Chukchi Seas for the surface and 25 m depth.

In general, the coastal stations were warmer and less saline than stations farther from shore and fluorescence values were greater at depth. In the Chukchi Sea the offshore stations were typically in well mixed cool, saline Arctic marine waters (Figures 7 & 8), while the Beaufort Sea water column was stratified with warm, fresh Mackenzie plume waters on the surface and Arctic marine waters underneath (Figures 9 & 10). However, northwest of Herschel Island there were stations occupied by well mixed polynya waters, similar to the situation observed in the offshore Chukchi stations (Figure 7 & 8). In the Beaufort Sea, northeast of the Mackenzie Trough and at the mouth of Liverpool Bay near Baillie Island, fluorescence was greater at the surface (Figures 9 & 10). This increased fluorescence at the surface also appeared at one station in the offshore waters of the Chukchi Sea (Figures 7 & 8).

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Table 1. Description of the stations and tows completed in the Chukchi and Beaufort Seas during the R/V *Mirai* cruise, September 2002.

Station	Date	Time	Latitude (N)	Longitude (W)	Bottom Depth (m)	Sampling Depth(m)
CHUKCHI SEA						
CS-01	06.09.2002	16:13	70.50.00	160.00.00	50	35
CS-03	08.09.2002	19:28	72.42.00	159.42.00	92	78
CS-05	08.09.2002	00:04	72.54.00	158.48.00	420	100
CS-07	09.09.2002	06:16	73.10.00	158.00.00	2420	100
CS-09	09.09.2002	16:05	73.30.00	157.00.00	3260	100
NWA-04	02.10.2002	15:00	74.53.83	159.30.00	1874	100
NWR-08	10.09.2002	08:00	74.25.00	157.50.00	3337	100
NWR-10	10.09.2002	12:18	74.35.00	158.10.00	1052	100
NSC-02	11.09.2002	12:23	74.15.00	162.33.58	1090	100
NSC-04	11.09.2002	17:30	74.00.00	163.13.51	300	100
NSC-06	11.09.2002	21:15	73.40.00	164.06.75	160	100
HC-01	12.09.2002	00:15	73.20.00	165.00.00	75	57
BEAUFORT SEA						
SHEBA-02	17.09.2002	18:54	70.33.72	141.42.72	493	100
SHEBA-01	17.09.2002	20:26	70.25.20	141.37.80	89	75
SHEBA-00	17.09.2002	21:37	70.11.94	141.30.48	58	43
KC-04	19.09.2002	09:11	70.52.50	133.58.00	80	65
KC-08W	19.09.2002	15:52	70.17.00	134.02.00	45	30
KC-08	19.09.2002	17:22	70.22.00	133.36.00	60	45
KC-08E	19.09.2002	19:35	70.25.00	133.10.00	41	26
MSE-01	20.09.2002	20:25	70.35.00	132.00.00	43	30
MSE-02	20.09.2002	22:42	70.50.00	131.00.00	47	32
CBAT-01	21.09.2002	08:30	70.45.00	128.00.00	50	35
CBAT-04	21.09.2002	11:50	70.45.00	127.20.00	196	180
CBAT-11	21.09.2002	13:32	70.33.00	127.35.00	73	58
CBAT-09	21.09.2002	15:20	70.34.67	127.30.00	200	180
CBAT-12	21.09.2002	18:38	70.45.00	128.30.00	34	20
CBAT-14	21.09.2002	22:25	70.57.50	128.15.00	50	35
CBAT-15	22.09.2002	00:06	71.05.00	129.00.00	40	25
PINGO	22.09.2002	13:23	70.24.00	135.25.00	75	50
MCZ-02	26.09.2002	10:07	69.53.75	139.30.00	35	20
MCJ-Z	26.09.2002	15:12	70.00.00	138.40.00	277	100
MCM-01	27.09.2002	08:27	69.24.00	138.00.00	50	35
MCZ-09	27.09.2002	18:34	70.12.00	137.00.00	51	36

Table 2. Biomass (mg·m^{-3}; wet mass) of zooplankton captured in the Chukchi and Beaufort Seas during the R/V *Mirai* cruise, September 2002.

BEAUFORT SEA		CHUKCHI SEA	
Station	**Biomass**	**Station**	**Biomass**
SHEBA-02	19.9	CS-01	43.7
SHEBA-01	18.2	CS-03	132.9
SHEBA-00	23.6	CS-05	53.1
KC-04	21.9	CS-07	60.0
KC-08W	0.1	CS-09	29.2
KC-08	81.8	NWA-04	0.1
KC-08E	89.9	NWR-08	12.8
MSE-01	98.7	NWR-10	19.6
MSE-02	80.7	NSC-02	65.1
CBAT-01	57.1	NSC-04	51.5
CBAT-04	2.4	NSC-06	46.3
CBAT-11	35.8	HC-01	26.5
CBAT-09	0.2		
CBAT-12	75.5		
CBAT-14	0.5		
CBAT-15	0.3		
PINGO	34.2		
MCZ-02	0.2		
MCJ-Z	0.1		
MCM-01	0.9		
MCZ-09	0.4		

Table 3. Abundance (ind.·m^{-3}) of zooplankton in the Chukchi and Beaufort Seas during the R/V *Mirai* cruise in September 2002.

Taxon/Station	**CS-01**	**CS-03**	**CS-05**	**CS-07**	**CS-09**	**NW-08**	**NW-10**	**NSC-02**	**NSC-04**	**NSC-06**	**HC-01**	**NWA-04**
Hydrozoa (medusae):												
Aglantha digitale	0		0	0	0	0	0	0	0	0	0	0
Sarsia princeps												
Halitholus cirratus												
Aeginopsis laurentii	0							0	0		0	0
Hydromedusae ndet.	0	0								0	0	
Ctenophora:												
Beroë cucumis					0							
Mertensia ovum	0						0		0	0	0	0
Polychaeta larvae	6	4	0	0	0	0				4	7	
Ostracoda			0	0		0	0	0				0
Cirripedia:												
Cirripedia cypris	7	15	1	1	1	0	0	0	0	3	8	0
Cirripedia nauplii		1										
Copepoda:												
Acartia sp.	2	10	1	4	0	0		1	2	1	2	0
Aetideidae ndet.		0							0	0		
Bradyidius similis												
Calanus finmarchicus/marshallae CI		0	0									
C.finmarchicus/marshallae CII	1	1	0	0	0				0	0	1	0
C.finmarchicus/marshallae CIII	1	1	1	0	1	0	0	0	1	0	1	0
C.finmarchicus/marshallae CIV	0	0	0		0	0		0	0	0	0	
C.finmarchicus/marshallae CV	0		0			0		0			0	0
C.finmarchicus/marshallae AF					0							
Calanus glacialis CI	6	5	1	3	1	0	0	3	1	6	7	0
C.glacialis CII	6	8	0	6	2	0	0	2	1	16	8	0
C.glacialis CIII	3	12	1	3	2	0	0	1	1	5	4	0
C.glacialis CIV	4	12	1	4	1	0	0	1	1	8	5	0

