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Composition and distribution of fish species collected during the fourth Chinese National Arctic Research Expedition in 2010

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Abstract There are awareness and concerns caused by the decreasing sea ice coverage around the Arctic and Antarctic due to effects of climate change. Emphasis in this study was on rapid changes in Arctic sea ice coverage and its impacts on the marine ecology during the fourth Chinese National Arctic Research Expedition in 2010. Our purpose was to establish a baseline of Arctic fish compositions, and consequent effects of climate change on the fish community and biogeography. Fish specimens were collected using a multinet middle-water trawl, French-type beam trawl, otter trawl, and triangular bottom trawl. In total, 36 tows were carried out along the shelf of the Bering Sea, Bering Strait, and Chukchi Sea in the Arctic Ocean. In total, 41 fish species belonging to 14 families in 7 orders were collected during the expedition. Among them, the Scorpaeniformes, including 17 species, accounted for almost one third of the total number (34.8%), followed by 14 species of the Perciformes (27.0%), 5 species of the Pleuronectiformes (22.3%), and 2 species of the Gadiformes (15.4%). The top 6 most abundant species were *Hippoglossoides robustus*, *Boregadus saida*, *Myoxocephalus scorpius*, *Lumpenus fabricii*, *Artediellus scaber*, and *Gymnocanthus tricuspis*. Abundant species varied according to the different fishing methods; numbers of families and species recorded did not differ with the various fishing methods; species and abundances decreased with depth and latitude; and species extending over their known geographic ranges were observed during the expedition. Station information, species list, and color photographs of all fishes are provided.

Keywords **Arctic, fish, geographic range, Bering Sea, Bering Strait, Chukchi Sea, climate change**

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0 Introduction

Climate changes are considered the major threat to biodiversity[1-2]. Responses to climate change include species range expansions[3-4], the advancement of spring phenology due to increasing temperatures[5-6], and decreases in aquatic body sizes[7-8]. Evidence of the changing Arctic includes temperature increases, shrinking sea ice coverage, and shifts in the ocean ecosystem[9]. It is crucial to develop effective conservation and adaptation strategies to hedge against the changing Arctic. In order to gain a better understanding of environmental changes to Arctic biodiversity and ecological impacts, the fourth Chinese National Arctic Research Expedition (4th CHINARE-Arctic) was conducted by the State Oceanic Administration of China in 2010. The present report is a part of the project documenting the effects of climate change on the nekton community and its distribution in the Pacific Arctic, including the Bering Sea, Bering Strait, and Chukchi Sea in the Arctic Ocean. Our perspective was to establish a long-term baseline of Arctic fish, including the species composition, abundances, and zoogeography.

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1 Materials and methods

Specimens were collected using a middle-water multinet, a French-type beam trawl (2.5 m wide, 0.5 m high, and 9 m long; mesh size 10 mm), an otter trawl (1.6 m wide, 0.5 m high, and 3 m long; mesh size 20 mm), and a triangular bottom trawl (2.2 m wide, 0.65 m high, and 6.5 m long; mesh size 20 mm) aboard the Chinese R/V *XUE LONG* icebreaker from 11 July to 1 September 2010. Stations sampled were distributed from the Bering Basin through the continental rise, the continental shelf of the Bering Sea, northern and southern Bering Strait, to the shelf of the Chukchi Sea and the Chukchi slope (Table 1, Figure 1). Every tow was operated for 10—60 min. The standard length (mm) and weight in grams (g) of all fish specimens were measured. Then specimens were fixed in a 10% buffered formalin-sea water solution and transferred to 70% ethyl alcohol. Specimens were identified using Coad et al.[10] and Mecklenburg et al.[11] Vouchers were deposited in the Biodiversity Collections in Third Institute of Oceanography, State Oceanic Administration, Xiamen and the Biodiversity Research Museum, Academia Sinica, Taipei.

Table 1 Station data from the Bering Sea to the Chukchi Sea during the 4th CHINARE-Arctic in 2010

