Research Journal of Recent Sciences ISSN 2277-2502
Vol. **1(2),** 61-84, Feb. **(2012)** *Res.J.Recent Sci.*

Multi-annual changes of bottom temperatures in the Pacific off the North Kuril Islands and South Kamchatka (Northwestern Pacific, Russia) and demography of selected groundfish species

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Available online at: www.isca.in
(Received 17th January 2012, revised 21st January 2012, accepted 27th January 2012)

Abstract

The results of eight oceanological and bottom trawl surveys (totally 650 stations) conducted within the Pacific waters off the northern Kuril Islands and southeastern Kamchatka in 1993-2000 during the same calendar period (late summer – autumn) are analyzed. Several periods with different thermal conditions were marked out. The 1993-1995s were characterized by the existence of two areas with low bottom temperatures (< 1°C): off central Paramushir Island and southeastern Kamchatka (cold years). The 1995 was coldest among three years with presence of wide area of negative bottom temperatures off the southeastern Kamchatka. The 1996-1998s were considerably warmer; the entire survey area was covered by waters with bottom temperatures > 1°C (warm years). In 1999, the situation has been changed and this year was somewhat colder than previous period (moderate year). 2000 was again warm year. During the whole study period, considerable changes of temperature conditions were registered in the northern part of the area surveyed only, while the rest part was covered by waters with bottom temperatures >1°C. The multi-annual changes of survey indices of 32 most common groundfish species (4 skates, Pacific cod, walleye pollock, sablefish, prowfish, 2 eelpouts, Atka mackerel, 5 sculpins, 6 snailfishes, sawback poacher, shortraker rockfish, Pacific ocean perch, broadbanded and shortspine thornyheads, Kamchatka flounder, northern rock and flathead soles, Pacific and Greenland halibuts) were analyzed. Correlation between demographic patterns of some species and bottom temperature changes were detected. Therefore it can be suggested that abundance of these species is affected by changes of bottom temperatures. At the same time, various species demonstrate similar tendencies of changes of their demography. Since the majority of species have long life span, they are not capable to respond quickly to climatic variability by changing of their abundance. The changes of their demographic patterns most likely show the redistribution of their biomass between areas or outside of area surveyed.

Key words: groundfish, survey indices, relative abundance, demographic patterns, bottom temperature, northern Kuril Islands, southeastern Kamchatka, Northwestern Pacific, Russia.

Introduction

The Pacific waters off the northern Kuril Islands and southeastern Kamchatka are one of the most productive areas of the Russian Far East EEZ. However, the relative importance of fishes from this area in the total Russian Far East catch remains insignificant. Low catch is associated with rocky grounds that restricted bottom trawling in most of the area.

Demersal ichthyofauna of the Pacific waters off the northern Kuril Islands and southeastern Kamchatka is studied intensively during two past decades. Many ichthyological and fisheries aspects were investigated. In the area studied about 20 fish species are commercially important; among them walleye pollock, Pacific cod, Atka mackerel, halibuts, rockfishes, thornyheads and flatfishes. Several species (skates and large sculpins, grenadiers, etc.) are prospective for fisheries but almost not being currently fished. There are several species that are very abundant in the area but have no commercial importance due to meat quality (snailfishes, poachers, soft sculpins, lumpsuckers). However, they play important role in ecosystems due to their high abundance.

Oceanographic conditions of the area under consideration are very dynamic due to interaction of East Kamchatka current with Strait's currents and bottom relief. As a result, tree quasi-stationary anticyclonic eddies exist off the southeastern Kamchatka, Paramushir Island coast and off the underwater plateau in the southern part of the study area (47°45'-48°55'N) southeast of Onekotan Island[1-5]. Relations between distributional features of key fish species from this area and some oceanographic characters (water structure, temperature and salinity) were considered[4]. There was also paper dealing with effect of eddies on spatial distributions of some groundfish species[6]. There are no other papers analysing relationships between oceanological parameters and distribution and aspects of life histories of groundfishes in the Pacific waters off the northern Kuril Islands and southeastern Kamchatka. Demographic changes of some commercially important fishes from this area were presented in several papers[7-9] but reasons of these changes were not shown. Meanwhile, relations between bottom temperatures and demographic changes of fishes are still poorly understood even for most abundant commercially important species. The analysis of this relation might be useful in understanding of ecosystem functioning and helpful in fisheries management since it can help to forecast trends of fish demography depending on climatic changes and temperature conditions.

The main objectives of this study is i) to describe patterns of spatial distribution of bottom temperature in different years based on data from oceanological surveys conducted during the same seasons (late summer – autumn), ii) to determine thermal type of the year (warm, intermediate, cold) based on data on mean bottom temperatures, iii) to analyze changes of relative abundance of 32 most abundant and common fish species based on indices of bottom trawl surveys, iv) to compare demographic patterns of fish in different parts of the study area (northern, central and southern) and changes of bottom temperature and v) to detect their possible relationships.

Material and Methods

This paper is based on the data obtained from 8 oceanological and bottom trawl surveys (total 650 stations) conducted during late August to early November (hydrological summer-autumn season) of 1993-2000 (figure-1). The investigated area was within 47°40´N to 52°N, 154°20´E to 158°50´E. Data were collected from three chartered commercial Japanese trawlers (*Tomi-Maru 53, Tomi-Maru 82,* and *Tora-Maru 58*). Bottom trawl surveys were conducted during the daytime at depths 76-833 m using a 5-7 m (vertically) by 25-30 m (horizontaly) bottom trawl net constructed from 100 mm (stretched mesh) polyethylene net. The net was outfitted with steel and rubber ball roller gear in the forward wings. Only successful trawl samples (horizontal and vertical net openings remained within normal range, the roller gear maintained consistent contact with the bottom, the net suffered no or little damage during the tow, there were no conflicts with derelict fishing gear) were used for analysis in the present study. Each haul was made along isobaths. The whole catch was analyzed.

Bottom temperature data were obtained with the use of STD-1000 sensor that measured this parameter from sea surface to the bottom continuously at each station. Positions of bottom trawl and oceanological stations were quite similar.

Survey indices (average catch per unit effort (CPUE) expressed in number of individuals per unit of fishing effort) were used to describe the relative abundance of particular fish species. Maps of distribution of bottom temperatures were drawn with the use of SURFER software (Golden Software Inc., 2002). To determine geographical differences of changes of thermic conditions and fish demographic patterns the area studied was divided into three sub-areas: northern (52°-51°50´N); central (51°50´-49°40´N) and southern (49°40´-47°40´N). Analysis of relations between mean survey indices and bottom temperatures is based on results of multiple correlation using analytical package of Excel for Microsoft Office.

Results and Discussion

Analysis of bottom temperatures showed significant differences of their distribution both between years and between sub-areas. In 1993, low temperatures (< 1°C) were observed mostly off Paramushir Island (figure-2). High temperatures occurred on the continental slope at great depths and on the shelf between Paramushir and Shumshu Islands (Second Kuril Strait). In 1994, low temperatures were found mostly off Paramushir Island and southeastern Kamchatka coasts (figure-3). Southern sub-area was considerably warmer. 1995 was even colder. Negative temperatures were observed off southeastern Kamchatka, low temperatures were also observed off Paramushir Island coast (figure-4). Meanwhile, considerably warmer waters covered southern part of the area but highest temperatures were registered on continental slopes. The 1996 was essentially warmer than previous years (Figure-5). Bottom temperatures were > 1°C within the entire area studied. Off Paramushir and southeastern Kamchatka they were somewhat lower than in the rest part of study area but higher than in 1993-1995s. Highest temperatures were registered again within continental slope. Unfortunately, the survey of 1997 was shortened and it is impossible to imagine the real picture of bottom temperature distribution. However, data available (figure-6) allows us to suggest warm thermal conditions within the entire area. The 1998 was probably warmest year during the whole period of observations. Waters with high bottom temperatures (figure-7) were observed not only within continental slope but on the shelves of Kamchatka and Paramushir Island as well. In 1999, negative temperatures were registered off the southeastern Kamchatka (figure-8). Off Paramushir Island, bottom temperatures were low but higher than in the northern sub-area. Southern sub-area was considerably warmer in comparison to northern and central ones. Highest temperatures were recorded again within slope areas. There were no negative temperatures recorded in 2000 (figure-9). Minimal temperatures (<1°C) were observed within several local areas at the outer shelf. High bottom temperatures were observed within the most part of the area surveyed.

Summarizing the thermal conditions of the area studied (table-1), it can be concluded that the first half of the 1990s was considerably colder than the second half of this decade and was represented by three cold years. The 1996, 1997 and 1998 can be characterized as warm years. Some fall of the temperature was observed in 1999 that allows us to characterize this year as intermediate. And finally, in the

2000 warmer thermal conditions were observed and this year can be determined as warm one.

Results of analysis of possible relations between changes of bottom temperatures in different sub-areas and those of survey indices with the use of multiple correlations are presented in table-2. It shows positive significant correlations ($R > 0.5$) between bottom temperature and survey indices of Aleutian skate *Bathyraja aleutica*, greypurple sculpin *Gymnocanthus detrisus* and northern rock sole *Lepidopsetta polyxystra* for the entire area studied, i.e. increasing of temperatures within the whole area is associated with increasing of relative abundance of these species. Meanwhile, several species (Atka mackerel *Pleurogrammus monopterygius*, armorhead sculpin *Gymnocanthus galeatus*, broadbanded thornyhead *Sebastolobus macrochir*, flathead sole *Hippoglossoides elassodon* and Pacific black halibut *Reinhardtius hippoglossoides matsuurae*) demonstrate negative significant correlation ($R < -0.5$) between their survey indices and bottom temperatures within entire study area, i.e. their relative abundance in the whole area under consideration decreases when bottom temperature increases.

There were essential differences of relationship considered in different parts of surveyed area. In the northern sub-area, only fore species show strong relationships between parameters considered. Thus, there were positive correlations between bottom temperature and survey indices of shortspine thornyhead *Sebastolobus alascanus* and Kamchatka flounder *Atheresthes evermanni* while Atka mackerel and flathead sole demonstrate negative correlation between their relative abundance and thermal conditions. In the central sub-area, relative abundance of three species only is closely associated with bottom temperature changes. By this, greypurple sculpin and dimdisc snailfish *Elassodiscus tremebundus* exhibit positive correlations while pink snailfish *Careproctus rastrinus*, on the contrary, shows negative one. In the southern sub-area, increasing of bottom temperatures causes increasing of relative abundance of shortspine thornyhead and greypurple sculpin only. Meanwhile, CPUEs of walleye pollock *Theragra chalcogramma*, Atka mackerel, armorhead sculpin, great sculpin *Myoxocephalus polyacanthocephalus*, Pacific ocean perch *Sebastes alutus* and broadbanded thornyhead in this sub-area decrease when bottom temperatures rise.

Matrixes were completed to determine similar patterns of demographic changes of all 32 species under study for the whole area and its different parts using results of multiple correlations. Totally 496 pairwise comparisons were made. The maximum number of significant correlations (119 or 24% of total number of pairs compared) between different species was recorded for the entire study area. By this, 72 pairs of species had similar tendencies of demographic changes (positive correlations) while abundance of 47 fish pairs has been changed in anti-phases (table-3). Aleutian skate and pink snailfish, Matsubara skate *Bathyraja matsubarai* and forktail snailfish *Careproctus furcellus*, great sculpin and Pacific halibut *Hippoglossus stenolepis*, Okhotsk skate *Bathyraja violacea* and Kamchatka flounder (figure-10) exhibited maximum similarities of demographic changes (correlation coefficient > 0.9). Negative correlations were considerably lower (> - 0.9).

Minimal number of strong relations between different species (80) was detected for the northern sub-area; amounts of positive and negative significant correlations comprised 52 and 28 pairs respectively (table-4). Most similar demographic patterns were characteristic of walleye pollock and prowfish *Zaprora silenus*, walleye pollock and great sculpin, walleye pollock and dimdisc snailfish, prowfish and great sculpin, prowfish and dimdisc snailfish, great sculpin and dimdisc snailfish (figure-11). Negative correlations similar to previous area were lower.

In the central sub-area, number of significant correlations was somewhat higher than in northern sub-area (90) with 76 positive and 14 negative ones (table-5). Here, highest correlation coefficients (>0.9) were detected for other species than in northern sub-area. Thus, close relationships of demographic patterns were detected for Aleutian and whiteblotched *Bathyraja maculata* skates, Aleutian skate and Pacific halibut, whiteblotched skate and Pacific halibut, Matsubara skate and sablefish *Anoplopoma fimbria*, Pacific cod *Gadus macrocephalus* and great sculpin, armorhead sculpin and northern rock sole, great sculpin and northern rock sole. Highest negative correlation (R=-0.93) was recorded between dimdisc snailfish and flathead sole (figure-12).

Even higher number of strong relationships between fish demographic changes (104) was registered for southern area (table-6), where number of positive and negative correlations comprised 74 and 30 respectively. Maximum similarities of demographic changes were observed for Aleutian skate and shortspine thornyhead, Aleutian skate and pink snailfish, Okhotsk skate and shortraker rockfish *Sebastes borealis*, pink snailfish and shortspine thornyhead, Aleutian skate and Okhotsk snailfish *Liparis ochotensis*, Okhotsk snailfish and pink snailfish (figure-13). Values of negative correlations were considerably lower.