Taxon/Station	**CS-01**	**CS-03**	**CS-05**	**CS-07**	**CS-09**	**NW-08**	**NW-10**	**NSC-02**	**NSC-04**	**NSC-06**	**HC-01**	**NWA-04**
C.glacialis CV	3	3	2	4	1	0	1	2	1	5	3	0
C.glacialis AF	0	0	1	0	0	0	0	0	0	1	0	0
C.glacialis AM								0				
Calanus hyperboreus CII												
C.hyperboreus CIII		0	0			0	1		0			0
C.hyperboreus CIV		1	0	0	0	0	0	0		0		0
C.hyperboreus CV	0	0	2	1	0	0	0	1	1	0	0	0
C.hyperboreus AF		0	0	0		0	0	0	0	0		0
Chiridius obtusifrons												
Eurytemora americana												
Evadne nordmanni												
Gaetanus tenuispinus												
Harpacticoida n.det.	0										0	
Heterorhabdus norvegicus						0	0					
Jaschnovia brevis	0	0	0								0	0
Jaschnovia tolli												
Metridia longa CI												
M.longa CII										0		
M.longa CIII	0	0									0	
M.longa CIV	1		0			0	0	0		0	1	0
M.longa CV		0	2	1	0	0		0	0	0		0
M.longa AF		0	1	0	0	1	0		0	0		0
M.longa AM			0	0		0						
Metridia lucens												
Microcalanus spp.		0				0	0			2		0
Oithona similis	3	1	0	0	1	0	0	1	1	5	3	0
Paraeuchaeta glacialis AF			0			0			0	0		0
Paraeuchaeta sp. CII						0	0	0	0			
Paraeuchaeta sp. CIII			0	0	0	0	0	0	0			0
Paraeuchaeta sp. CIV			0	0	0	0	0	0	0			0
Paraeuchaeta sp. CV			0			0	0	0	0			0
Podon leuckarti												

Taxon/Station	**CS-01**	**CS-03**	**CS-05**	**CS-07**	**CS-09**	**NW-08**	**NW-10**	**NSC-02**	**NSC-04**	**NSC-06**	**HC-01**	**NWA-04**
Pseudocalanus spp. CI					0							
Pseudocalanus spp. CII					0					0		
Pseudocalanus spp. CIII	0	3	0		0			0			0	
Pseudocalanus spp. CIV	11	33	3	7	1	0	0	5	2	13	13	0
Pseudocalanus spp. CV	10	28	6	8	3	0	0	13	12	19	12	0
Pseudocalanus spp. AF	7	13	2	3	2	0	0	2	3	25	8	0
Pseudocalanus spp. AM		3	0	0	0	0	0	0	1	5		
Pseudophenna typica												
Scaphocalanus magnus												
Scolecithricella minor			0			0	0	0		0		0
Spinocalanus abyssalis												
Triconia borealis												
Calanoida nauplii	0	0		0	0					0	0	
Isopoda					0		0					
Cumacea												
Mysidacea			0									
Amphipoda:												
Apherusa glacialis	0	0	0	0	0						0	
Gammarus wilkitzkii												
Hyperia galba												
Hyperoche medusarum									0			
Themisto abyssorum		0	0	0	0	0		0	0			0
T. libellula	0	0	0	0	0	0	0	0	0	0	0	0
Onisimus glacialis												
O. litoralis			0		0							
O. nanseni												
Amphipoda n.det.	0					0	0				0	

Taxon/Station	**CS-01**	**CS-03**	**CS-05**	**CS-07**	**CS-09**	**NW-08**	**NW-10**	**NSC-02**	**NSC-04**	**NSC-06**	**HC-01**	**NWA-04**
Euphausiacea:												
Thysanoessa inermis		0		0								0
T. longicaudata	0	0	0	0						0	0	
T. raschii												
Euphausiacea nauplii												
Decapoda – larvae					0	0						
Pteropoda:												
Clione limacina		0							0	0		
Limacina helicina	0	5	1	0	0	1	1	3	1	6	0	0
Echinodermata – larvae	0	0		0	0				0		0	
Chaetognatha:												
Eukrohnia hamata			0	1	0	0	1	0	0	0		0
Sagitta elegans	2	5	4	6	2	0	0	4	2	1	2	0
Appendicularia:												
Oikopleura spp.	1	3	1	2	1	0	0	2	2	2	1	0
Fritillaria borealis	2	0	1	1	1	0	3	1	2	10	2	0
Total	63	151	34	56	20	4	10	44	36	134	75	3

Taxon/Station	**SHEBA-00**	**SHEBA-01**	**SHEBA-02**	**KC-04**	**KC-08W**	**KC-08**	**KC-08E**	**MSE-01**	**MSE-02**	**CBAT-01**
Hydrozoa (medusae):										
Aglantha digitale	0	0	0	0	0	0	0	1	1	2
Sarsia princeps										0
Halitholus cirratus										
Aeginopsis laurentii	0	0	0	0	0	0	0	0	0	2
Hydromedusae ndet.					0		0	0		
Ctenophora:										
Beroë cucumis										
Mertensia ovum	0	0	0	0	0	0	0	0		0
Polychaeta larvae	0		0							1
Ostracoda			0							0
Cirripedia:										
Cirripedia cypris	0	0	0		0		0			0
Cirripedia nauplii	0									
Copepoda:										
Acartia sp.	4	1	1	0	1	2				1
Aetideidae ndet.										0
Bradyidius similis										0
Calanus finmarchicus/marshallae CI	0		0		0					
C.finmarchicus/marshallae CII	0	1	1		0	8	0	8	2	3
C.finmarchicus/marshallae CIII	0	3	2	0	0	10	0	20	11	4
C.finmarchicus/marshallae CIV		0			0			2	4	0
C.finmarchicus/marshallae CV	0									
C.finmarchicus/marshallae AF										
Calanus glacialis CI	2	1	1	0	0	4		5		3
C.glacialis CII	5	1	1		1	10		22	1	9
C.glacialis CIII	11	7	1	1	0	50	0	105	8	10
C.glacialis CIV	4	4	1	0	0	37		63	46	15

Taxon/Station	**SHEBA-00**	**SHEBA-01**	**SHEBA-02**	**KC-04**	**KC-08W**	**KC-08**	**KC-08E**	**MSE-01**	**MSE-02**	**CBAT-01**
C.glacialis CV	1	0	1	0	0	5	0	5	4	4
C.glacialis AF	0	0	0	1	0	1		1	0	1
C.glacialis AM								0		0
Calanus hyperboreus CII										
C.hyperboreus CIII		0			0				1	1
C.hyperboreus CIV	0	0	0	2	0	4		4	5	2
C.hyperboreus CV	1	0	0	1	0	1		1	1	1
C.hyperboreus AF	0	0	0		0	0		0	0	0
Chiridius obtusifrons										
Eurytemora americana										
Evadne nordmanni										0
Gaetanus tenuispinus										
Harpacticoida n.det.			0							
Heterorhabdus norvegicus										
Jaschnovia brevis	1			0	0	0		0	0	0
Jaschnovia tolli	0									
Metridia longa CI	0			0						
M.longa CII					0	1		0	1	3
M.longa CIII				0		1			1	
M.longa CIV			0	0						0
M.longa CV			0			0		0		
M.longa AF			1					0	0	0
M.longa AM										0
Metridia lucens										
Microcalanus spp.		0						0	1	1
Oithona similis	1	1	1	0	0	1				1
Paraeuchaeta glacialis AF			0			0				
Paraeuchaeta sp. CII			0							
Paraeuchaeta sp. CIII			0							
Paraeuchaeta sp. CIV			0	0	0	0				
Paraeuchaeta sp. CV			0							
Podon leuckarti								0		1