Station	Date(DD/MM/YYYY)	Longitude	Latitude	Depth/m	Substrate	Deployment*
B07	12/07/2010	176°12.24′E	58°00.00′N	300—500	mud	MMT
B14	15/07/2010	177°41.53′W	60°55.27′N	131	mud	FBT
BB02	15/07/2010	176°54.96′W	61°38.82′N	106—110	mud	FBT
BB05	16/07/2010	175°19.87′W	62°32.64′N	107—108	mud	OT
BB06	16/07/2010	174°22.85′W	63°00.48′N	70—71	mud	OT
NB08	18/07/2010	167°20.52′W	62°39.52′N	29	mud	OT
NB08B	18/07/2010	167°24.84′W	62°41.45′N	24—25	mud	OT
NB09-NB10	18/07/2010	170°58.67′W	62°50.72′N	37	mud	OT
NB09-NB10B	18/07/2010	171°03.07′W	62°52.65′N	37	mud	OT
BS02	19/07/2010	171°00.03′W	64°20.14′N	32—34	rock, mud	OT
BS05	19/07/2010	169°30.17′W	64°20.00′N	32	mud	OT
BS08	19/07/2010	168°01.13′W	64°19.71′N	28—29	mud	TT
CC08	21/07/2010	166°57.80′W	68°18.00′N	27	mud	TT
C02	21/07/2010	167°20.15′W	69°07.40′N	41—43	mud	OT
R06	21/07/2010	168°59.00′W	69°30.00′N	45	mud	OT
R08	22/07/2010	168°58.81′W	71°00.19′N	37	mud	OT
C05	23/07/2010	164°43.70′W	70°45.60′N	28—29	sand, rock	OT
Co10	25/07/2010	157°55.61′W	71°37.21′N	55	mud	OT
Co1	25/07/2010	157°09.53′W	71°14.81′N	38—44	rock, mud	OT
M06	28/08/2010	171°59.85′W	75°19.80′N	527—626	rock	FBT
M07	28/08/2010	172°01.87′W	74°59.68′N	269—382	mud	FBT
SR12	29/08/2010	169°00.08′W	74°29.86′N	174—179	mud	FBT
SR11	29/08/2010	168°59.25′W	73°59.69′N	171—169	mud	TT
SR10	29/08/2010	169°00.05′W	73°00.04′N	71—72	mud	TT
SR09	29/08/2010	168°59.54′W	71°59.89′N	44—45	mud	TT
SR07	30/08/2010	168°58.61′W	70°00.28′N	30—31	sand, mud	TT
SR03	30/08/2010	169°00.92′W	67°59.85′N	49	mud	TT
SL01-SL02, SL05-SL09	01/09/2010	170°54′W	62°33′N	40	sand, mud	OT
SL03-SL04	01/09/2010	170°54′W	62°33′N	40	sand, mud	FBT

*MMT is multinet middle-water trawl; FBT is French-type beam trawl; OT is otter trawl; TT is triangular trawl.

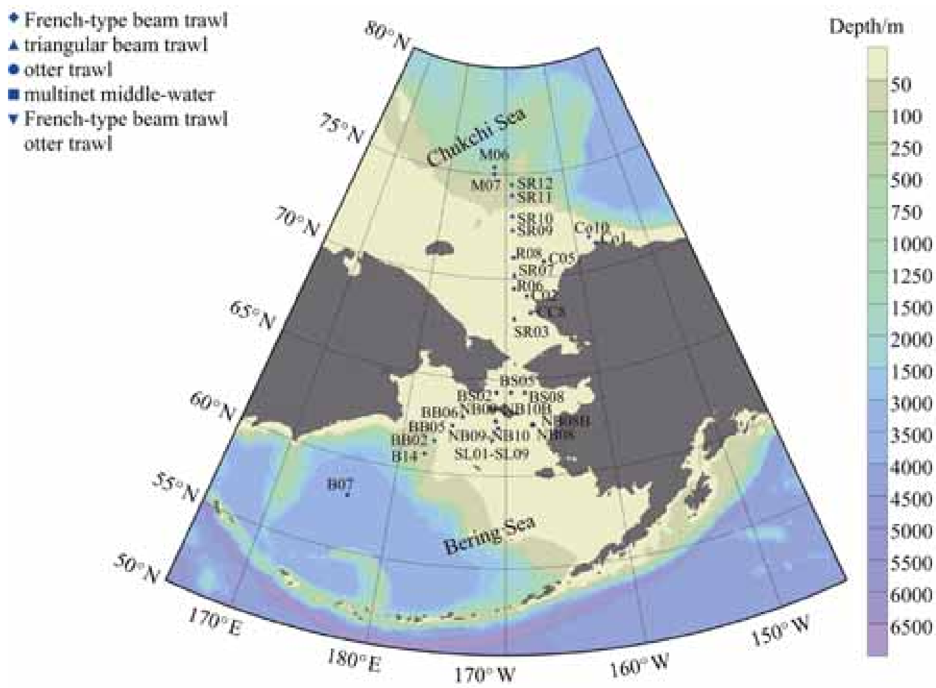

Figure 1 Stations sampled from Bering Sea and Chukchi Sea during the 4th CHINARE-Arctic in 2010 (multinet middle-water trawl, circles), French-type beam trawl (triangles), otter trawl (squares), and triangular trawl (diamonds).