Taking into account above-mentioned materials some conclusive remarks should be made. Demographic patterns of a number of commercially important fishes for the area studied were previously described in several papers[7-9] and there was suggested that fluctuations of their abundance are caused by climatic changes. However, no any evidences of such relationship were provided. Meanwhile, cyclic demographic changes of groundfish species due to climate changes are also known from other areas of the North Pacific, for instance from the eastern Bering Sea [10]. As it was shown above, many groundfish species, inhabiting the Pacific waters off the northern Kuril Islands and southeastern Kamchatka, demonstrate significant correlation between changes of their relative abundance and bottom temperature. At the same time, many species show very similar trends of demographic changes. By this, different species exhibit different patterns of changes of relative abundance that most probably associated with different temperature preferences of these species. Ichthyofauna of the study area is represented by heat-loving, cold-loving, stenothermic and eurythermic fishes differently responding to changes of thermal conditions. Relative abundance of many species in the area surveyed has been changed considerably from year to year (table-7). Moreover, there are also significant annual variations of survey indices between sub-areas. Meanwhile, study area is closely related to other areas, such as Pacific waters off southern Kuril Islands, northeastern Kamchatka, Sea of Okhotsk, waters of Commander and Aleutian Islands. Population status of many fish species, inhabiting this area, is unknown. The majority of species under consideration have long life span (10-20 years and longer), so they are not capable to respond quickly to climatic variability by significant fluctuations of their abundance. Therefore, changes of their demographic patterns most likely show the redistribution of their biomasses between sub-areas and/or outside of area surveyed. There are some examples of possibilities of such redistribution due to migrations or range extensions. For instance, migrations of Pacific cod between western and eastern Kamchatka and Pacific side of the northern Kuril Islands are known[11]. Range extensions from the Aleutian Islands and active migrations of some species from the western Bering Sea and eastern Kamchatka to study area were also described[12].

Conclusion

The first half of the 1990s was considerably colder than the second half of this decade and was represented by three cold years. The 1996, 1997 and 1998 can be characterized as warm years. Some fall of the temperature was observed in 1999 that allows characterizing this year as intermediate one. In the 2000, warmer thermal conditions were observed and this year can be determined as warm one. The analysis of multi-annual changes of survey indices of the most common groundfish species show that there is a correlation between demographic patterns of some species and bottom temperature changes. It can be suggested that abundance of these species is affected by changes of bottom temperatures. At the same time, various species demonstrate similar trends of changes of their demography. Since the majority of species have long life span, they are not capable to respond quickly to climatic variability by changing of their abundance. The changes of their demographic patterns most likely show the redistribution of their biomass between areas or outside of the area surveyed.

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Table-1
Thermal conditions (bottom temperatures) in different parts of study area, summer-autumn 1993-2000 (NA – not available)

Year	Area			Year type
	North	Center	South	
1993	Low	Low	Medium	Cold
1994	Low	Low	High	Cold
1995	Low	Low	High	Cold
1996	High	High	Medium	Warm
1997	NA	Medium	High	Warm (?)
1998	High	High	Medium	Warm
1999	Low	Medium	Medium	Intermediate
2000	High	High	Medium	Warm

Table-2
Relationships (correlation coefficients) between mean bottom temperatures in different parts of the study area and mean survey indices of particular species (coefficients > 0.5 are given in bold, NA = not available)

No.	Species	Area			
		South	Center	North	All areas combined
1	*Bathyraja aleutica*	0.372	0.180	-0.345	**0.664**
2	*B. maculata*	-0.010	0.297	0.310	-0.044
3	*B. matsubarai*	0.177	0.262	0.499	-0.082
4	*B. violacea*	0.346	-0.414	-0.413	-0.073
5	*Gadus macrocephalus*	0.004	0.357	-0.271	0.286
6	*Theragra chalcogramma*	**-0.561**	0.004	-0.055	0.240
7	*Anoplopoma fimbria*	-0.460	0.119	0.352	0.029
8	*Zaprora silenus*	-0.456	0.109	-0.096	0.226
9	*Lycodes albolineatus*	-0.376	-0.008	0.029	-0.052
10	*L. brunneofasciatus*	0.176	-0.465	-0.265	-0.428
11	*Pleurogrammus monopterygius*	**-0.665**	-0.416	**-0.621**	**-0.548**
12	*Malacocottus zonurus*	-0.078	0.144	0.028	0.214
13	*Gymnocanthus galeatus*	**-0.843**	-0.063	-0.044	**-0.544**
14	*G. detrisus*	**0.586**	**0.685**	-0.034	**0.583**
15	*Myoxocephalus polyacanthocephalus*	**-0.611**	0.086	-0.075	0.355
16	*Triglops scepticus*	-0.242	0.110	0.357	0.211
17	*Sarritor frenatus*	0.331	-0.389	-0.029	0.298
18	*Elassodiscus tremebundus*	0.108	**0.527**	0.070	0.268
19	*Liparis ochotensis*	0.480	-0.467	-0.004	0.265
20	*Polypera simushirae*	-0.170	NA	NA	-0.442
21	*Sebastes alutus*	**-0.649**	-0.230	0.023	-0.378
22	*S. borealis*	0.082	-0.299	0.270	-0.142
23	*Sebastolobus macrochir*	**-0.557**	0.026	0.207	**-0.667**
24	*S. alascanus*	**0.567**	0.324	**0.937**	-0.071
25	*Careproctus furcellus*	0.207	0.201	0.133	-0.008
26	*C. rastrinus*	0.415	**-0.523**	-0.358	0.399
27	*C. roseofuscus*	-0.367	0.377	0.321	0.448
28	*Atheresthes evermanni*	-0.101	-0.030	**0.701**	-0.180
29	*Hippoglossoides elassodon*	0.168	-0.674	**-0.856**	**-0.563**
30	*Hippoglossus stenolepis*	-0.075	-0.103	-0.377	-0.183
31	*Lepidopsetta polyxystra*	0.212	0.325	0.166	**0.537**
32	*Reihhardtius hippoglossoides matsuurae*	-0.026	-0.338	0.109	**-0.578**

Table-3
Matrix of similarity of relative abundance indices of different fish species in the entire study area (bold numbers show positive or negative significant correlation; numbers from 1 to 32 indicate species as shown in Table-2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1																																
2	-0.12																															
3	0.08	-0.47																														
4	0.17	**0.83**	-0.22																													
5	-0.21	-0.25	-0.50	**-0.63**																												
6	-0.24	-0.38	-0.11	**-0.63**	**0.74**																											
7	-0.33	0.28	-0.15	0.29	0.07	0.43																										
8	-0.01	0.23	-0.03	-0.12	0.30	**0.53**	0.11																									
9	0.08	0.14	**0.53**	0.07	-0.46	-0.03	-0.15	**0.62**																								
10	0.11	**0.56**	-0.02	**0.61**	**-0.58**	**-0.75**	-0.42	0.06	0.36																							
11	-0.25	**0.69**	**-0.52**	**0.52**	-0.19	-0.45	-0.19	0.10	0.08	**0.80**																						
12	**0.66**	0.45	-0.32	**0.72**	-0.40	-0.35	0.10	0.02	0.05	0.44	0.34																					
13	-0.52	**-0.52**	-0.13	**-0.53**	0.46	0.49	0.18	-0.18	-0.44	-0.37	-0.05	-0.39																				
14	0.01	0.00	-0.17	-0.33	0.39	0.18	-0.19	0.09	-0.04	-0.41	-0.29	-0.40	-0.38																			
15	0.00	-0.10	**-0.52**	-0.40	**0.91**	**0.74**	0.19	**0.50**	-0.34	-0.42	-0.10	-0.07	0.36	0.13																		
16	-0.13	0.39	-0.40	0.18	0.48	0.49	**0.62**	**0.55**	-0.16	-0.14	0.07	0.16	0.09	-0.17	**0.72**																	
17	**0.61**	**0.51**	-0.01	**0.64**	-0.45	-0.23	0.07	0.46	**0.53**	**0.50**	0.26	**0.83**	**-0.63**	-0.29	-0.08	0.26																
18	0.13	0.46	-0.41	0.11	0.26	-0.29	**-0.52**	0.26	-0.01	0.42	0.45	0.00	-0.48	0.48	0.23	0.12	0.12															
19	0.26	**0.68**	-0.27	**0.84**	-0.29	-0.33	**0.52**	-0.10	-0.22	0.22	0.16	**0.63**	-0.45	-0.22	-0.04	**0.51**	**0.52**	0.08														
20	**-0.53**	0.04	0.14	0.23	-0.16	-0.11	**0.57**	**-0.53**	-0.45	-0.16	-0.09	-0.24	0.38	-0.38	-0.23	0.17	-0.42	-0.46	0.36													
21	-0.16	-0.17	**0.57**	-0.12	-0.40	0.19	0.06	0.43	**0.83**	0.13	-0.02	-0.06	0.09	-0.34	-0.31	-0.20	0.26	-0.50	-0.41	-0.16												
22	0.17	0.12	0.32	**0.58**	**-0.71**	-0.28	**0.54**	-0.36	0.07	0.06	-0.14	**0.49**	-0.09	**-0.57**	**-0.53**	-0.04	0.37	**-0.71**	**0.54**	**0.52**	0.27											
23	-0.27	-0.27	0.21	0.06	-0.35	0.03	0.35	-0.35	-0.06	-0.02	0.03	0.10	**0.63**	-0.76	-0.29	-0.15	-0.11	**-0.86**	-0.08	**0.52**	0.47	**0.65**										
24	0.17	**-0.51**	0.47	-0.05	-0.21	-0.12	0.17	**-0.60**	-0.41	-0.25	**-0.52**	-0.02	0.32	-0.48	-0.18	-0.08	-0.23	**-0.58**	0.18	**0.63**	-0.13	**0.55**	**0.50**									
25	0.15	**-0.53**	**0.93**	-0.39	-0.33	0.05	-0.31	0.24	**0.68**	0.00	-0.47	-0.32	-0.13	-0.08	-0.33	-0.37	0.07	-0.27	-0.47	-0.19	**0.68**	0.07	0.08	0.23								
26	**0.92**	-0.11	0.15	0.33	-0.47	-0.40	-0.24	-0.23	0.06	0.21	-0.16	**0.76**	-0.41	-0.25	-0.26	-0.28	**0.61**	-0.14	0.30	-0.33	-0.03	0.46	0.07	0.32	0.14							
27	0.30	0.07	0.06	-0.10	-0.12	-0.14	-0.46	0.18	0.45	0.03	-0.07	-0.03	**-0.64**	**0.75**	-0.26	**-0.50**	0.16	0.40	-0.29	**-0.71**	0.10	-0.34	**-0.59**	**-0.61**	0.21	0.16						
28	0.23	**0.81**	-0.31	**0.94**	**-0.60**	**-0.69**	0.03	-0.05	0.14	**0.80**	**0.73**	**0.77**	-0.48	-0.38	-0.36	0.08	**0.68**	0.26	**0.66**	0.00	-0.07	0.40	0.04	-0.21	-0.39	0.37	-0.03					
29	**-0.55**	0.15	-0.47	-0.09	0.48	0.22	0.09	0.17	-0.34	0.20	**0.55**	-0.16	**0.64**	-0.40	**0.52**	**0.50**	-0.27	0.18	-0.07	0.25	-0.14	-0.35	0.20	-0.10	-0.42	**-0.56**	**-0.65**	0.04				
30	-0.31	-0.33	**-0.51**	**-0.58**	**0.83**	0.47	-0.15	0.03	**-0.57**	-0.26	0.13	-0.34	**0.74**	0.00	**0.72**	0.25	**-0.56**	0.18	-0.41	-0.03	-0.35	**-0.64**	0.01	-0.05	-0.38	-0.42	-0.37	-0.43	**0.75**			
31	0.13	0.09	**-0.50**	-0.25	**0.81**	**0.64**	0.15	**0.64**	-0.18	-0.31	-0.07	0.02	0.04	0.28	**0.95**	**0.76**	0.12	0.43	0.09	-0.37	-0.34	**-0.55**	**-0.54**	-0.34	-0.30	-0.20	-0.06	-0.23	0.36	**0.52**		
32	-0.42	**-0.66**	0.11	**-0.58**	0.14	0.25	-0.09	-0.39	-0.23	-0.32	-0.12	-0.43	**0.83**	-0.22	-0.08	-0.45	**-0.66**	**-0.58**	**-0.70**	0.22	0.28	-0.02	**0.67**	0.26	0.11	-0.23	-0.24	-0.50	0.24	0.47	-0.37	