Taxon/Station	**SHEBA-00**	**SHEBA-01**	**SHEBA-02**	**KC-04**	**KC-08W**	**KC-08**	**KC-08E**	**MSE-01**	**MSE-02**	**CBAT-01**
Pseudocalanus spp. CI	0							0		
Pseudocalanus spp. CII										
Pseudocalanus spp. CIII		0								0
Pseudocalanus spp. CIV	4	9	7	0	0	2	0	15	54	3
Pseudocalanus spp. CV	5	4	4	1	1	6	0	7	15	2
Pseudocalanus spp. AF	2	1	2	0	0	2	0	3	4	1
Pseudocalanus spp. AM	0	0	0		0				1	0
Pseudophenna typica										0
Scaphocalanus magnus										
Scolecithricella minor			0							0
Spinocalanus abyssalis										
Triconia borealis			0							
Calanoida nauplii		0	0							
Isopoda	0		0			0				0
Cumacea										
Mysidacea	0									
Amphipoda:										
Apherusa glacialis										
Gammarus wilkitzkii			0							
Hyperia galba										0
Hyperoche medusarum										
Themisto abyssorum	0		0	0				0		
T. libellula	0	0	0	0	0	0	0			0
Onisimus glacialis				0	0					
O. litoralis										
O. nanseni										0
Amphipoda n.det.	0	0		0	0					0

Taxon/Station	**SHEBA-00**	**SHEBA-01**	**SHEBA-02**	**KC-04**	**KC-08W**	**KC-08**	**KC-08E**	**MSE-01**	**MSE-02**	**CBAT-01**
Euphausiacea:										
Thysanoessa inermis										
T. longicaudata										
T. raschii	0									
Euphausiacea nauplii										
Decapoda – larvae	0		0	0						
Pteropoda:										
Clione limacina				0	0	0	0	0	0	0
Limacina helicina	0	0	1	0	0	5	3	4	3	4
Echinodermata – larvae	0		0							0
Chaetognatha:										
Eukrohnia hamata	0	0	0	0	0	0	1	0		0
Sagitta elegans	1	1	0	0	1	0	0	0	0	1
Appendicularia:										
Oikopleura spp.	1	0	1	1	1	2	0	1	1	2
Fritillaria borealis	6	1	1	1	0	5	0	4	2	1
Total	51	36	28	12	6	154	6	272	167	75

Taxon/Station	**CBAT-04**	**CBAT-11**	**CBAT-09**	**CBAT-12**	**CBAT-14**	**CBAT-15**	**PINGO**	**MCZ-02**	**MCJ-Z**	**MCM-01**	**MCZ-09**
Hydrozoa (medusae):											
Aglantha digitale	0	2	6	0	1	0		1	0	0	
Sarsia princeps				0							
Halitholus cirratus								0			
Aeginopsis laurentii	0	0	1	0	1	0	0	0	0	0	
Hydromedusae ndet.					0	0	0	0		0	
Ctenophora:											
Beroë cucumis	0			0	0						
Mertensia ovum	0	0	0	0	0	0	0		0	0	0
Polychaeta larvae	0	0	0	0	0	0		0		0	0
Ostracoda	0				0		0	0	0		
Cirripedia:											
Cirripedia cypris	0	0	0		0		0	0	0	0	0
Cirripedia nauplii											0
Copepoda:											
Acartia sp.		0	0	0	0	0		0	1	2	7
Aetideidae ndet.											
Bradyidius similis		0								0	
Calanus finmarchicus/marshallae CI					0						
C.finmarchicus/marshallae CII		0	0	8	0	1	0		0	1	0
C.finmarchicus/marshallae CIII	0	2	0	6	6	18	1	0	3	5	2
C.finmarchicus/marshallae CIV	0	0	0	2	0	3	0	0	2	2	3
C.finmarchicus/marshallae CV	0	0					0		0	0	
C.finmarchicus/marshallae AF											
Calanus glacialis CI	0	0	1	2	2		0			0	
C.glacialis CII	0	2	1	22	3	2	1		1	7	1
C.glacialis CIII	2	2	1	32	4	31	1	1	8	13	8
C.glacialis CIV	2	6	1	38	7	20	2	1	4	9	9

Taxon/Station	**CBAT-04**	**CBAT-11**	**CBAT-09**	**CBAT-12**	**CBAT-14**	**CBAT-15**	**PINGO**	**MCZ-02**	**MCJ-Z**	**MCM-01**	**MCZ-09**
C.glacialis CV	2	1	1	8	2	3	1	1	1	1	2
C.glacialis AF	0	0		0	0	1	1	0	0	0	0
C.glacialis AM	0				0			0			
Calanus hyperboreus CII			0								
C.hyperboreus CIII	0	0		0			1	0	0	0	0
C.hyperboreus CIV	8	2	3	2	2	1	3	1	0	1	1
C.hyperboreus CV	4	1	2	0	0	0	1	0	0	0	0
C.hyperboreus AF	1	0		0	0	0	0	0			0
Chiridius obtusifrons					0	0					
Eurytemora americana		0									
Evadne nordmanni		0	0								
Gaetanus tenuispinus			0								
Harpacticoida n.det.											
Heterorhabdus norvegicus	0							0			
Jaschnovia brevis	0	0		0	0		0		0		0
Jaschnovia tolli								0			
Metridia longa CI											
M.longa CII	1	1	0	1	1	0	0	0	0		0
M.longa CIII		1		0	0		0	0	0	0	0
M.longa CIV	0	0	1		0		0	0	0		
M.longa CV	2	0	1	0		0	0	0			
M.longa AF	1	0	1	0	0	0		0			
M.longa AM				0							
Metridia lucens									0		
Microcalanus spp.	0	0	0	0	1		0	0		0	
Oithona similis	0	1	1		1		0	0	0		0
Pareuchaeta glacialis AF			0								
Paraeuchaeta sp. CII			0					0	0		
Paraeuchaeta sp. CIII	0							0			
Paraeuchaeta sp. CIV	0		0					0	0		
Paraeuchaeta sp. CV	0		0	0				0			
Podon leuckarti	0	1	0	0	0						

Taxon/Station	**CBAT-04**	**CBAT-11**	**CBAT-09**	**CBAT-12**	**CBAT-14**	**CBAT-15**	**PINGO**	**MCZ-02**	**MCJ-Z**	**MCM-01**	**MCZ-09**
Pseudocalanus spp. CI											
Pseudocalanus spp. CII											
Pseudocalanus spp. CIII	0	1	0	0						0	
Pseudocalanus spp. CIV	3	15	3	7	7	29	1	0	2	6	2
Pseudocalanus spp. CV	1	6	1	6	6	17	3	1	2	13	2
Pseudocalanus spp. AF	1	5	1	3	2	10	0	1	1	5	1
Pseudocalanus spp. AM		0				0		0	0	0	1
Pseudophenna typica											
Scaphocalanus magnus								0			
Scolecithricella minor	0		0	0				0	0		
Spinocalanus abyssalis								0			
Triconia borealis		0	0								
Calanoida nauplii	0				0						
Isopoda				0	0				0		
Cumacea					0	0					
Mysidacea											
Amphipoda:											
Apherusa glacialis						0					
Gammarus wilkitzkii											
Hyperia galba	0					0					
Hyperoche medusarum											
Themisto abyssorum	0		0		0	0	0	0	0		
T. libellula	0		0	0	0	0	0		0	0	
Onisimus glacialis											
O. litoralis						0					
O. nanseni											
Amphipoda n.det.	0		0	0	0		0			0	0

Taxon/Station	**CBAT-04**	**CBAT-11**	**CBAT-09**	**CBAT-12**	**CBAT-14**	**CBAT-15**	**PINGO**	**MCZ-02**	**MCJ-Z**	**MCM-01**	**MCZ-09**
Euphausiacea:											
Thysanoessa inermis					0					0	0
T. longicaudata			0			0				0	
T. raschii								0		1	0
Euphausiacea nauplii					0						
Decapoda – larvae				0	0	0				0	0
Pteropoda:											
Clione limacina	0	0	0	0	1	0	0	0	0	0	0
Limacina helicina	1	2	0	2	3	2	1	0	0	1	0
Echinodermata – larvae	0	0	1		0	0					
Chaetognatha:											
Eukrohnia hamata	0	0	2	0		0	0	0	0		0
Sagitta elegans	0	0	1	0	1	1	0	0	0	4	2
Appendicularia:											
Oikopleura spp.	0	0	0	1	1	1	0	0	0	1	0
Fritillaria borealis		0	0	0	2	2	1	0			
Total	31	52	24	148	54	143	20	7	27	72	44

Table 4. Summary of ichthyoplankton captured in the Chukchi and Beaufort Seas during the R/V *Mirai* cruise in September 2002.