2 Results of fish collections and composition

Specimens were collected from 36 stations (one multinet middle-water trawl and 35 bottom trawls) including the Bering Sea, Bering Strait, and Chukchi Sea, at depths ranging 24—626 m. Successful samples were obtained from 1 (2.8%) multinet middle-water trawl, 7 (19.4%) French-type beam trawls, 21 (58.3%) otter trawls, and 7 (19.4%) triangular beam trawls. Forty-one fish species belonging to 14 families in 7 orders were collected during the expedition (Table 2). Among them, the Scorpaeniformes, including 17 species, accounted for almost one third of the total number (34.8%, 427 individuals), followed by 14 species in the Perciformes (27.0%, 331 individuals), 5 species in the Pleuronectiformes (22.3%, 273 individuals), and 2 species in the Gadiformes (15.4%, 189 individuals). In addition, the most abundant family was the Cottidae (25%, 307 individuals), followed in order by the Pleuronectidae (22.3%, 273 individuals), Gadidae (15.4%, 189 individuals), Zoarcidae (13.6%, 167 individuals), and Stichaeidae (13.2%, 162 individuals, Table 2).

Taxonomy and zoogeography of Arctic marine fish

Rajiformes
Bathyrajiidae
Bathyraja parmifera (Bean, 1881)
(Figure 2)
Three specimens were collected from 3 stations to the south of St. Lawrence Is. at a depth of 40 m. This is close to the northernmost record for *B. parmifera*. In addition, egg pouches were collected at Chukchi slope stations (M06 and M07) at depths of 269—626 m. This is the 1st record of its spawning ground, and the northernmost record has significant biological meaning.

Clupeidae
Clupea pallasii Valenciennes, 1847
(Figure 3)
The otter trawl collected 2 specimens only from station NB08 of east of St. Lawrence Island at depths of 35—45 m (Table 1).
This is probably a synonym of *Clupea harengus* Linnaeus, 1758; however, that species is considered an Atlantic Arctic species. Genetic divergence between them needs to be elucidated to determine the species boundary.

Gadidae
Arctogadus glacialis (Peters, 1872)
(Figure 4)
The French-type beam trawl collected only 10 individuals at station M06 in the northern Chukchi Sea at depths of 529—626 m (Table 1). It was accompanied by abundant Arctic cod, *Boreogadus saida*, in the 2 harvests.

Boreogadus saida (Lepechin, 1774)
(Figure 5)
Specimens were collected from 23 stations at depths of 28 m (station C05)—695 m (station M06) by all 3 types of bottom trawls (Table 1). In addition, 2 other specimens were collected at a temporal ice camp (173°32.36′W, 86°50.05′N) by cage. *Boreogadus saida* was the 2nd most

abundant species collected during the expedition (179 individuals, 14.6%).

Ammodytidae

Ammodytes hexapterus Pallas, 1814

(Figure 6)

Only 2 specimens were collected at stations north of St. Lawrence Island and south of Bering Strait at stations BS02 and BS05 at depths of 28—34 m (Table 1).

Zoarcidae

Gymnelus hemifasciatus Andriashev, 1937

(Figure 7)

Eleven specimens were collected on the shelf of Bering Sea (stations B14, SL08, and SL09), and the Chukchi Sea (station SR07), at depths of 30—131 m.

Lycodes adolfi Nielsen & Fosså 1993

(Figure 8)

Twelve specimens were collected from station M06, at depths of 529—695 m in the northern Chukchi Sea (Table 1). The 1st record on the Chukchi slope was in 2009[12]. This was the 2nd time to confirm a distributional expansion. However, the depth range on the Chukchi slope was shallower than bathymetric records (1 371—1 880 m)[13] in the Atlantic Arctic.

Lycodes mucosus Richardson, 1855

(Figure 9)

Only 5 specimens were collected from stations at depths of 32—40 m between the south Bering Strait and St. Lawrence Is. (Table 1).