Table-4
Matrix of similarity of relative abundance indices of different fish species in the northern sub-area (bold numbers show positive or negative significant correlation, numbers from 1 to 32 indicate species as shown in Table-2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21	22	23	24	25	26	27	28	29	30	31	32
1																															
2	**0.77**																														
3	0.32	**0.60**																													
4	-0.14	-0.37	-0.12																												
5	**0.50**	0.28	-0.35	**-0.56**																											
6	-0.13	-0.07	-0.22	-0.37	0.32																										
7	-0.41	-0.27	0.18	0.36	-0.34	0.17																									
8	-0.09	-0.02	-0.18	-0.22	0.23	**0.98**	0.20																								
9	-0.28	-0.28	0.33	-0.03	**-0.57**	0.09	0.10	0.05																							
10	0.20	0.15	0.44	0.16	-0.43	-0.41	**-0.52**	-0.34	0.36																						
11	-0.42	**-0.83**	**-0.54**	0.45	-0.12	-0.20	-0.08	-0.22	0.03	0.19																					
12	-0.45	-0.49	-0.41	-0.06	0.33	0.18	0.31	0.12	-0.44	-0.43	**0.51**																				
13	0.26	0.11	0.16	-0.39	**0.54**	-0.16	-0.18	-0.26	-0.32	0.10	0.23	**0.57**																			
14	0.05	0.14	0.45	-0.19	-0.36	0.41	-0.12	0.43	**0.78**	0.49	-0.26	**-0.57**	-0.31																		
15	0.10	0.20	-0.11	-0.30	0.34	**0.93**	0.05	**0.97**	-0.10	-0.26	-0.34	0.06	-0.18	0.40																	
16	-0.29	0.13	0.17	-0.16	-0.28	**0.70**	0.21	**0.77**	0.23	-0.03	-0.42	-0.15	-0.49	**0.61**	**0.76**																
17	-0.44	-0.28	0.14	0.41	**-0.74**	0.33	0.27	0.44	**0.56**	0.31	0.05	-0.31	**-0.68**	**0.67**	0.33	**0.72**															
18	0.13	0.29	-0.06	-0.38	0.32	**0.90**	0.11	**0.92**	0.00	-0.41	**-0.56**	-0.14	-0.34	0.42	**0.93**	**0.74**	0.28														
19	0.11	0.11	0.32	**0.63**	-0.30	0.06	**0.76**	0.20	-0.11	-0.21	-0.19	-0.02	-0.25	-0.04	0.16	0.19	0.33	0.17													
21	-0.28	-0.37	-0.46	-0.22	0.49	-0.09	-0.02	-0.19	**-0.53**	-0.35	0.50	**0.90**	**0.70**	**-0.72**	-0.20	-0.45	**-0.63**	-0.35	-0.34												
22	-0.13	-0.08	0.19	0.39	-0.08	-0.28	**0.74**	-0.24	-0.39	-0.38	0.08	**0.53**	0.31	**-0.60**	-0.28	-0.27	-0.24	-0.32	**0.66**	0.39											
23	-0.30	-0.28	-0.14	-0.49	0.47	0.27	0.20	0.14	-0.20	-0.38	0.26	**0.86**	**0.74**	-0.31	0.09	-0.13	-0.44	-0.02	-0.24	**0.83**	0.35										
24	**-0.57**	-0.05	0.45	-0.04	-0.48	-0.08	**0.61**	-0.08	0.08	-0.11	-0.18	0.32	0.06	-0.06	-0.13	0.33	0.21	-0.13	0.25	0.15	**0.55**	0.34									
25	0.07	0.05	**0.54**	-0.35	-0.22	-0.06	-0.02	-0.16	**0.84**	0.32	-0.17	-0.41	0.10	**0.62**	-0.23	-0.07	0.08	-0.09	-0.23	-0.35	-0.28	0.02	0.05								
26	-0.02	-0.08	0.38	0.60	**-0.73**	-0.06	0.09	0.08	**0.53**	**0.66**	0.13	-0.48	-0.44	**0.64**	0.04	0.34	**0.82**	-0.05	0.41	**-0.70**	-0.16	**-0.61**	-0.01	0.20							
27	0.33	0.28	-0.38	-0.23	0.45	-0.06	-0.25	-0.11	-0.30	**-0.51**	-0.39	-0.31	-0.28	-0.36	-0.06	-0.28	-0.49	0.20	-0.22	-0.05	-0.23	-0.28	-0.46	-0.15	**-0.57**						
28	-0.42	0.13	0.25	-0.27	-0.37	-0.14	-0.18	-0.13	-0.01	0.33	-0.15	0.05	-0.01	0.10	-0.06	0.41	0.21	-0.13	-0.35	0.09	-0.12	0.08	**0.63**	-0.09	0.02	-0.31					
29	0.25	-0.19	-0.30	0.27	0.35	0.21	-0.23	0.27	-0.32	0.23	**0.57**	0.37	0.39	-0.05	0.31	-0.12	0.00	0.01	0.10	0.27	0.00	0.18	-0.48	-0.37	0.21	-0.40	-0.35				
30	**0.65**	0.44	0.15	-0.19	0.42	-0.34	**-0.76**	-0.33	-0.34	**0.60**	0.12	-0.07	**0.61**	-0.06	-0.13	-0.40	-0.45	-0.30	-0.37	0.18	-0.23	0.01	-0.44	-0.05	-0.03	-0.08	0.06	**0.52**			
31	0.00	0.15	**-0.59**	-0.32	**0.56**	0.41	-0.15	0.40	-0.64	**-0.65**	-0.28	0.20	-0.20	-0.41	0.47	0.22	-0.28	**0.53**	-0.18	0.26	-0.14	0.09	-0.18	**-0.65**	**-0.63**	**0.65**	0.06	-0.07	-0.13		
32	-0.31	-0.38	-0.19	-0.41	0.36	-0.10	-0.06	-0.26	-0.11	-0.14	0.47	**0.75**	**0.78**	-0.39	-0.31	-0.45	**-0.55**	-0.41	**-0.50**	**0.88**	0.23	**0.89**	0.22	0.13	**-0.59**	-0.21	0.13	0.12	0.19	-0.08	

Table-5
Matrix of similarity of relative abundance indices of different fish species in the central sub-area (bold numbers show positive or negative significant correlation, numbers from 1 to 32 indicate species as shown in Table-2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21	22	23	24	25	26	27	28	29	30	31	32
1																															
2	**0.95**																														
3	0.02	0.09																													
4	0.06	-0.18	0.14																												
5	**0.77**	**0.86**	-0.04	**-0.51**																											
6	-0.26	-0.32	-0.41	0.00	0.04																										
7	-0.08	-0.02	**0.94**	0.33	-0.28	**-0.53**																									
8	0.27	0.06	-0.21	0.13	0.08	0.01	-0.30																								
9	-0.20	-0.23	0.02	0.06	-0.41	-0.48	0.15	**0.53**																							
10	0.10	-0.18	-0.27	**0.61**	-0.40	-0.22	-0.14	**0.61**	0.39																						
11	0.29	0.00	-0.21	**0.53**	-0.15	-0.15	-0.18	**0.73**	0.29	**0.95**																					
12	**0.85**	**0.69**	-0.20	0.15	**0.52**	-0.26	-0.27	**0.65**	0.09	**0.51**	**0.65**																				
13	**0.69**	**0.77**	-0.05	-0.40	**0.89**	-0.03	-0.24	-0.12	**-0.51**	-0.30	-0.07	0.39																			
14	0.00	0.01	0.03	-0.32	0.29	**0.51**	-0.20	0.48	0.08	-0.32	-0.17	0.08	-0.08																		
15	**0.76**	**0.84**	-0.02	-0.42	**0.95**	-0.03	-0.23	-0.06	-0.49	-0.34	-0.09	0.46	**0.99**	0.03																	
16	**0.81**	**0.63**	0.08	0.40	0.31	-0.44	0.08	**0.51**	0.09	**0.58**	**0.67**	**0.92**	0.23	-0.12	0.30																
17	-0.02	-0.05	-0.27	0.30	-0.32	-0.26	-0.03	0.18	**0.68**	0.29	0.17	0.05	-0.27	-0.23	-0.28	0.02															
18	-0.36	-0.32	**0.73**	-0.01	-0.31	-0.18	**0.66**	-0.04	0.10	-0.15	-0.18	-0.30	-0.47	0.28	-0.42	-0.07	**-0.51**														
19	0.29	0.02	-0.40	0.78	-0.16	0.32	-0.30	0.34	-0.12	**0.66**	**0.67**	0.44	-0.07	-0.17	-0.09	0.46	0.29	-0.48													
21	0.48	0.22	-0.41	0.45	0.00	-0.21	-0.34	**0.66**	0.23	**0.89**	**0.90**	**0.82**	-0.01	-0.20	0.01	**0.80**	0.21	-0.32	**0.69**												
22	-0.30	-0.21	-0.35	-0.25	-0.27	-0.31	-0.17	0.03	**0.70**	0.04	-0.11	-0.22	-0.20	-0.21	-0.24	-0.34	**0.80**	-0.40	-0.22	-0.07											
23	-0.46	-0.32	-0.25	-0.50	-0.19	-0.12	-0.19	**-0.51**	-0.19	-0.19	-0.36	-0.41	-0.10	-0.36	-0.15	-0.41	-0.33	0.13	-0.49	-0.23	0.16										
24	-0.36	-0.27	0.00	-0.19	-0.30	-0.20	0.10	-0.45	-0.18	-0.11	-0.32	-0.28	-0.36	-0.25	-0.35	-0.14	-0.41	0.46	-0.37	-0.13	-0.13	**0.84**									
25	-0.35	-0.29	-0.47	-0.38	-0.26	-0.15	-0.36	-0.09	0.15	0.10	-0.10	-0.09	-0.34	-0.16	-0.34	-0.14	-0.09	0.09	-0.28	0.13	0.29	**0.84**	**0.80**								
26	-0.27	-0.26	-0.06	0.16	-0.46	-0.44	0.16	0.09	**0.76**	0.28	0.14	-0.18	-0.29	-0.38	-0.35	-0.17	**0.87**	-0.29	-0.01	0.04	**0.87**	-0.11	-0.31	-0.03							
27	-0.20	-0.19	**0.81**	0.32	-0.28	-0.04	**0.78**	0.03	0.22	-0.21	-0.19	-0.29	-0.44	0.40	-0.38	-0.07	-0.05	**0.73**	-0.19	-0.39	-0.26	-0.47	-0.12	-0.48	0.00						
28	**0.56**	0.34	0.35	**0.77**	0.01	-0.21	0.38	0.45	0.14	**0.53**	**0.61**	**0.60**	-0.05	0.00	0.01	**0.78**	0.18	0.07	**0.62**	**0.56**	-0.39	**-0.78**	-0.42	**-0.58**	-0.02	0.41					
29	0.39	0.31	-0.49	0.28	0.18	0.05	-0.38	0.04	-0.02	0.27	0.30	0.30	0.41	-0.41	0.35	0.18	**0.62**	**-0.93**	**0.60**	0.35	0.36	-0.36	**-0.61**	-0.34	0.43	**-0.51**	0.20				
30	**0.59**	**0.64**	-0.09	-0.44	**0.86**	0.11	-0.33	0.00	-0.49	-0.27	0.00	0.34	**0.97**	0.04	**0.95**	0.14	-0.31	-0.45	-0.07	-0.02	-0.21	-0.13	-0.44	-0.37	-0.30	-0.43	-0.09	0.37			
31	**0.96**	**0.97**	-0.08	-0.21	**0.86**	-0.25	-0.20	0.23	-0.16	-0.08	0.10	**0.80**	**0.73**	0.11	**0.81**	**0.67**	-0.02	-0.39	0.09	0.35	-0.16	-0.31	-0.28	-0.19	-0.27	-0.29	0.33	0.33	**0.62**		
32	-0.48	-0.34	-0.11	**-0.58**	0.03	0.19	-0.22	-0.39	-0.28	-0.34	-0.30	**-0.56**	0.28	-0.17	0.16	**-0.67**	-0.35	-0.05	-0.48	-0.48	0.16	**0.58**	0.12	0.18	0.01	-0.36	**-0.78**	-0.08	0.39	-0.38	