STATION	*Boreogadus saida*	*Liparis spp.*	*Anisarchus medius*
CBAT-01	1		
CBAT-09	1		
CBAT-12	5		
CBAT-14	6		
CBAT-15	2	1	
CS-01		1	
CS-07	3		
HC-01	20	2	11
KC-08	1		
KC-08E	3		
MCJ-Z	1	3	
MCM-01	3		
MCZ-02	2	1	
MCZ-09	15		
MSE-01	2		
MSE-02	5		
SH-00	3		
SH-01	1		
Total captured in the Chukchi Sea	23	3	11
Total captured in the Beaufort Sea	51	5	0
Total captured	74	8	11
Percent of total catch	79.6 %	8.6 %	11.8 %
Frequency of occurrence	51.5 %	15.2 %	3.0 %

Table 5. Standard length (mm) of larval fish captured in the Chukchi and Beaufort Seas during the R/V *Mirai* cruise in September 2002.

STATION	SPECIES	STANDARD LENGTH
CBAT-01	*Boreogadus saida*	33
CBAT-09	*Boreogadus saida*	49
CBAT-12	*Boreogadus saida*	30
CBAT-12	*Boreogadus saida*	30
CBAT-12	*Boreogadus saida*	30
CBAT-12	*Boreogadus saida*	36
CBAT-12	*Boreogadus saida*	33
CBAT-14	*Boreogadus saida*	24
CBAT-14	*Boreogadus saida*	25
CBAT-14	*Boreogadus saida*	26
CBAT-14	*Boreogadus saida*	28
CBAT-14	*Boreogadus saida*	33
CBAT-14	*Boreogadus saida*	39
CBAT-15	*Boreogadus saida*	36
CBAT-15	*Boreogadus saida*	36
CBAT-15	*Liparis tunicatus*	38
CS-01	*Liparis fabricii*	19
CS-07	*Boreogadus saida*	17
CS-07	*Boreogadus saida*	23
CS-07	*Boreogadus saida*	44
HC-01	*Anisarchus medius*	34
HC-01	*Liparis fabricii*	13
HC-01	*Anisarchus medius*	41
HC-01	*Liparis fabricii*	31
HC-01	*Anisarchus medius*	36
HC-01	*Anisarchus medius*	46
HC-01	*Anisarchus medius*	41
HC-01	*Anisarchus medius*	40
HC-01	*Anisarchus medius*	44
HC-01	*Anisarchus medius*	40
HC-01	*Anisarchus medius*	38
HC-01	*Anisarchus medius*	39
HC-01	*Anisarchus medius*	36
KC-08	*Boreogadus saida*	23
KC-08E	*Boreogadus saida*	23
KC-08E	*Boreogadus saida*	34
KC-08E	*Boreogadus saida*	23
MCZ-02	*Boreogadus saida*	30
MCZ-02	*Boreogadus saida*	32
MCZ-02	*Liparis fabricii*	28
MCJ-Z	*Boreogadus saida*	41
MCJ-Z	*Liparis fabricii*	27
MCJ-Z	*Liparis fabricii*	20
MCJ-Z	*Liparis fabricii*	31
MCM-01	*Boreogadus saida*	33
MCM-01	*Boreogadus saida*	35
MCM-01	*Boreogadus saida*	27
MCZ-09	*Boreogadus saida*	33
MCZ-09	*Boreogadus saida*	28
MCZ-09	*Boreogadus saida*	33
MCZ-09	*Boreogadus saida*	33
MCZ-09	*Boreogadus saida*	30
MCZ-09	*Boreogadus saida*	30
MCZ-09	*Boreogadus saida*	28
MCZ-09	*Boreogadus saida*	32

Table 5. Continued

STATION	SPECIES	STANDARD LENGTH
MCZ-09	*Boreogadus saida*	23
MCZ-09	*Boreogadus saida*	25
MCZ-09	*Boreogadus saida*	18
MCZ-09	*Boreogadus saida*	32
MCZ-09	*Boreogadus saida*	25
MCZ-09	*Boreogadus saida*	23
MCZ-09	*Boreogadus saida*	20
MSE-01	*Boreogadus saida*	23
MSE-01	*Boreogadus saida*	30
MSE-02	*Boreogadus saida*	28
MSE-02	*Boreogadus saida*	29
MSE-02	*Boreogadus saida*	32
MSE-02	*Boreogadus saida*	44
MSE-02	*Boreogadus saida*	34
SHEBA-01	*Boreogadus saida*	21

Table 6. Mean, maximum and minimum abundance (ind.·fish larvae) of stomach contents found in analyzed Arctic cod (N = 44) collected in the Chukchi and Beaufort Seas during the R/V *Mirai* cruise in September 2002.

Taxon	Mean	Max	Min
Rotifera	0.0	2	0
Polychaeta larvae	0.2	1	0
Acartia spp.	1.5	16	0
Calanus glacialis	6.4	27	0
C. hyperboreus	0.5	1	0
C. finmarchicus/marshallae	0.1	2	0
Calanus spp.	0.4	3	0
Eurytemora spp.	0.7	3	0
Jaschnovia tolli	0.2	1	0
Limnocalanus grimaldii	0.5	1	0
Microcalanus spp.	0.5	4	0
Oithona similis	4.4	50	0
Pseudocalanus spp.	59.5	405	0
Triconia borealis	0.2	2	0
Copepoda eggs	7.4	158	0
Copepoda nauplii	16.5	117	0
Podon leuckarti	0.5	1	0
Isopoda	0.2	1	0
Thysanoessa spp.	0.2	1	0
Limacina helicina	0.8	1	0