Table 2 Fishes collected from the Bering Sea and Chukchi Sea during the 4th CHINARE-Arctic in 2010

Oder	Family	Science	Stations	Individual	%
Clupeiformes	Clupeidae	*Clupea pallasii*	NB08	2	0.2
Gadiformes	Gadidae	*Arctogadus glacialis*	M06	10	0.8
		Boreogadus saida	BB02, BS08, C02, C05, Co1, Co10, M06, M07, NB08, NB08B, NB09-NB10, R06, R08, SL04, SL05, SL06, SL07, SR07, SR09, SR10, SR11, SR12, NB09-NB10B	179	14.6
Perciformes	Ammodytidae	*Ammodytes hexapterus*	BS02, BS08	2	0.2
	Zoarcidae	*Gymnelus hemifasciatus*	B14, SL08, SL09, SR07	11	0.9
		Lycodes adolfi	M06	12	1.0
		Lycodes mucosus	BS05, SL09	5	0.4
		Lycodes palearis	B14, BB02, BB05, BB06	51	4.2
		Lycodes polaris	BB06, Co10, R08, SR11	5	0.4
		Lycodes raridens	BB06, BS05, NB09-NB10, SR09, NB09-NB10B	19	1.5
		Lycodes sagittarius	M06, M07	9	0.7
		Lycodes seminudus	M06, M07	55	4.5
	Stichaeidae	*Anisarchus medius*	B14, R06, R08, SR10, SR11	16	1.3
		Eumesogrammus praecisus	BS05, SL08, SL09	15	1.2
		Leptoclinus maculatus	B14, BB06	6	0.5
		Lumpenus fabricii	BB06, BS08, CC08, NB08, NB08B, NB09-NB10B	100	8.2
		Stichaeus punctatus	CC08	25	2.0
Pleuronectiformes	Pleuronectidae	*Hippoglossoides robustus*	B14, BB02, BB06, BS05, BS08, NB08, NB08B, NB09-NB10, R06, R08, SL01, SL02, SL03, SL04, SL05, SL06, SL09, SR03, SR09, NB09-NB10B	191	15.6
		Lepidopsetta polyxystra	BS02, BS05, SL06	6	0.5
		Limanda aspera	CC08, NB08, NB08B, NB09-NB10, SL01, SL02, SL04, SL05, SL07, NB09-NB10B	50	4.1

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		Pleuronectes quadritubercula-tus	NB08, NB08B, NB09-NB10, SL01, SL02, SL05, SL06, SL07, SL08, NB09-NB10B	25	2.0
		Reinhardtius hippoglossoides	M07	1	0.1
Rajiformes	Bathyrajiidae	*Bathyraja parmifera*	SL01, SL02, SL03	3	0.2
Scorpaenifor-mes	Agonidae	*Aspidophoroides olrikii*	BS05, BS08, CC08, NB09-NB10, R06, SL01, SL02, SL03, SL04, SL05, SR03, SR09, NB09-NB10B	38	3.1
	Cottidae	*Artediellus atlanticus*	M07	12	1.0
		Artediellus scaber	C02, CC08, R08	64	5.2
		Enophrys diceraus	CC08SL08	3	0.2
		Gymnocanthus tricuspis	BS05, BS08, C02, C05, CC08, Co10, NB08, NB09-NB10, R06, R08, SL01, SL04SR03, SR07, NB09-NB10B	59	4.8
		Hemilepidotus papilio	BS08, NB09-NB10, SL09, NB09-NB10B	7	0.6
		Icelus spatula	B14, BS08	18	1.5
		Myoxocephalus scorpius	BS05, BS08, CC08, Co1, NB08, NB08B, SR03, SR07	143	11.7
		Triglops pingelii	SL09	1	0.1
	Cyclopteridae	*Eumicrotremus orbis*	BS05, NB09-NB10, NB09-NB10B	3	0.2
	Hemitripteridae	*Nautichthys pribilovius*	CC08, SR07	4	0.3
	Liparidae	*Careproctus reinhardti*	B14, M07, SR11	6	0.5
		Liparis fabricii	B14, BB06, BS05, BS08, M06, NB08, NB08B, NB09-NB10, SL01, SL02, SL04, SL05, SR11, SR12, NB09-NB10B	51	4.2
		Liparis gibbus	SL03	1	0.1
		Liparis ochotensis	NB08	1	0.1
		Liparis tunicata	BS08, SL04, SL09, NB09-NB10B	5	0.4
	Psychrolutidae	*Cottunculus microps*	M06, M07	11	0.9
Stomiiformes	Stomiidae	*Chauliodus macouni*	B07	1	0.1
Total				1 226	100

Lycodes palearis Gilbert, 1896
(Figure 10)
Fifty-five specimens were collected in a restricted area on the western margin of the Bering shelf at depths of 70—131 m (Table 1).

Lycodes polaris (Sabine, 1824)
(Figure 11)
Five specimens were collected at 4 stations at depth of 40—171 m including the western St. Lawrence Island, north Bering Strait, eastern Chukchi, and off Barrow, Alaska.