Table-6
Matrix of similarity of relative abundance indices of different fish species in the southern sub-area (bold numbers show positive or negative significant correlation, numbers from 1 to 32 indicate species as shown in Table-2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1																																
2	-0.15																															
3	0.05	-0.28																														
4	**0.74**	0.11	0.05																													
5	-0.49	-0.34	-0.10	-0.41																												
6	-0.01	-0.30	0.47	0.01	0.23																											
7	-0.34	0.32	-0.29	0.22	0.27	0.37																										
8	-0.08	-0.31	0.07	-0.23	-0.50	0.03	-0.19																									
9	-0.07	0.25	0.46	-0.22	**-0.62**	0.28	-0.19	**0.57**																								
10	**0.63**	0.43	0.06	0.46	**-0.60**	-0.12	-0.32	-0.26	0.21																							
11	-0.31	0.23	**-0.51**	-0.17	0.42	0.36	**0.63**	-0.30	-0.26	-0.01																						
12	**0.63**	0.13	**-0.64**	**0.58**	-0.46	-0.27	0.11	0.10	-0.25	0.45	0.21																					
13	-0.22	-0.07	0.13	-0.11	0.15	**0.89**	**0.60**	0.21	0.35	-0.21	**0.58**	-0.11																				
14	0.39	0.00	-0.37	0.24	-0.21	**-0.63**	-0.26	0.09	-0.21	-0.11	**-0.54**	0.34	**-0.60**																			
15	-0.23	-0.28	-0.24	**-0.66**	-0.11	0.07	-0.25	**0.75**	0.42	-0.28	0.11	0.04	0.29	-0.01																		
16	-0.33	-0.18	-0.45	-0.16	-0.09	-0.39	0.18	**0.65**	-0.12	**-0.56**	-0.06	0.26	-0.09	0.30	0.44																	
17	**0.75**	0.37	-0.28	**0.74**	**-0.65**	-0.43	-0.15	-0.15	-0.12	**0.79**	-0.12	**0.81**	-0.42	0.33	-0.35	-0.10																
18	-0.21	0.73	-0.23	-0.31	-0.17	-0.48	-0.25	-0.33	0.16	**0.52**	0.17	-0.05	-0.36	-0.11	-0.03	-0.29	0.25															
19	**0.91**	-0.15	-0.11	**0.76**	-0.17	-0.07	-0.19	-0.40	-0.44	**0.55**	-0.11	**0.62**	-0.30	0.37	-0.44	-0.37	**0.72**	-0.18														
20	**-0.53**	0.07	0.11	0.09	**0.55**	0.33	**0.75**	-0.38	-0.37	-0.39	0.43	-0.31	0.35	**-0.51**	**-0.50**	0.05	-0.36	-0.21	-0.28													
21	0.02	-0.15	**0.52**	-0.14	-0.27	**0.80**	0.03	0.46	**0.77**	0.10	0.10	-0.21	**0.77**	**-0.55**	0.41	-0.26	-0.29	-0.23	-0.26	-0.11												
22	0.45	0.23	0.04	**0.90**	-0.22	0.22	**0.54**	-0.34	-0.24	0.37	0.16	0.46	0.17	-0.11	**-0.71**	-0.18	**0.56**	-0.27	**0.54**	0.44	-0.04											
23	0.22	0.36	-0.01	0.48	-0.29	**0.56**	**0.60**	-0.08	0.22	0.44	**0.56**	0.40	**0.67**	**-0.52**	-0.18	-0.26	0.33	-0.05	0.18	0.30	0.50	**0.71**										
24	**0.91**	-0.23	0.33	**0.72**	-0.27	0.10	-0.36	-0.29	-0.13	**0.54**	-0.42	0.31	-0.26	0.30	-0.47	**-0.54**	**0.56**	-0.26	**0.89**	-0.33	0.00	0.47	0.11									
25	**0.64**	-0.28	0.49	0.13	-0.40	0.26	**-0.63**	0.20	**0.49**	0.37	**-0.52**	-0.04	-0.01	0.21	0.17	-0.50	0.15	-0.14	0.38	**-0.71**	0.50	-0.15	-0.06	**0.67**								
26	**0.96**	-0.15	0.01	**0.82**	-0.34	-0.02	-0.22	-0.25	-0.28	**0.62**	-0.19	**0.64**	-0.25	0.30	-0.41	-0.35	**0.77**	-0.22	**0.97**	-0.32	-0.11	**0.59**	0.27	**0.92**	0.46							
27	0.29	0.05	0.05	-0.19	**-0.70**	0.02	**-0.51**	**0.61**	**0.72**	0.48	-0.12	0.26	0.11	-0.06	**0.66**	-0.03	0.25	0.27	-0.05	**-0.77**	**0.57**	-0.34	0.16	0.04	**0.57**	0.08						
28	0.08	**0.86**	-0.32	0.28	**-0.57**	-0.34	0.18	-0.14	0.21	**0.68**	0.25	0.45	-0.12	-0.12	-0.21	-0.07	**0.66**	**0.69**	0.04	-0.03	-0.10	0.37	**0.51**	-0.11	-0.27	0.10	0.28					
29	-0.42	0.12	0.25	-0.03	-0.09	-0.37	-0.02	0.07	-0.05	-0.05	-0.23	-0.25	-0.35	-0.28	-0.29	0.33	-0.01	0.19	-0.38	0.44	-0.28	0.08	-0.16	-0.33	**-0.53**	-0.31	-0.23	0.26				
30	-0.06	0.02	-0.09	-0.26	-0.47	-0.28	-0.24	**0.75**	**0.55**	-0.29	-0.50	0.02	-0.09	**0.57**	**0.60**	**0.51**	-0.11	-0.09	-0.35	**-0.57**	0.15	-0.48	-0.36	-0.23	0.29	-0.29	0.46	-0.09	-0.16			
31	0.35	-0.28	-0.38	0.46	-0.11	-0.25	0.20	0.27	-0.37	-0.36	-0.27	**0.51**	-0.18	**0.74**	-0.01	**0.59**	0.24	**-0.63**	0.36	-0.10	-0.37	0.26	-0.16	0.22	-0.06	0.33	-0.26	-0.26	-0.20	0.40		
32	-0.12	-0.46	**0.58**	-0.31	**0.62**	**0.67**	-0.12	-0.34	-0.02	-0.17	0.11	**-0.66**	0.35	-0.49	-0.08	**-0.63**	**-0.60**	-0.20	-0.04	0.22	0.39	-0.20	-0.07	0.17	0.32	-0.09	-0.19	**-0.62**	-0.25	-0.45	-0.49	

Table-7
Survey indices of the most common groundfish species in different parts of the study area, summer-autumn 1993-2000 (numbers from 1 to 32 are species as in Table-2)

Year	Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1993	Southern	1.4	12.4	0.0	0.0	9.2	1133.2	0.1	0.0	2.4	1.2	85.8	382.7	4.1	0.0	0.1	110.0	0.3	58.2	0.5	1.1	102.1	9.1	50.8	0.0	5.5	2.6	3.0	9.3	0.4	2.1	0.2	2.8
	Central	0.9	2.0	0.4	0.0	36.7	805.5	0.0	0.0	2.8	2.8	31.3	8.3	8.2	4.0	6.7	0.8	1.4	79.7	0.5	0.0	0.1	0.2	16.6	2.5	7.3	4.3	0.8	2.4	11.3	270.3	0.1	7.6
	Northern	0.0	0.0	0.0	0.0	25.9	816.7	2.2	0.0	0.0	2.5	9.0	23.9	20.8	0.0	1.1	0.0	0.0	0.0	0.0	0.0	14.9	6.1	60.0	22.7	0.0	0.0	0.0	12.0	48.8	175.0	1.1	9.6
	All	**0.7**	**4.8**	**0.1**	**0.0**	**23.6**	**920.0**	**0.8**	**0.0**	**1.7**	**2.1**	**41.7**	**140.2**	**11.4**	**1.2**	**2.5**	**37.3**	**0.5**	**43.7**	**0.3**	**0.4**	**39.8**	**5.3**	**43.8**	**8.9**	**4.1**	**2.2**	**1.2**	**8.2**	**21.2**	**145.5**	**0.5**	**6.7**
1994	Southern	1.0	5.7	12.0	0.8	6.4	673.7	0.0	0.1	5.0	1.9	2.0	165.4	0.0	0.5	0.0	85.9	2.4	109.1	0.2	1.1	30.6	8.2	25.8	0.2	11.2	2.7	1.2	7.1	3.3	2.4	0.1	2.9
	Central	0.4	0.5	0.2	0.0	8.0	498.8	0.0	0.0	6.5	8.6	0.0	14.8	0.0	0.0	0.0	8.8	0.0	153.3	0.0	0.0	20.0	0.4	37.2	46.8	46.3	0.0	0.1	2.0	0.9	31.5	0.5	3.2
	Northern	7.8	0.7	0.7	0.0	23.5	477.7	0.7	0.0	3.9	7.7	0.1	1.8	17.7	20.5	2.4	2.7	7.5	155.4	2.5	0.0	0.6	3.2	21.4	10.1	94.9	16.9	1.4	7.0	47.9	281.7	0.3	2.0
	All	**2.9**	**2.8**	**5.4**	**0.4**	**11.9**	**567.4**	**0.2**	**0.0**	**5.1**	**5.5**	**0.9**	**75.4**	**5.3**	**6.3**	**0.7**	**40.0**	**3.3**	**135.0**	**0.8**	**0.5**	**18.7**	**4.6**	**27.6**	**15.9**	**45.8**	**6.2**	**0.9**	**5.7**	**16.0**	**93.8**	**0.3**	**2.7**
1995	Southern	7.8	9.9	12.1	0.4	0.2	1290.3	0.0	0.4	18.4	3.2	10.5	282.7	4.1	0.6	0.1	48.0	4.0	32.8	0.0	0.0	358.2	5.5	49.9	0.3	36.8	11.3	16.6	10.8	0.7	11.0	0.1	2.7
	Central	0.0	0.4	0.1	0.0	2.3	373.6	0.0	0.1	17.1	7.9	1.4	10.5	0.6	4.3	0.1	1.4	58.1	41.1	0.1	0.0	9.9	13.4	15.7	5.0	25.2	22.1	1.2	2.3	14.7	58.9	0.4	3.3
	Northern	0.1	0.0	0.4	0.0	5.1	895.2	2.6	0.0	15.4	6.0	5.3	3.0	5.6	28.8	0.0	5.1	31.3	73.4	0.0	0.0	0.5	0.3	27.9	18.8	194.0	18.4	0.0	8.4	16.4	82.6	0.0	4.8
	All	**3.8**	**5.0**	**6.0**	**0.2**	**1.9**	**929.7**	**0.6**	**0.2**	**17.4**	**5.2**	**6.6**	**141.4**	**3.4**	**7.7**	**0.1**	**24.9**	**26.1**	**43.9**	**0.0**	**0.0**	**177.5**	**6.8**	**34.9**	**5.6**	**66.4**	**16.1**	**8.4**	**7.7**	**8.2**	**40.6**	**0.2**	**3.3**
1996	Southern	21.8	13.1	4.4	6.3	0.8	628.8	0.0	0.1	3.6	5.7	9.0	590.9	0.0	8.7	0.0	23.4	38.8	36.5	3.4	0.0	29.5	18.5	47.9	0.8	29.2	120.3	7.9	22.1	0.7	4.2	0.4	1.2
	Central	1.6	5.2	1.3	24.7	0.0	194.4	0.0	0.0	10.9	5.1	2.6	10.5	0.0	0.1	0.0	12.0	20.1	208.2	0.0	0.0	0.0	0.0	4.6	13.8	3.8	9.6	12.5	7.4	3.3	24.5	0.2	0.7
	Northern	0.5	0.4	0.5	0.0	2.1	438.7	0.8	0.0	5.7	7.5	0.0	1.6	0.7	21.1	1.9	15.6	35.5	145.7	0.2	0.0	0.1	0.5	12.0	31.6	42.1	17.5	1.6	23.6	10.1	147.3	1.0	1.1
	All	**11.0**	**7.8**	**2.6**	**9.3**	**1.0**	**468.5**	**0.2**	**0.0**	**6.0**	**6.0**	**5.0**	**287.8**	**0.2**	**9.8**	**0.5**	**18.4**	**33.2**	**108.9**	**1.7**	**0.0**	**14.3**	**9.1**	**27.4**	**12.3**	**26.2**	**65.1**	**7.4**	**18.8**	**3.8**	**47.2**	**0.5**	**1.0**
1997	Southern	5.5	29.3	5.2	0.0	5.7	520.6	0.0	0.0	7.9	1.8	0.2	225.6	0.0	11.0	0.0	1.3	4.3	205.0	0.7	0.1	9.3	2.0	18.9	0.3	26.8	6.0	4.3	6.3	0.2	10.4	0.3	2.4
	Central	0.8	0.6	0.5	0.0	29.5	981.7	0.0	0.2	10.6	0.7	2.6	15.6	0.0	287.1	0.8	4.6	10.3	165.8	0.3	0.0	3.7	0.1	1.8	3.3	12.8	1.2	9.0	4.5	1.3	82.8	0.9	1.6
	Northern	4.2	0.4	0.0	0.0	26.3	703.5	0.8	0.0	2.3	0.8	0.1	1.0	0.0	6.7	1.5	1.0	1.4	245.0	0.5	0.0	2.2	0.7	10.6	2.7	32.1	1.3	34.2	4.9	14.2	121.5	1.7	1.0
	All	**3.5**	**10.9**	**2.0**	**0.0**	**20.0**	**734.1**	**0.2**	**0.1**	**7.2**	**1.1**	**1.0**	**86.9**	**0.0**	**105.4**	**0.7**	**2.3**	**5.5**	**203.2**	**0.5**	**0.0**	**5.3**	**0.9**	**10.5**	**2.1**	**23.5**	**2.9**	**14.7**	**5.3**	**4.7**	**68.1**	**0.9**	**1.7**
1998	Southern	4.2	0.8	0.1	0.0	2.6	255.3	0.0	0.5	6.4	0.2	1.2	449.2	0.0	11.0	0.1	425.4	9.6	0.3	0.1	0.0	0.2	1.3	18.1	0.0	12.8	0.0	9.2	5.9	1.7	14.3	0.5	0.0
	Central	8.2	30.5	0.4	0.0	90.2	417.5	0.0	0.1	5.8	1.8	28.5	36.7	11.2	66.1	12.0	22.3	19.3	40.1	1.0	0.0	27.8	0.3	3.1	1.2	9.2	1.8	0.7	6.3	14.4	279.1	9.5	0.3
	Northern	1.6	0.2	0.1	0.0	20.2	3535.1	3.4	0.3	6.0	2.1	1.4	8.6	0.2	27.1	9.2	21.5	42.7	626.8	2.9	0.0	0.0	0.5	28.0	14.0	28.2	16.9	1.7	7.9	46.9	73.4	1.4	0.2
	All	**5.0**	**12.0**	**0.2**	**0.0**	**41.2**	**1245.2**	**0.9**	**0.3**	**6.1**	**1.3**	**11.7**	**166.3**	**4.3**	**36.7**	**7.3**	**156.4**	**22.7**	**192.8**	**1.3**	**0.0**	**10.7**	**0.7**	**15.1**	**4.4**	**15.8**	**5.5**	**3.8**	**6.6**	**19.4**	**132.6**	**4.2**	**0.2**
1999	Southern	4.0	54.7	0.7	0.1	0.3	248.8	0.0	0.1	10.7	5.7	39.8	438.2	0.1	2.9	0.1	96.6	25.9	494.2	0.2	0.1	43.8	5.4	43.5	0.0	11.6	4.5	13.7	51.2	2.1	7.1	0.0	0.3
	Central	3.7	4.3	0.2	31.7	5.7	432.8	0.0	0.3	13.7	36.7	332.6	36.0	1.0	14.0	0.7	24.9	29.9	87.4	3.2	0.0	66.9	1.3	0.3	0.0	14.9	10.0	2.1	8.7	12.7	87.6	2.2	0.1
	Northern	2.3	0.0	0.0	20.0	6.8	274.7	0.0	0.0	5.7	8.5	10.4	3.3	0.3	17.2	1.1	3.3	38.1	0.7	1.6	0.0	0.5	0.0	0.1	0.0	8.5	28.0	0.4	7.1	62.1	198.7	0.5	0.1
	All	**3.5**	**27.3**	**0.4**	**13.8**	**3.4**	**307.6**	**0.0**	**0.2**	**10.3**	**15.2**	**116.5**	**219.7**	**0.4**	**9.5**	**0.5**	**53.9**	**30.0**	**260.5**	**1.4**	**0.0**	**40.1**	**3.0**	**20.8**	**0.0**	**11.8**	**11.7**	**7.2**	**28.5**	**19.4**	**75.7**	**0.8**	**0.2**
2000	Southern	3.2	47.2	4.5	4.1	1.4	740.5	0.1	0.2	9.5	2.0	25.5	397.4	2.5	5.4	0.0	208.1	16.4	59.5	0.1	1.2	73.2	19.0	56.8	0.1	4.8	5.6	2.1	34.0	2.1	8.7	0.4	0.1
	Central	1.6	1.4	0.1	36.0	0.4	988.0	0.0	0.0	4.5	10.3	35.4	13.1	0.4	12.7	0.1	7.5	33.5	41.0	3.5	0.0	19.7	0.4	3.5	6.5	9.1	5.7	3.7	6.3	16.4	43.2	0.4	0.1
	Northern	0.8	0.2	0.4	19.8	0.7	298.5	7.2	0.0	4.8	2.3	2.8	8.1	0.3	9.1	0.5	6.7	32.6	81.7	6.6	0.0	0.7	9.8	15.7	31.7	26.8	20.4	0.8	7.3	22.0	27.3	0.5	0.2
	All	**2.2**	**23.7**	**2.4**	**16.0**	**1.0**	**683.8**	**2.0**	**0.1**	**7.1**	**4.1**	**21.9**	**201.8**	**1.4**	**8.1**	**0.2**	**106.5**	**24.8**	**60.9**	**2.7**	**0.6**	**41.1**	**12.1**	**33.1**	**10.0**	**11.7**	**9.6**	**2.2**	**20.3**	**10.8**	**22.0**	**0.4**	**0.1**