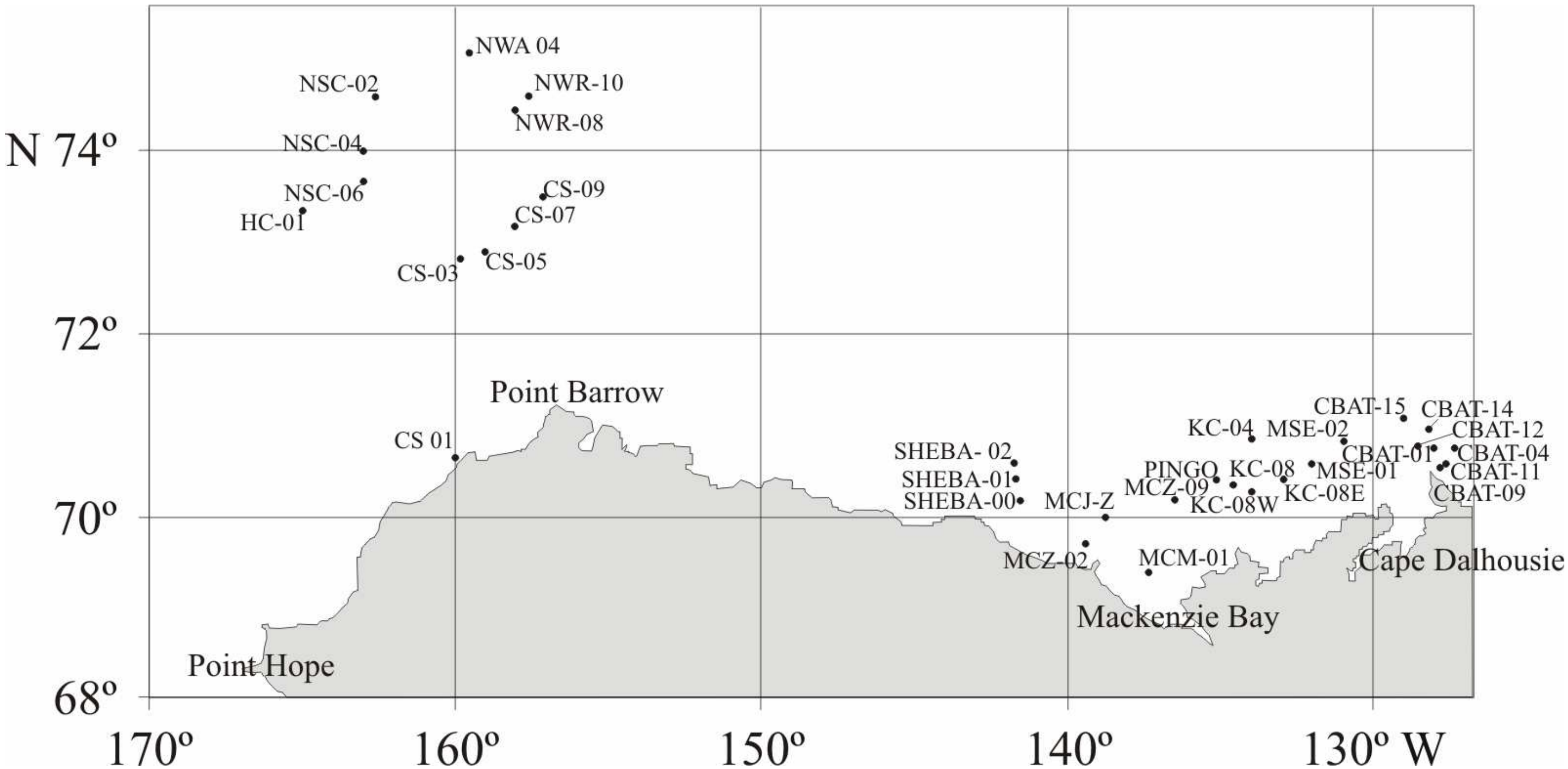


Figure 1. Map of the Chukchi and Beaufort Sea with sample stations located within the study area. Depth contours in meters.

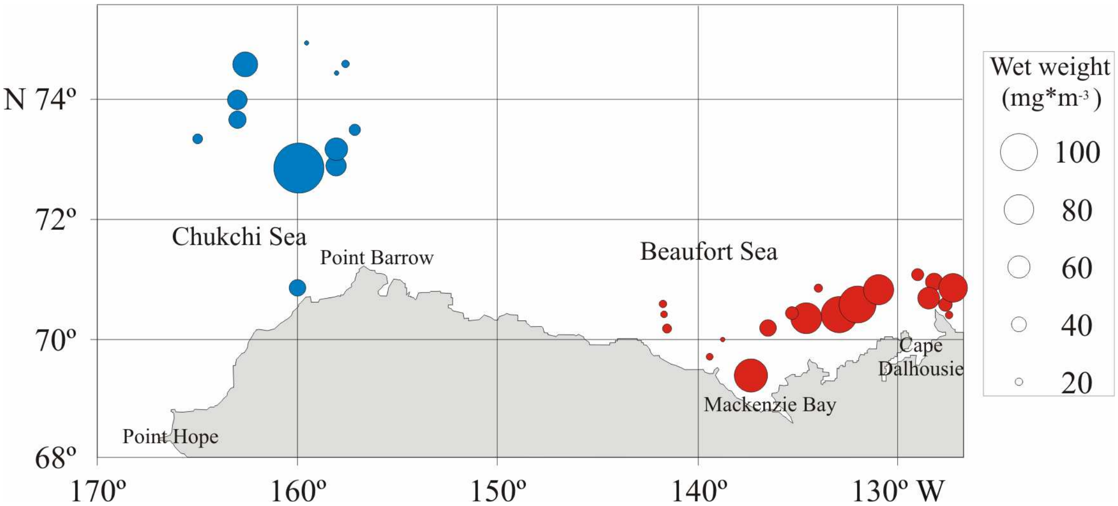


Figure 2. Distribution of zooplankton biomass (mg·m^{-3}; wet mass) captured in the Chukchi and Beaufort Sea during the R/V *Mirai* cruise in September 2002.

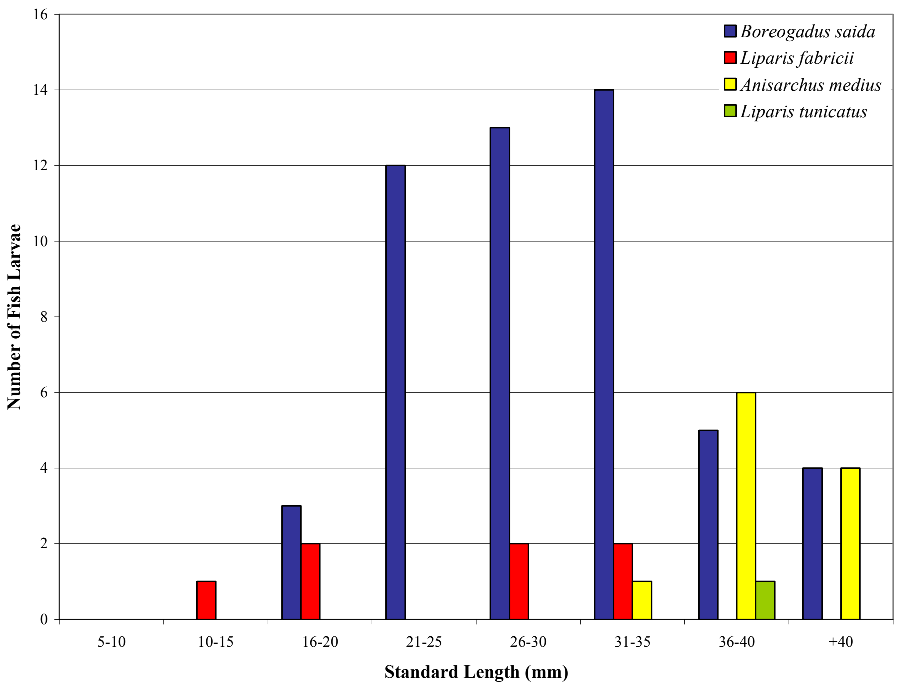


Figure 3. Frequency of larval fish (N = 70) from the Chukchi and Beaufort Sea per standard length classes (mm) during the R/V *Mirai* cruise in September 2002.