Lycodes raridens Taranetz & Andriashev, 1937
(Figure 12)
Nineteen specimens were collected from 5 stations including the Bering Sea, south Bering Strait, and Chukchi Sea (Table 1). The record from station SR09 extends the range more northerly to almost 72°N than an earlier record[14].

Lycodes sagittarius McAllister, 1976
(Figure 13)
Nine specimens were collected from only 2 stations in the northern Chukchi Sea at depths of 269—626 m (Table 1). The records extend northward to 75°N beyond the original reference in the Beaufort Sea (71°59.89′N, 168°59.54′W, 357 m depth) and are deeper[15-16]. This is also the 1st record in the Chukchi Sea.

Lycodes seminudus Reinhardt, 1837
(Figure 14)
Fifty-five specimens were collected from only 2 stations in the northern Chukchi Sea at depths of 269—626 m. *Lycodes seminudus* was previously recorded in the Atlantic

Arctic and Beaufort Sea; however, this is the second record off the Chukchi Sea since 2009[12]. According to collection localities, it is distributed in deeper water than other congeneric species.

Pleuronectidae
Hippoglossoides robustus Gill & Townsend, 1897
(Figure 15)
This was the most abundant species (191 individual, 15.6%) of the expedition, and was collected at 20 stations including the Bering Sea, south Bering Strait, and Chukchi Sea at depths of 24 m (station NB08B)—131 m (station B14). Two specimens were collected at station SR09 (71°59.89′N, 168°59.54′W), close to the northernmost limit of its distributional range.

Lepidopsetta polyxystra Orr & Matarese, 2000
(Figure 16)
Six specimens were collected at stations around St. Lawrence Is. at depths of 28—40 m. Stations (BS02 and BS05) extend the northernmost record in 2007 to 64° beyond the original range[12,17].

Limanda aspera (Pallas, 1814)
(Figure 17)
Fifty (4.1%) specimens were collected at 10 stations at depths of 24—40 m.

Pleuronectes quadrituberculatus Pallas, 1814
(Figure 18)
Twenty-five (2.0%) specimens were collected from stations south of St. Lawrence Is. at depths of 24—40 m.

Reinhardtius hippoglossoides (Walbaum, 1792)
(Figure 19)
This species is abundant in Bering Sea from the early records, but only 1 specimen was collected from station M07 on the Chukchi slope at a depth of 269—382 m in this survey. This almost reaches its northernmost record[12].

Scorpaeniformes
Agonidae
Ulcina olrikii (Lütken, 1877)
(Figure 20)
Thirty-eight specimens were collected at 14 stations including the Bering Sea, south Bering Strait, and Chukchi Sea at depths of 27—49 m.

Cottidae
Artediellus atlanticus Jordan & Evermann, 1898
(Figure 21)
Eleven specimens were collected at only 1 station (M07) on the Chukchi slope at depths of 269—382 m. Normally distributed in the North Atlantic, it was recently recorded on the Chukchi slope in 2009[12].

Artediellus scaber Knipowitsch, 1907
(Figure 22)
Sixty-four (5.2% in number) specimens were collected at 3 stations in the eastern Chukchi Sea at depths of 27—43 m. It was the 5th dominant species of the expedition.

Enophrys diceraus (Pallas, 1787)
(Figure 23)
Three specimens were collected from 2 stations (CC08 and SL08) south of St. Lawrence Is. in the Bering Sea and in the eastern Chukchi Sea at depths of 27—40 m.

Gymnocanthus tricuspis (Reinhardt, 1830)
(Figure 24)
Fifty-nine (4.8%) specimens were collected from 15 stations in the Bering Sea and Chukchi Sea at depths of 27—55 m.

Hemilepidotus papilio (Bean, 1880)
(Figure 25)
Seven specimens were collected from 4 stations in the Bering Sea and south Bering Strait at depths of 28—40 m.

Icelus spatula Gilbert & Burke, 1912
(Figure 26)
Eighteen (1.5%) specimens were collected from 2 stations in the Bering Sea and south Bering Strait at depths of 28—131 m.

Myoxocephalus scorpius (Linnaeus, 1758)
(Figure 27)
There were 143 (11.7%) specimens collected at 8 stations in the Bering Sea, south Bering Strait, and eastern Chukchi Sea at depths of 24—49 m. It was the 3rd most abundant species of the expedition.

Triglops pingelii Reinhardt, 1837
(Figure 28)
Only 1 specimen was collected from station (SL09) south of St. Lawrence Island at a depth of 40 m.