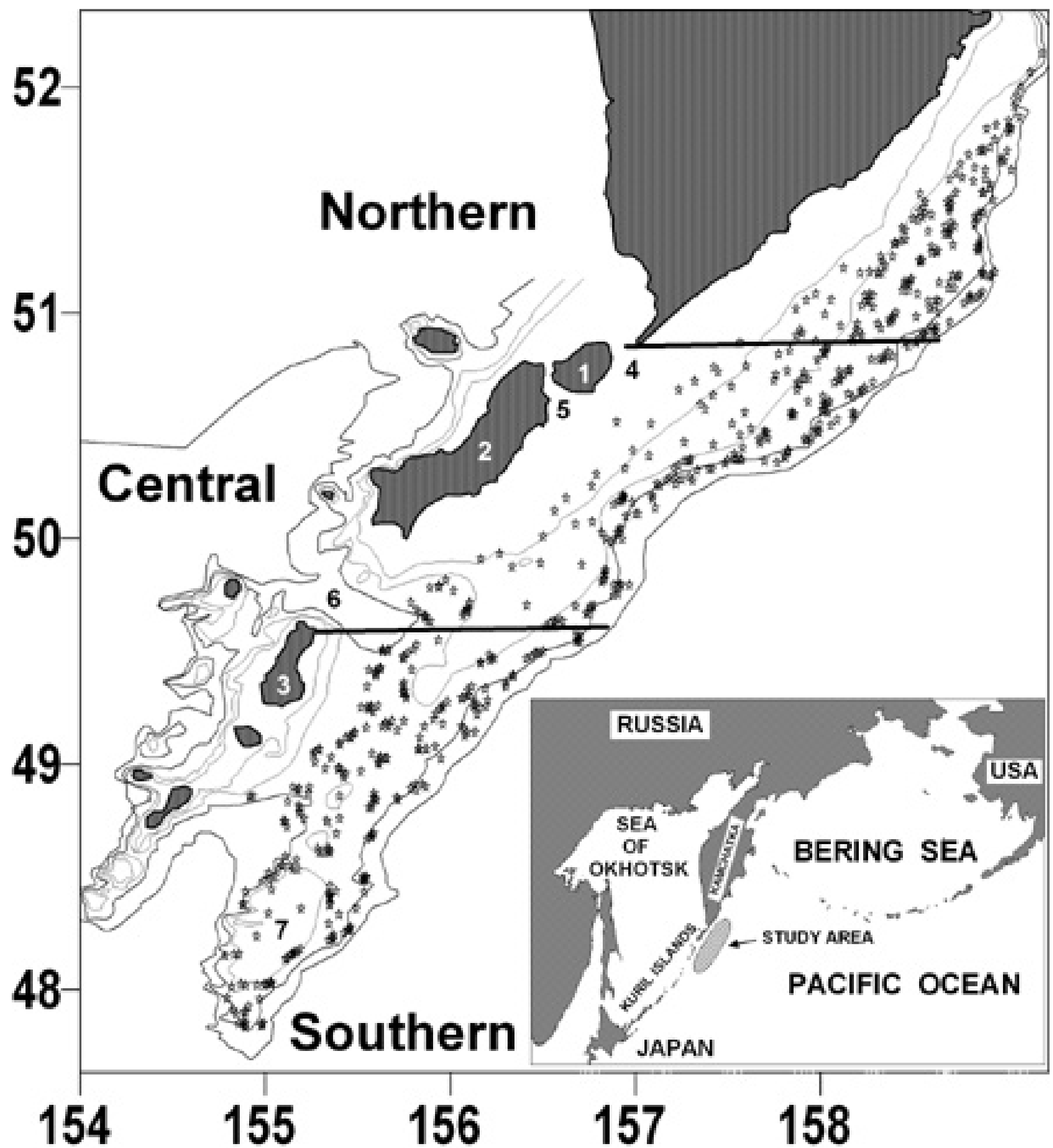

Figure-1

Map of the study area (with sub-areas) showing positions (asterisks) of bottom trawl and oceanological stations (thin line are isobaths 100, 200, 500 and 1000 m; 1 – Shumshu Isl., 2 – Paramushir Isl., 3 – Onekotan Isl., 4 – First Kuril Strait, 5 – Second Kuril Strait, 6 – Fourth Kuril Strait, 7 – underwater plateau)