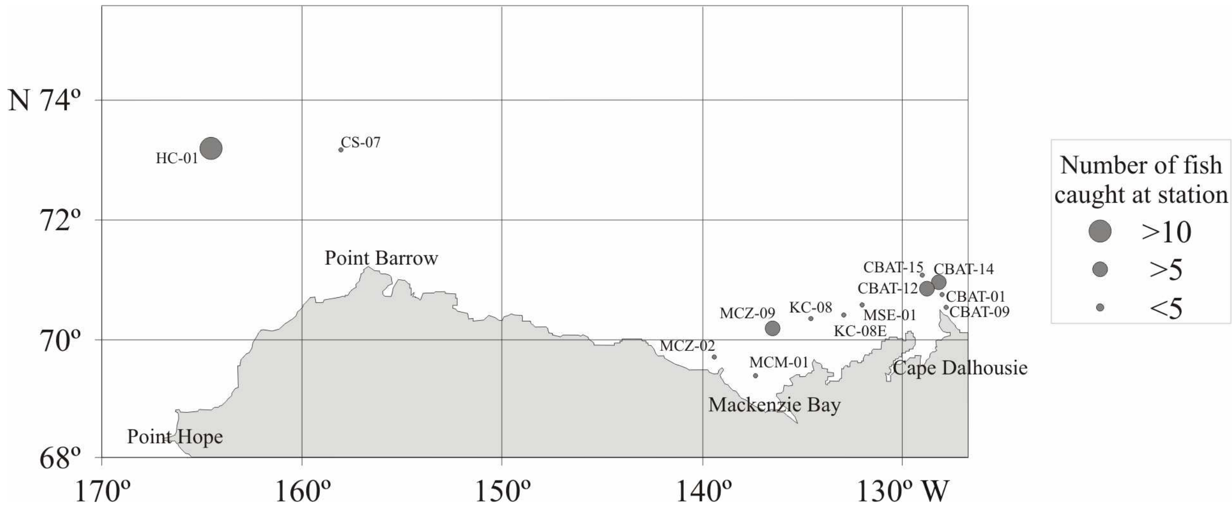


Figure 4. Distribution of *Boreogadus saida* (Arctic cod) in the Chukchi and Beaufort Sea during R/V *Mirai* cruise in September 2002.

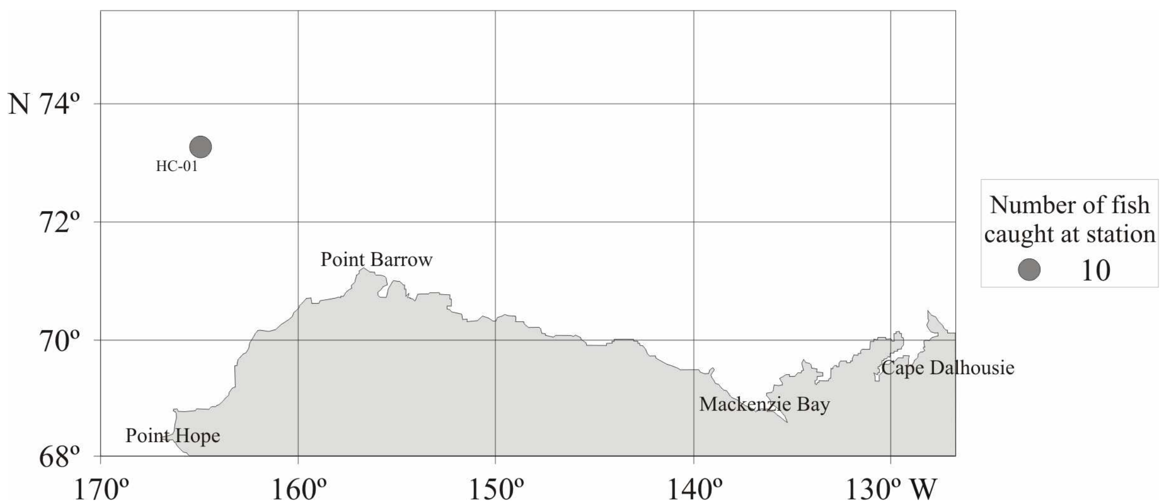


Figure 5. Distribution of *Anisarchus medius* (Slender eelblenny) in the Chukchi and Beaufort Sea during the R/V *Mirai* cruise in September 2002.

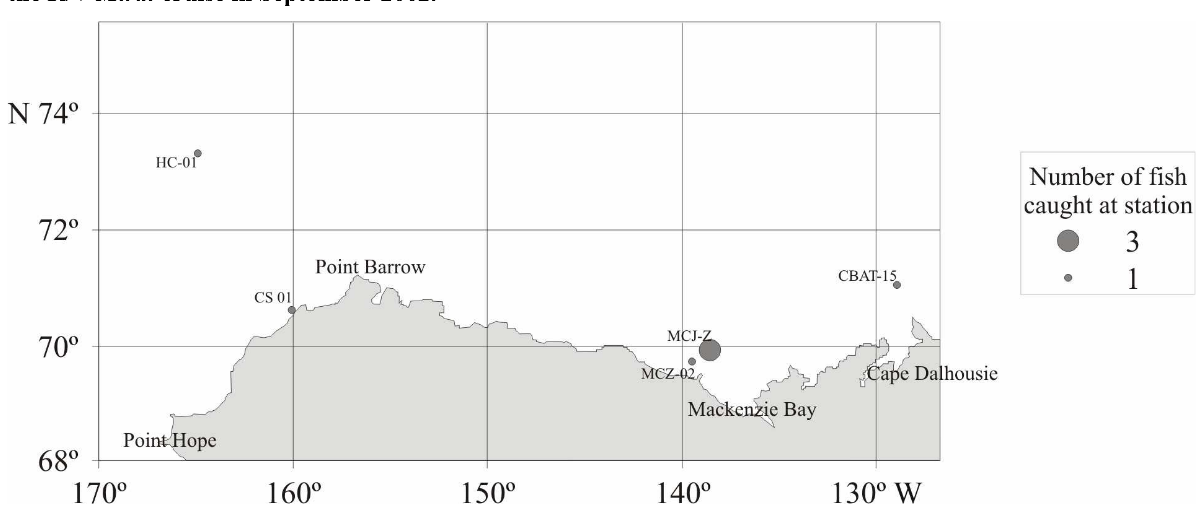


Figure 6. Distribution of the genus *Liparis* (Snailfishes) captured in the Chukchi and Beaufort Sea during the R/V *Mirai* cruise in September 2002.