Cyclopteridae
Eumicrotremus orbis (Günther 1861)
(Figure 29)
It is not common in the north Bering Sea. However, three specimens were collected from 3 stations (BS05, NB09-NB10, and NB09-NB10B) around St. Lawrence Is. in the Bering Sea and south Bering Strait at depths of 32—37 m. This almost reaches its northernmost range.

Hemitripteridae
Nautichthys pribilovius (Jordan & Gilbert, 1898)
(Figure 30)
Three specimens were collected from 2 stations (CC08 and SR07) in the eastern Chukchi Sea at depths of 27—31 m. The record from station SR07 is close to its northernmost range in the Chukchi Sea.

Liparidae
Careproctus reinhardti (Krøyer, 1862)
(Figure 31)
Six specimens were collected from 3 stations on the Bering slope (station B14), in the eastern Chukchi Sea (station SR07), and on the Chukchi slope (M07) at depths of 131—382 m. It seems to be an Arctic species; however, 1 specimen collected at station B14 on the Bering slope (60°55.27′N, 177°41.53′W) at a depth of 131 m could be the southernmost record.

Liparis fabricii Krøyer, 1847
(Figure 32)
Fifty-one (4.2%) specimens were collected from 15 stations in the Bering Sea, south Bering Strait, and Chukchi Sea at depths of 24—626 m. The record from station B14 (60°55.27′N, 177°41.53′W) on the Bering slope at a depth of 131 m extends its southernmost range in 2007[12] to the north of St. Lawrence Is. (64°30′N, 170°26′W).

Liparis gibbus Bean, 1881
(Figure 33)
Only 1 specimen was collected from southern St. Lawrence Is. (station SL03) at a depth of 40 m.

Liparis ochotensis Schmidt, 1904
(Figure 34)
Only 1 specimen was collected at station (NB08; 62°39.52′N, 167°20.52′W) southeast of St. Lawrence Is. at a depth of 29 m. This is almost the northernmost range of this species.

Liparis tunicatus Reinhardt, 1836
(Figure 35)
Five specimens were collected from 4 stations between south of St. Lawrence Is. and the south Bering Strait at depths of 28—40 m were at its southernmost extent.

Psychrolutidae
Cottunculus microps Collett, 1875
(Figure 36)
Eleven (0.9%) specimens were collected from stations (M06 and M07) on the Chukchi slope at depths of 269—626 m. One specimen collected from the Chukchi slope at depths of 227—236 was the 1st record from the western Arctic (Mecklenburg et al. 2011)[17]. Our records prove its range extends from the Atlantic Arctic to the Pacific Arctic.

Stichaeidae
Anisarchus medius (Reinhardt, 1837)
(Figure 37)
Sixteen (1.3%) specimens were collected at 5 stations on the Bering slope and in the Chukchi Sea at depths of 37—169 m.

Eumesogrammus praecisus (Krøyer, 1836)
(Figure 38)
Fifteen (1.2%) specimens were collected from 3 stations south of St. Lawrence Is. to the south Bering Strait at depths of 32—40 m.

Leptoclinus maculatus (Fries, 1838)
(Figure 39)
Six specimens were collected from 2 stations on the Bering slope and in the Bering Sea at depths of 70—131 m.

Lumpenus fabricii Reinhardt, 1836
(Figure 40)
One hundred (8.2%) specimens were collected from 6 stations in the Bering Sea, south Bering Strait, and Chukchi Sea at depths of 24—70 m. It was the 4th most abundant species of this expedition.

Stichaeus punctatus (Fabricius, 1780)
(Figure 41)
Twenty-five (2.0%) specimens were collected at station CC08 in the eastern Chukchi Sea at a depth of 27 m.

Stomiiformes
Stomiidae
Chauliodus macouni Bean, 1890
(Figure 42)
Only 1 specimen was collected at station (B07, with a depth of 3 873 m) in the Bering Sea by multinet middle-water trawl at a depth range of 300—500 m. This is the 1st record of this mesopelagic deep-sea fish in the Bering Sea and almost in the northernmost of its distribution.