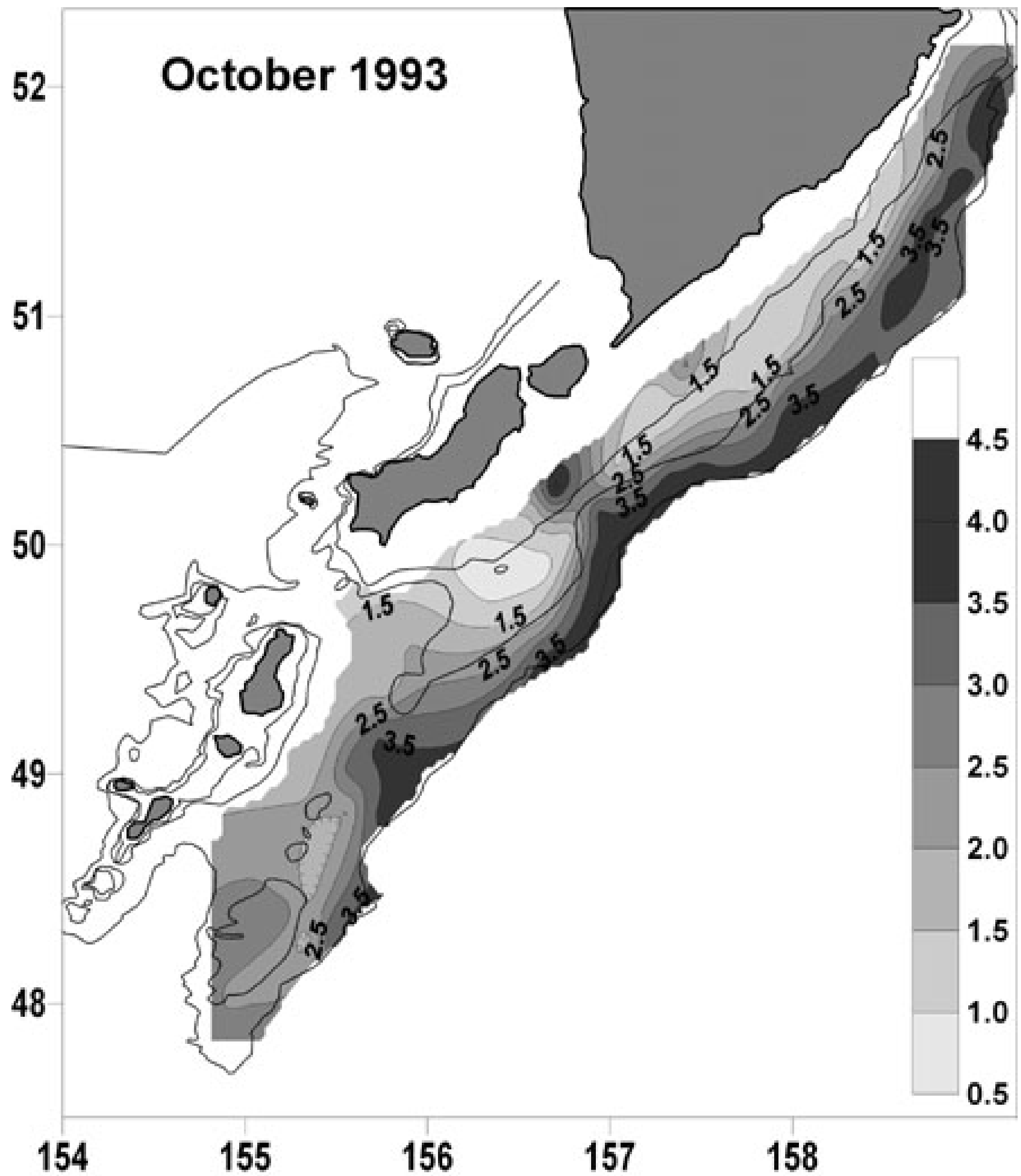

Figure-2
Distribution of bottom temperatures in study area in October 1993

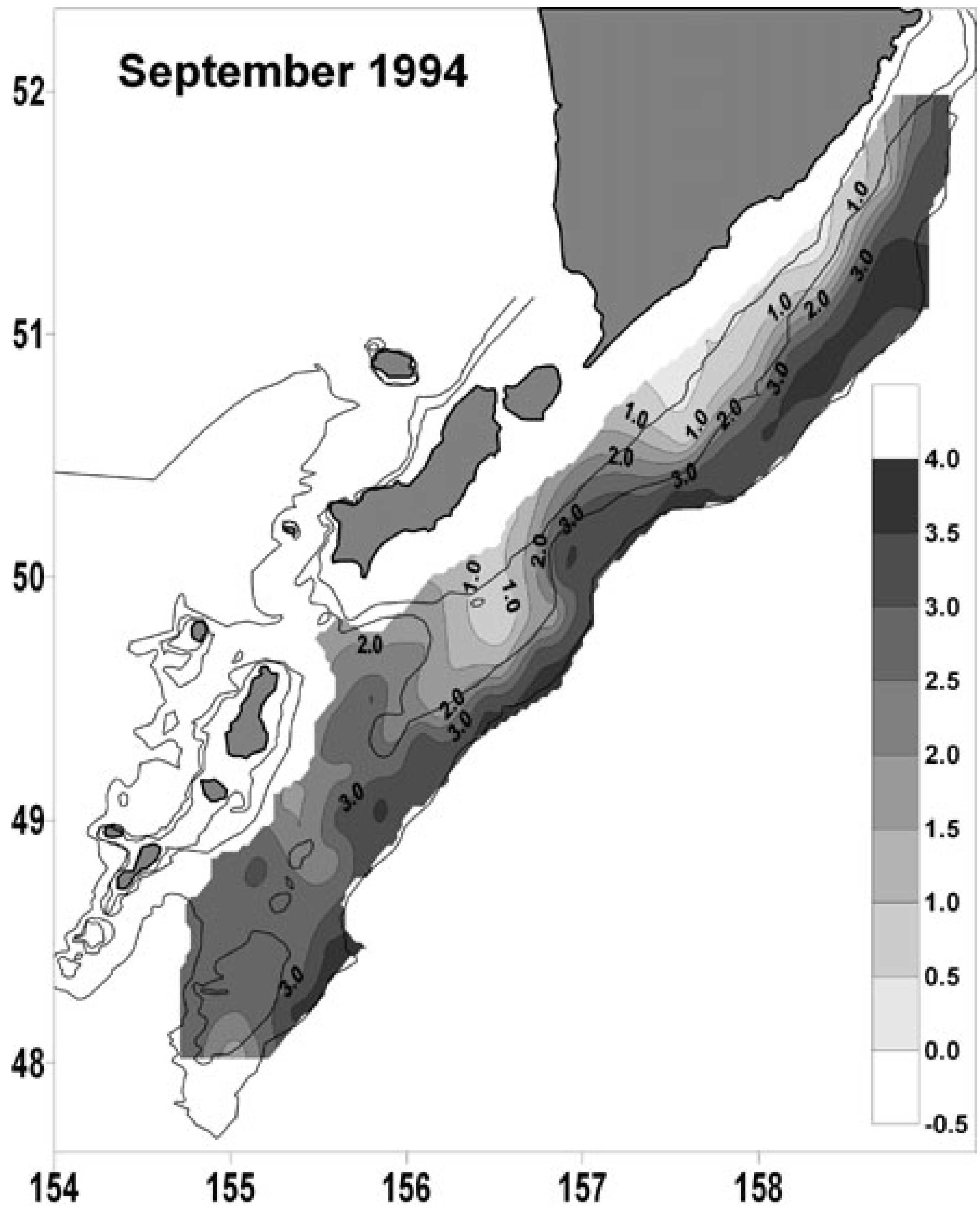

Figure-3
Distribution of bottom temperatures in study area in September 1994

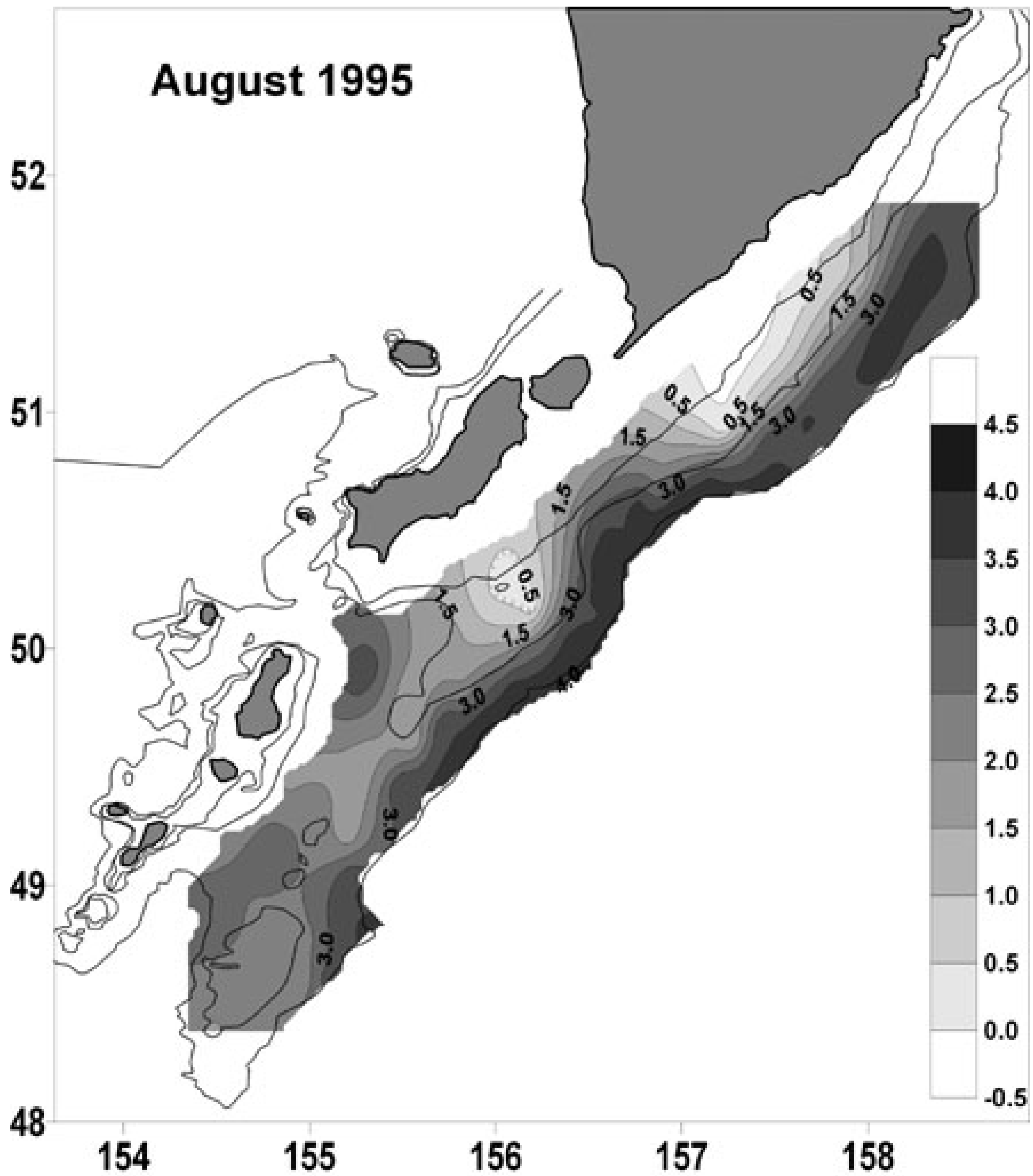

Figure-4
Distribution of bottom temperatures in study area in August 1995

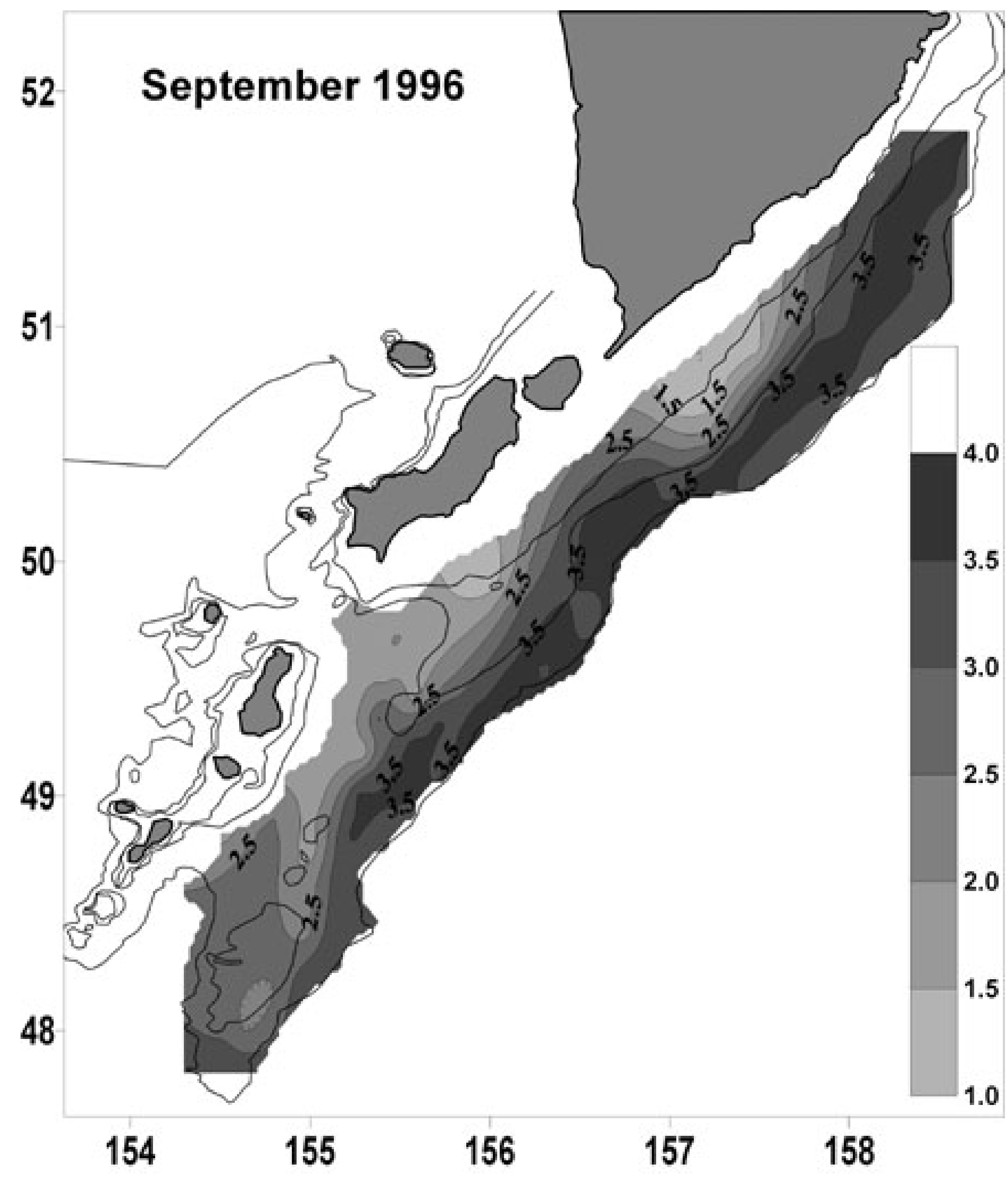

Figure-5
Distribution of bottom temperatures in study area in September 1996