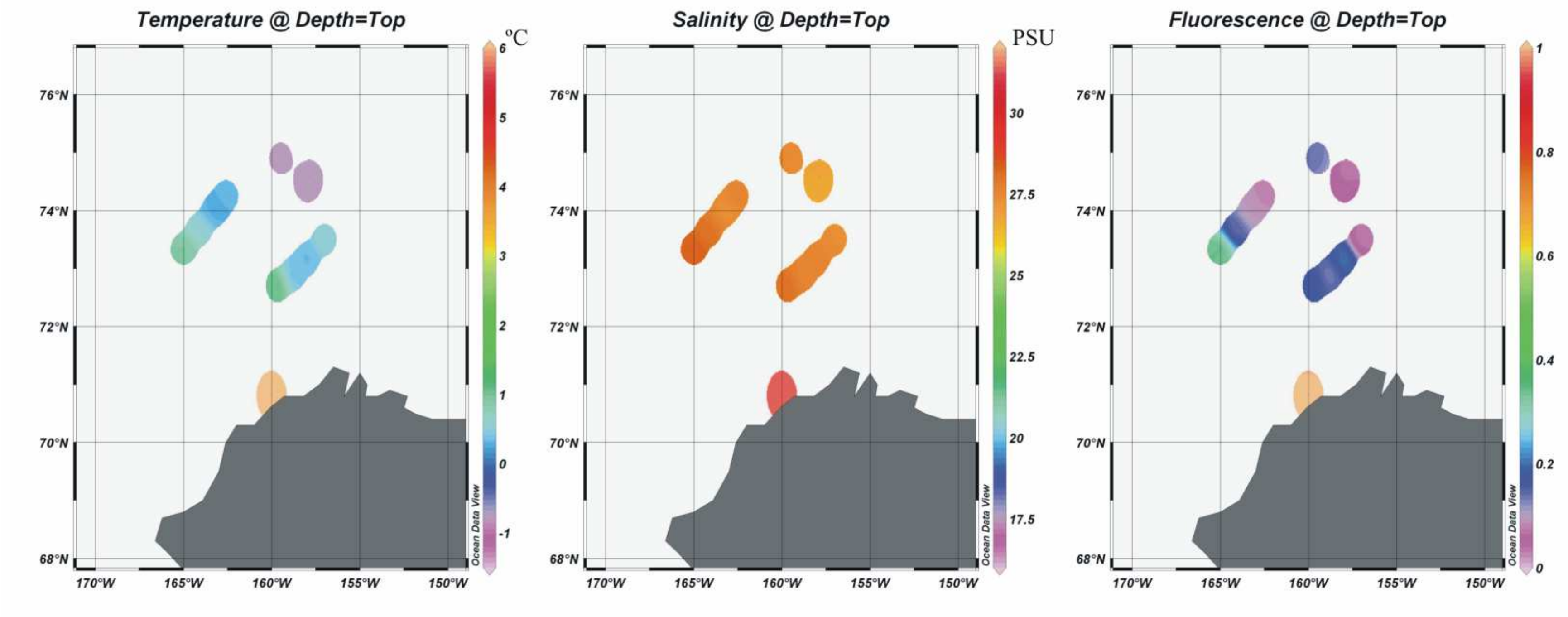


Figure 7. Temperature, salinity and fluorescence observed at 0 m in the Chukchi Sea during the R/V *Mirai* cruise in September 2002.

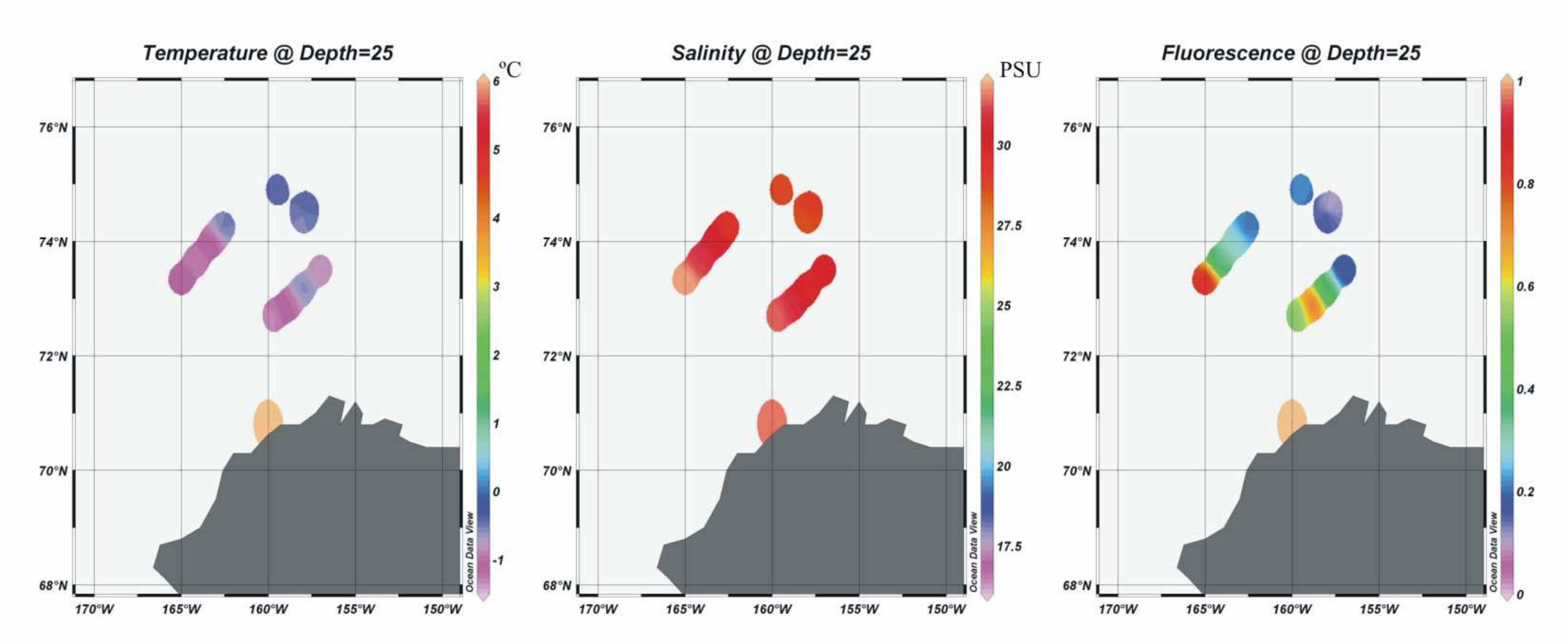


Figure 8. Temperature, salinity and fluorescence observed at 25 m in the Chukchi Sea during the R/V *Mirai* cruise in September 2002.