3 Discussion

The most abundant families sampled during the expedition using 3 types of bottom trawls and combining the data were the Cottidae, Pleuronectidae, Gadidae, Zoacidae, and Stichaeidae; in terms of the number of species, the Cottidae and Zoacidae each had 8 species, followed by the Pleuronectidae, Liparidae, and Stichaeidae with 5 species each. These results were similar to those of an earlier report in 2004[14]. However, the ranking of the species abundances differed; the most 6 abundant species of our study were *Hippoglossoides robustus* (vs. 3rd in 2004), *Boregadus saida* (2nd vs. 4th), *Myoxocephalus scorpius* (3rd vs. 2nd), *Lumpenus fabricii* (4th vs. 7th), *Artediellus scaber* (5th, the same), and *Gymnocanthus tricuspis* (6th vs. 1st). In addition, the 4 most abundant species comprised half of the fish specimens, which comprised 79% in 2004[14].

3.1 Numbers of families and species did not differ among the 3 different fishing methods, but the abundant species varied by method

Using 3 types of bottom trawls, 7, 21 and 7 trawls were conducted with the French-type beam trawl, otter trawl, and triangular trawl, respectively. In total, 283 individuals belo-

Figure 2 *Bathyraja parmifera*

Figure 3 *Clupea pallasii*

Figure 4 *Arctogadus glacialis*

Figure 5 *Boreogadus saida*

Figure 6 *Ammodytes hexapterus*

Figure 7 *Gymnelus hemifasciatus*

Figure 8 *Lycodes adolfi*

Figure 9 *Lycodes mucosus*

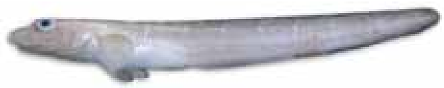

Figure 10 *Lycodes palearis*

Figure 11 *Lycodes polaris*

Figure 12 *Lycodes raridens*

Figure 13 *Lycodes sagittarius*

Figure 14 *Lycodes seminudus*

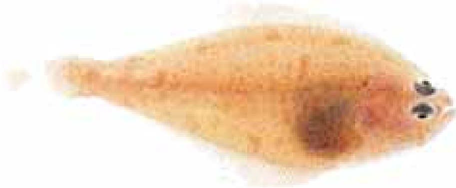

Figure 15 *Hippoglossoides robustus*

Figure 16 *Lepidopsetta polyxystra*

Figure 17 *Limanda aspera*

Figure 18 *Pleuronectes quadrituberculatus*

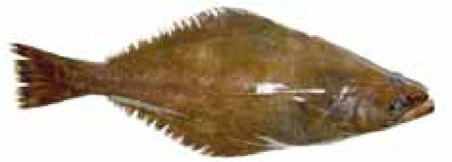

Figure 19 *Reinhardtius hippoglossoides*

Figure 20 *Ulcina olrikii*

Figure 21 *Artediellus atlanticus*

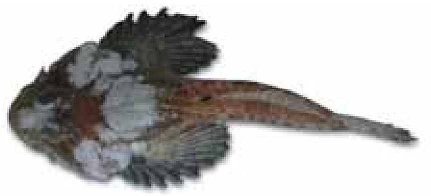

Figure 22 *Artediellus scaber*

Figure 23 *Enophrys diceraus*

Figure 24 *Gymnocanthus tricuspis*

Figure 25 *Hemilepidotus papilio*

Figure 26 *Icelus spatula*

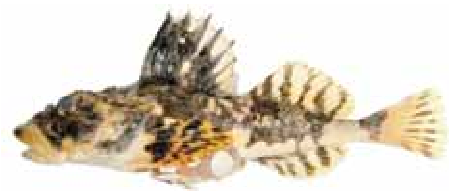

Figure 27 *Myoxocephalus scorpius*

Figure 28 *Triglops pingelii*

Figure 29 *Eumicrotremus orbis*

Figure 30 *Nautichthys pribilovius*

Figure 31 *Careproctus reinhardti*

Figure 32 *Liparis fabricii*

Figure 33 *Liparis gibbus*

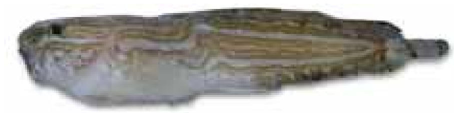

Figure 34 *Liparis ochotensis*

Figure 35 *Liparis tunicatus*

Figure 36 *Cottunculus microps*

Figure 37 *Anisarchus medius*

Figure 38 *Eumesogrammus praecisus*

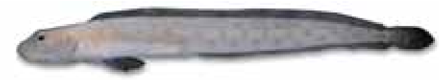

Figure 39 *Leptoclinus maculates*

Figure 40 *Lumpenus fabricii*

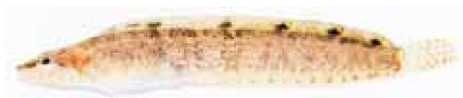

Figure 41 *Stichaeus punctatus*

Figure 42 *Chauliodus macouni*

nging to 22 species in 9 families were collected with the French-type beam trawl, 659 individuals belonging to 28 species in 11 families with the otter trawl, and 283 individuals belonging to 21 species in 9 families with the triangular trawl. Even though the numbers of families and species collected with the otter trawl were slightly higher than French-type beam trawl and triangular trawl, this was because more-intensive collection efforts were made with the otter trawl. Among them, the abundant species varied with the different fishing methods. The 3 most abundant species collected with the French-type beam trawl were *Lycodes seminudus* (55 individuals, mainly at stations M06 and M07 on the Chukchi slope), *B. saida* (54 individuals), and *L. palearis* (37 individuals); with the otter trawl, they were *H. robustus* (168 individuals), *B. saida* (116 individuals), and *L. fabricii* (93 individuals); with the triangular trawl, they were *M. scorpius* (126 individuals, mainly at station CC08 with 104 specimens), *Artediellus scaber* (62 individuals), and *Stichaeus punctatus* (25 individuals). In addition, the dominant species by