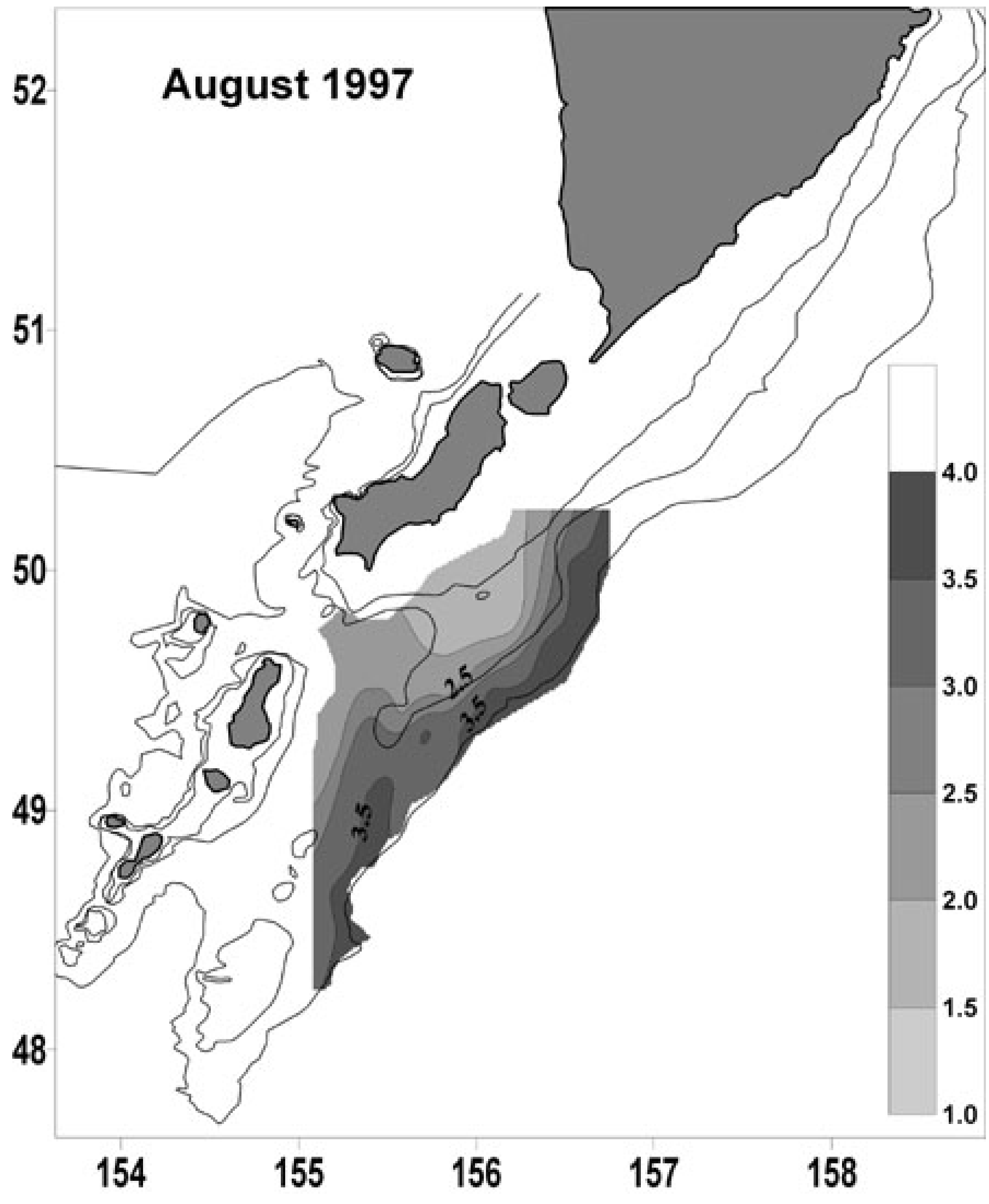

Figure-6
Distribution of bottom temperatures in study area in August 1997

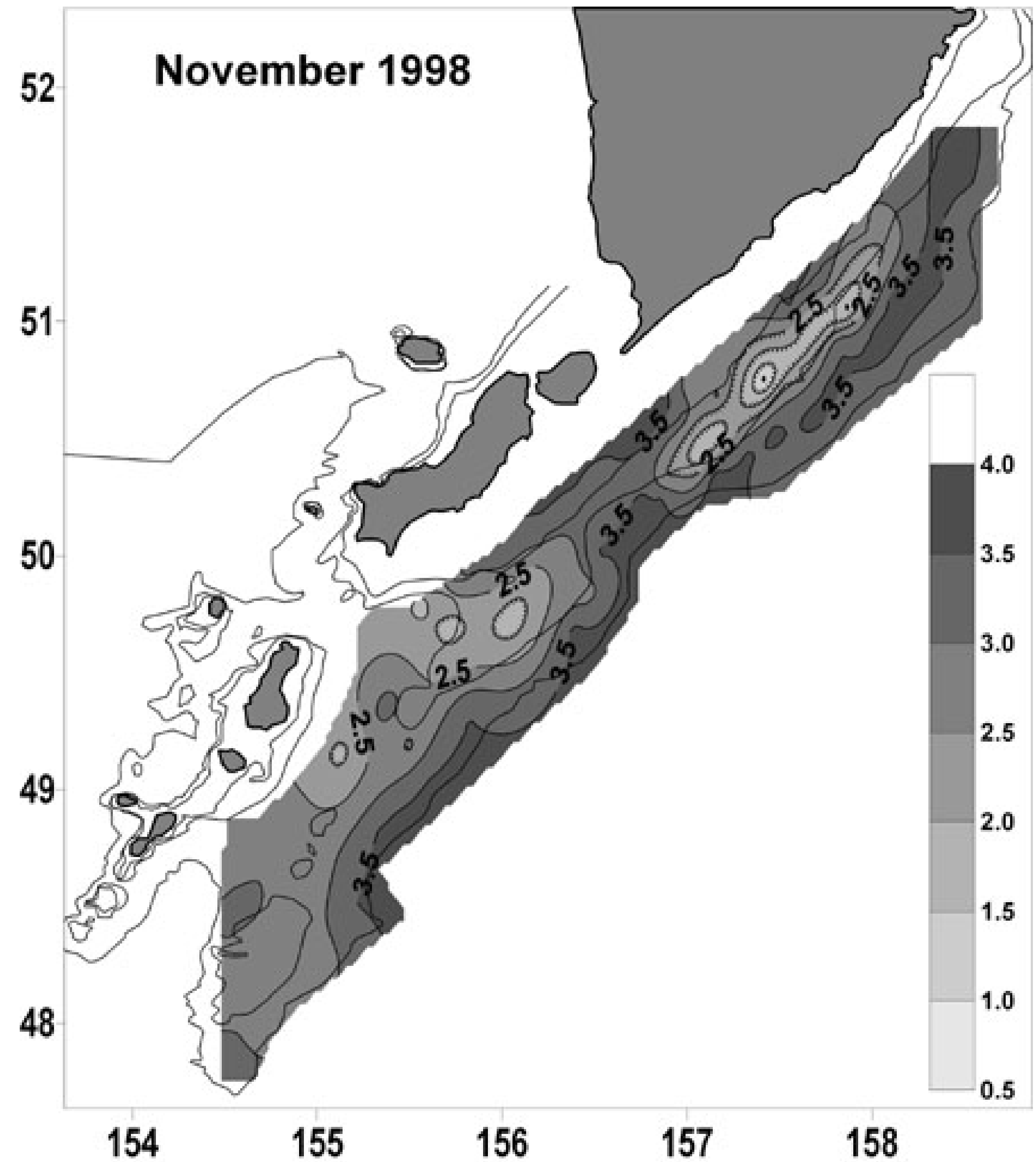

Figure-7
Distribution of bottom temperatures in study area in November 1998

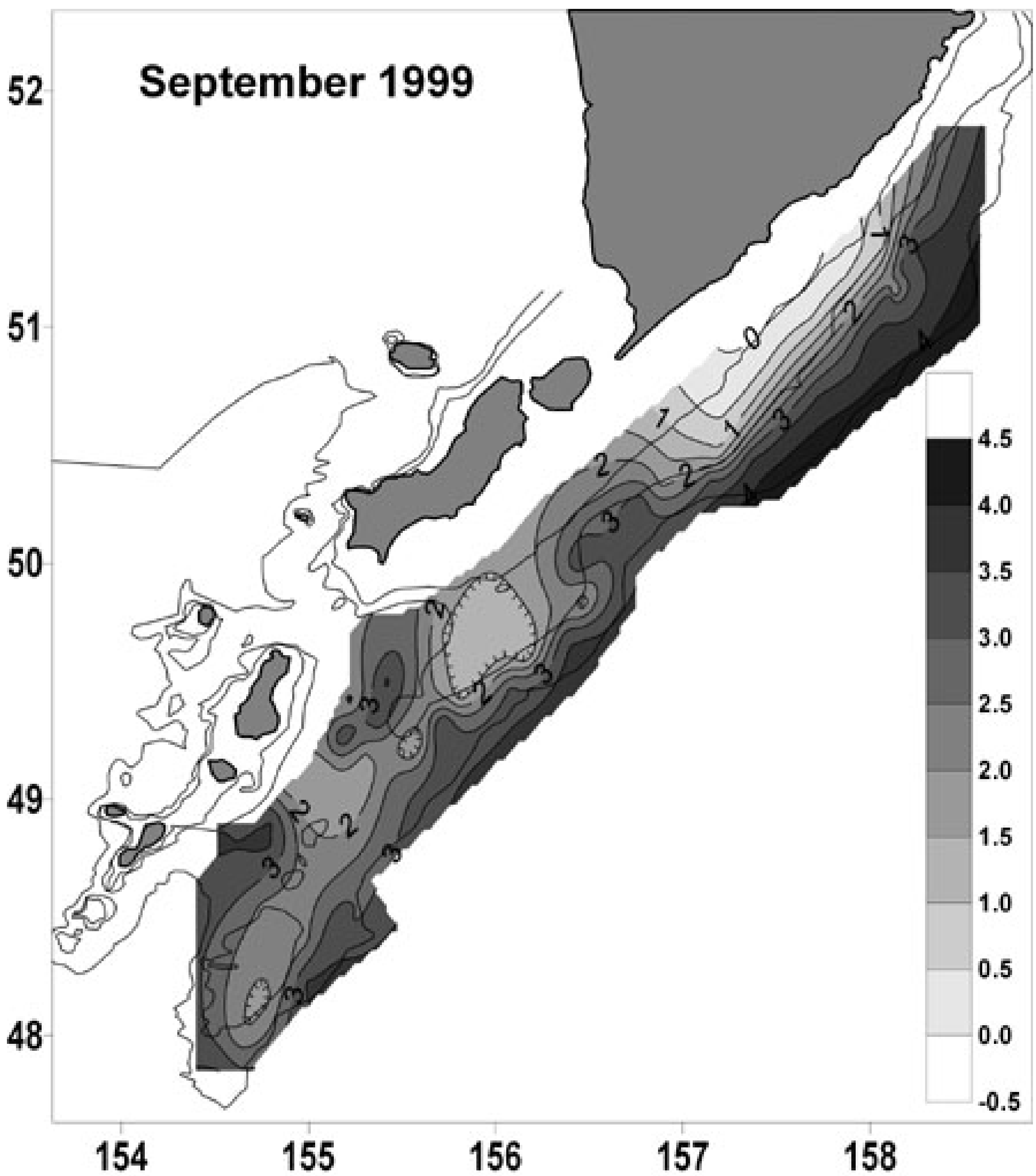

Figure-8
Distribution of bottom temperatures in study area in September 1999

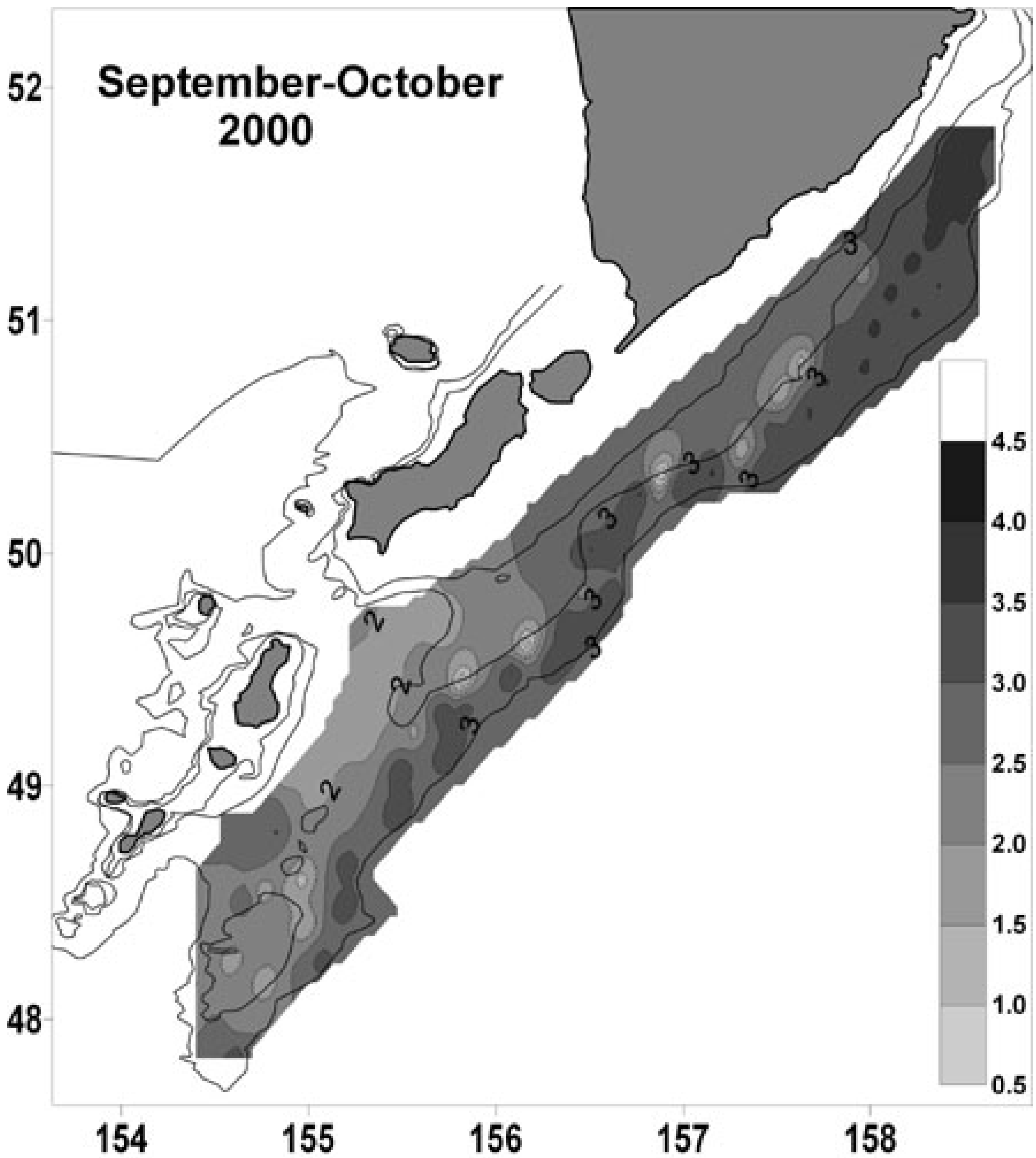

Figure-9
Distribution of bottom temperatures in study area in September-October 2000