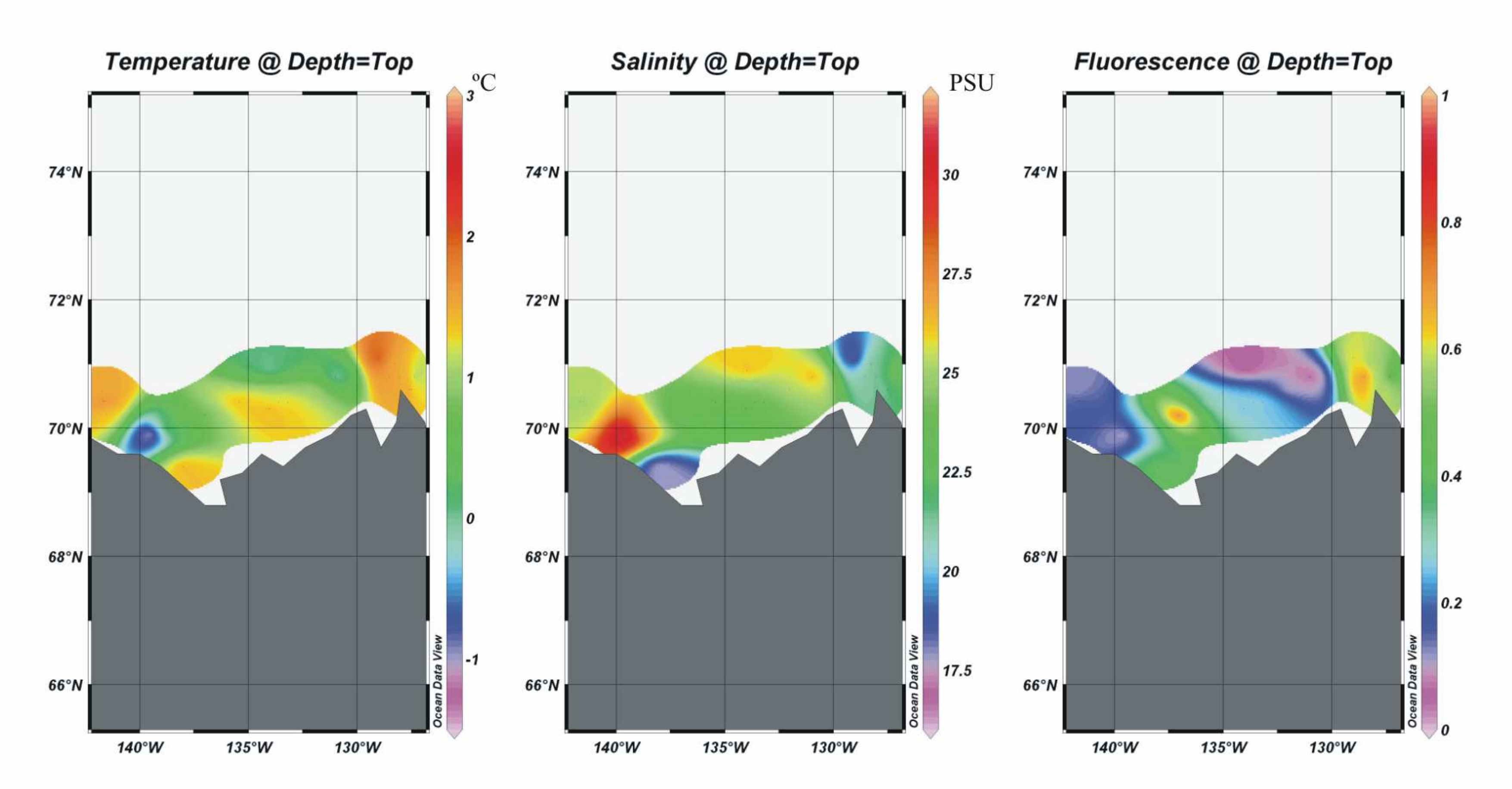


Figure 9. Temperature, salinity and fluorescence observed at 0 m in the Beaufort Sea during the R/V *Mirai* 2002 fall cruise.

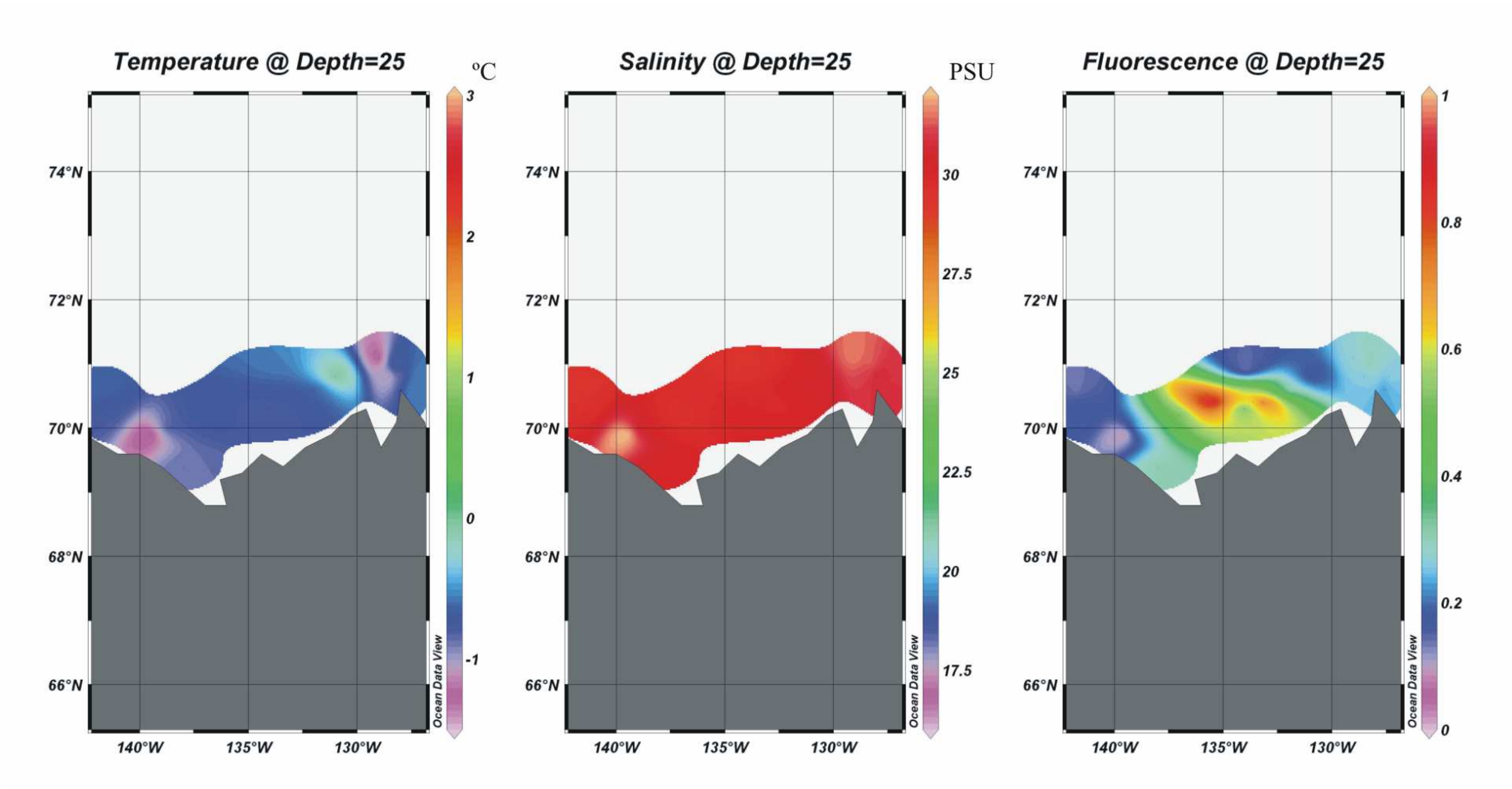
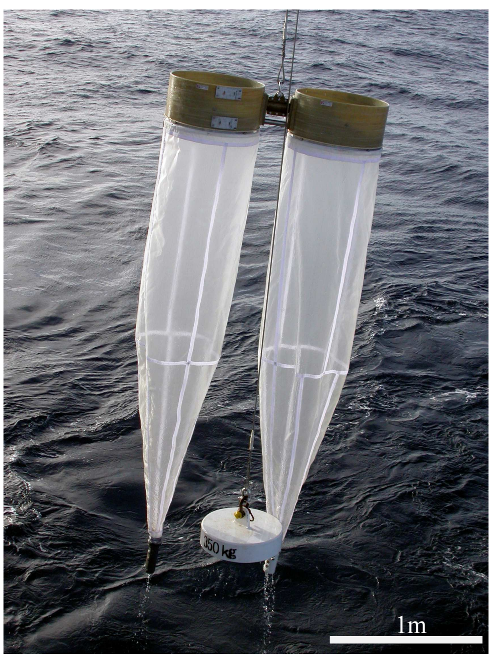


Figure 10. Temperature, salinity and fluorescence observed at 25 m in the Beaufort Sea during the R/V *Mirai* cruise in September 2002.

APPENDICES

Appendix 1. R/V *Mirai* in Dutch Harbour, Alaska, U.S.A. (Photo courtesy of Richard Crawford)



Appendix 2. Bongo net deployment from the R/V *Mirai* (Photo courtesy of Richard Crawford)