French-type beam trawl were mainly collected at stations with deeper depth (M06, M07, and B14); by otter trawl were mainly at stations on north Bering Shelf (NB08, NB09, and NB10); by triangular trawl were mainly at station CC08 in eastern Chukchi Sea. Reasons to the different dominant species by fishing gear were mainly the lake of experimental design due to the unexpected weather situations, and the insufficient sampling efforts on the wide geographic range distribution on Arctic fishes. The average species numbers in catches were 5.6 (with the French-type beam and otter trawls) and 5.7 (with the triangular trawl). However, the average individual numbers were a little lower with the otter trawl (32.6 individuals per catch) than the others (40.4 individuals in both).

3.2 Species numbers and abundances decreased with depth and latitude

Our results indicate decreasing trends in species numbers and abundances with depth with the otter trawl; however, the trend was not clear with either the French-type beam trawl or triangular trawl. In addition, numbers of species and individuals at depths of 20—40 m with the otter trawl were higher than the others due to greater sampling efforts as mentioned earlier. A decreasing trend in species number with depth was also observed at Russian-American Long-term Census of the Arctic stations; however, a fish abundance trend was not seen[14].

3.3 Extension of previously documented geographic ranges was evident

Among the 41 fish species collected during the expedition, 17 species had a North Pacific to Arctic region distribution; the remaining 24 species had a Arctic-Boreal distribution. Geographic range extension was observed and could be classified into the following types: northward extension, southward extension, extension from the Atlantic Arctic to the Pacific Arctic, and a significant range extension from historical documentation. In total, 10 species, including *L. raridenc* and *L. sagittarius* in the Zoarcidae; *H. robustus*, *L. polyxystra*, and *R. hippoglossoides* in the Pleuronectidae; *B. parmifera* in the Bathyrajiidae; *E. orbis* in the Cyclopteridae; *N. pribilovius* in the Hemitripteridae; *L. ochotensis* in the Liparicae; and *C. macouni* in the Stomiidae, exhibited a northerly extension beyond their known geographic range or were found at the northernmost limit of their range. However, 3 species belonging to the Arctic Boreal, including *C. reinhardti*, *L. fabricii* and *L. tunicata* in the Liparidae, contrarily exhibited a southerly range extension. In addition, for 2 species formally known only to be distributed in the Atlantic Arctic until recently, a trans-Arctic distribution from the Atlantic Arctic to the Pacific Arctic was documented[12]. The mechanism of this trans-Arctic distribution is poorly known. In addition, *L. seminudus* extended its known western border from the Beaufort Sea to the Chukchi slope.

4 Conclusions

Fishes collected during the CHINARE-Arctic in 2010 Arctic expedition included 41 fish species belong to 14 families in 7 orders. The most abundant groups (families) were the sculpins (Cottidae), Bering flounder (Pleuronectide), Arctic cod (Godidae), eelpouts (Zoacidae), and eelblennys (Stichaeidae). The 6 most abundant species were *Hippoglossoides robustus*, *Boregadus saida*, *Myoxocephalus scorpius*, *Lumpenus fabricii*, *Artediellus scaber* and *Gymnocanthus tricuspis*. These results are similar to earlier reports[12,14]. However, abundant species varied by fishing methods; numbers of families and species recorded did not differ with the fishing method; species numbers and abundances decreased with depth and latitude; and some species were observed to have extended their known geographic range. We could not clarify a connection between range extension and the changing climate in the Arctic region. Further long-term investigation is needed because of a lack of collection efforts of the Arctic benthic fishes.

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