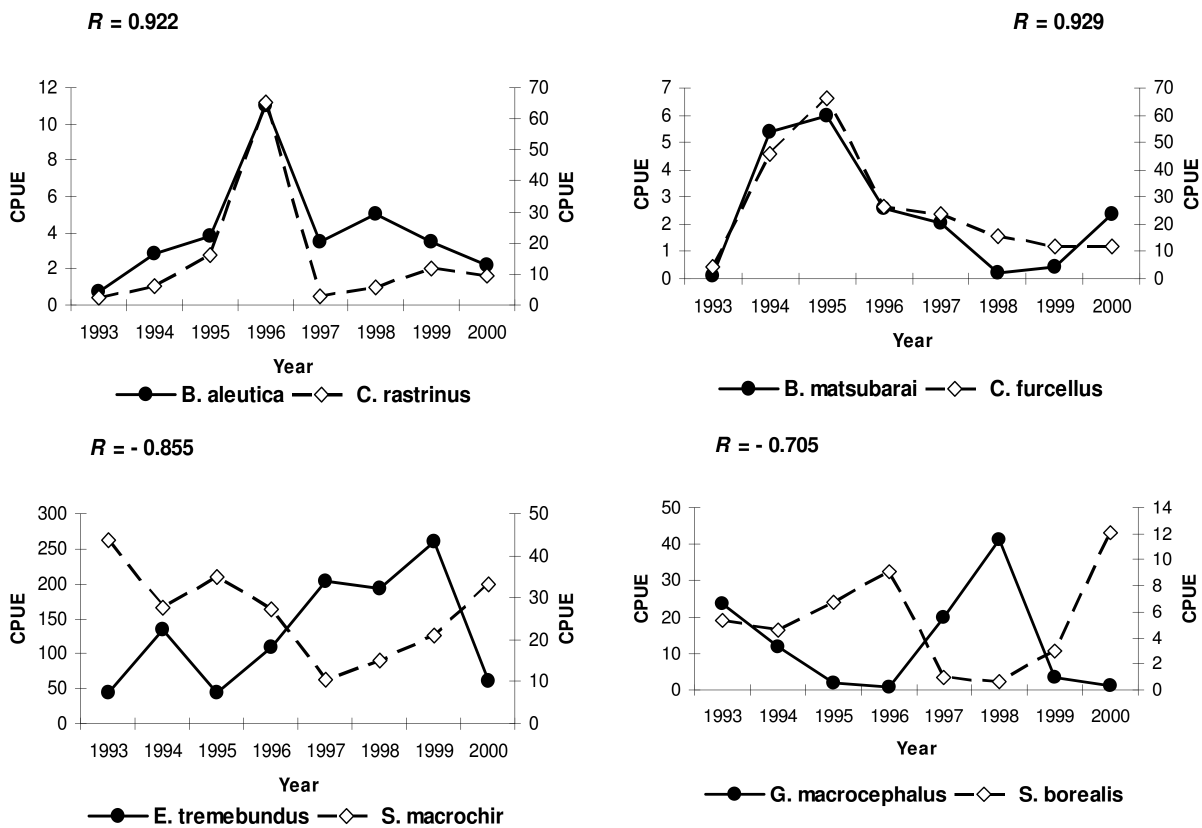

Figure-10
Examples of high positive (top) and negative (bottom) correlations between demographic changes of some fishes for the entire study area

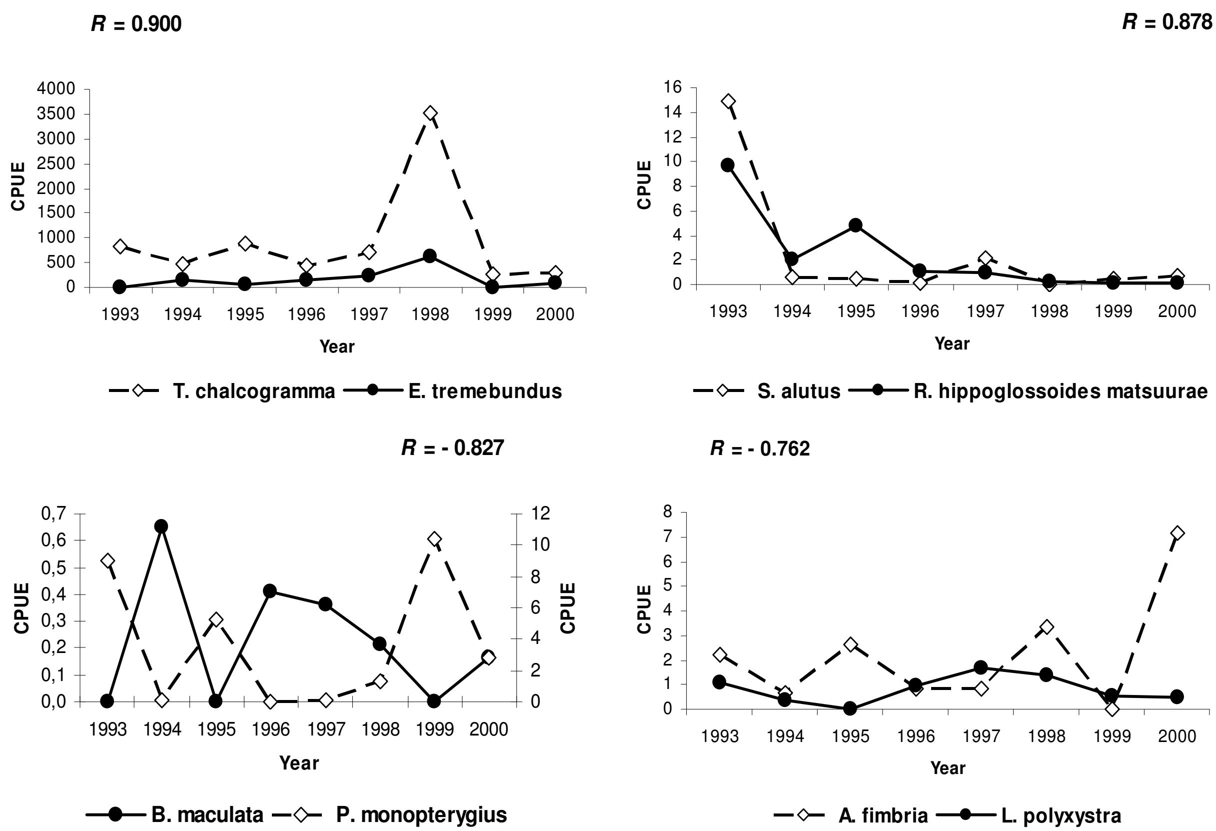

Figure-11
Examples of high positive (top) and negative (bottom) correlations between demographic changes of some fishes for the northern sub-area

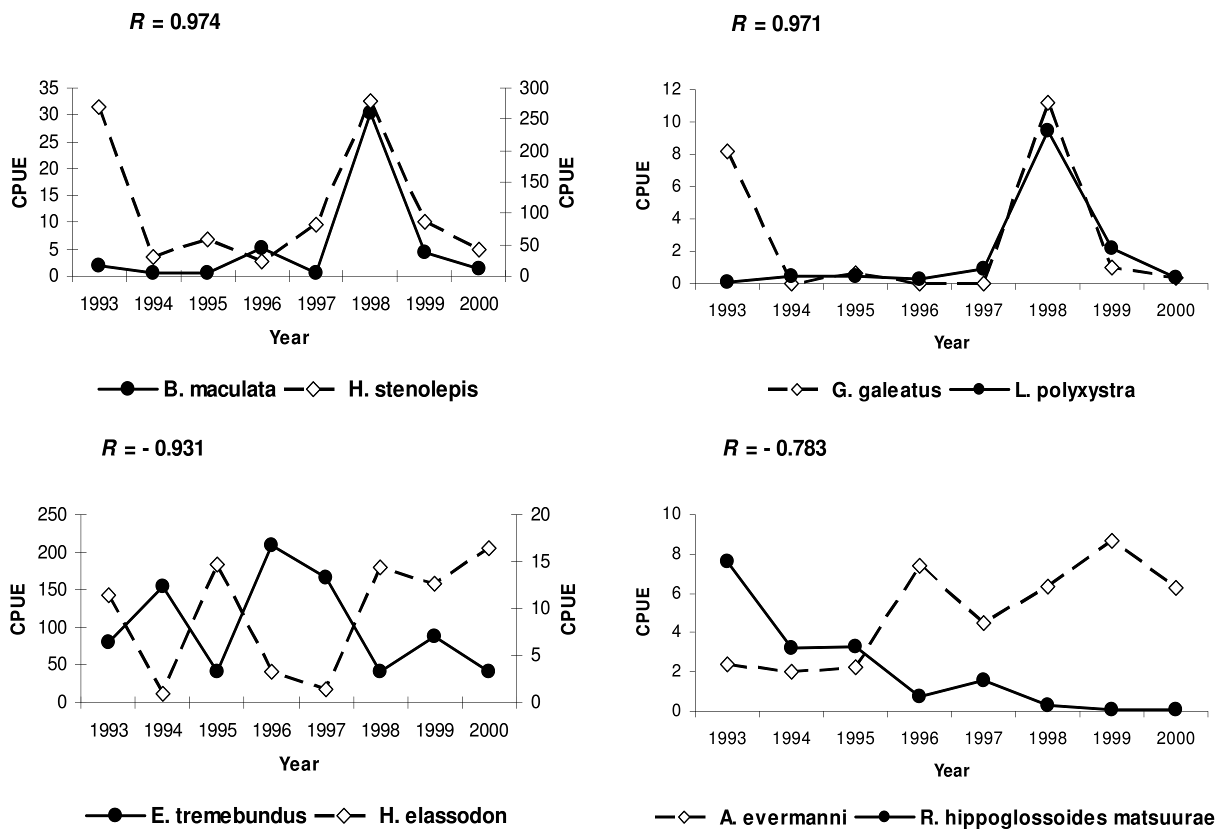

Figure-12
Examples of high positive (top) and negative (bottom) correlations between demographic changes of some fishes for the central sub-area

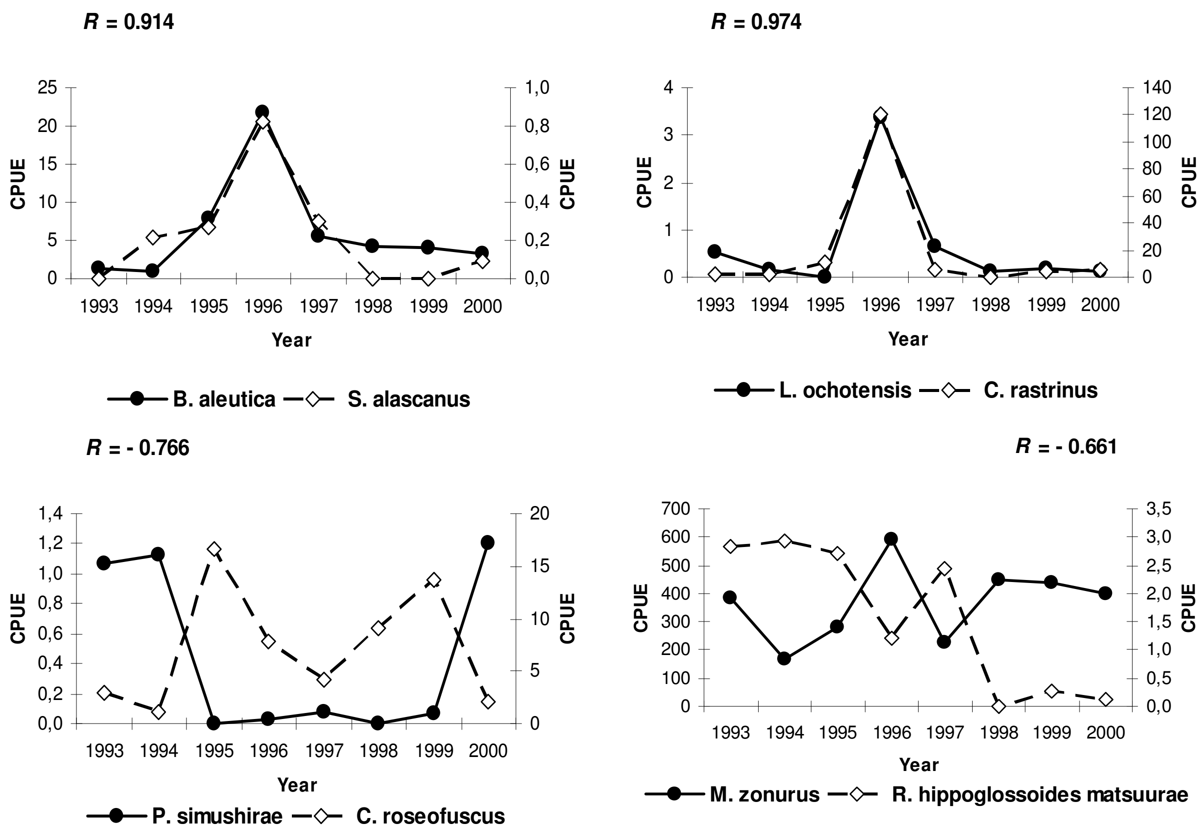

Figure-13
Examples of high positive (top) and negative (bottom) correlations between demographic changes of some fishes for the southern sub-area