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unculan Fauna of the Northern Bering Chukchi Seas

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ABSTRACT. Sipuncula is a species-poor phylum, yet sipunculans can play an important role in high-latitude marine ecosystems: they are active burrowers and important hioturbators, and they often occur in very high numbers and biomass. In the Arctic Ocean, sipunculan studies and associated publications have been concentrated mainly in the Atlantic sector of the Arctic, with very few publications for the Pacific sector. This chapter presents a synopsis of the composition and distribution of sipunculans in the waters of the northern Bering and Chukchi Seas in the Pacific Arctic region hased on our own samples and published data. From 2007 to 2011, 263 stations were sampled within our research program, and 2,141 sipunculan specimens were found and identified to species level. Six taxa belonging to two families were found during this study; Golfingidae (Golfingia margaritacea, Golfingia vulgaris, Nephasoma diaphanes diaphanes, Nephasoma diaphanes corrugatum, and Nephasoma eremita) and Phascolionidae (Phascolion strombus). Golfingia margaritacea was the dominant species, whereas the other taxa were much less abundant. Other studies found two other species in the family Golfingiidae that were not observed during our field program (Nephasoma lilljeborgi and Nephasoma abyssorum abyssorum); however, both species are typical of deep-sea communities, and this study focused only on shallow continental shelves ranging down to 130 m in depth.

INTRODUCTION

The phylum Sipuncula is a group of marine nonsegmented coelomate worms that to date, after several taxonomic revisions, comprises approximately 150 valid species (Cutler, 1994). Most sipunculan species are predominantly tropical and subtropical worms, and only a few species occur in the Arctic (Kedra and Murina, 2007). However, although species numbers are limited, these species often play a considerable role in highlatitudes marine ecosystems, where they may occur in very high numbers and biomass and can dominate benthic communities (Grebmeier et al., 2006; Kedra and Włodarska-Kowalczuk, 2008). Sipunculans are active burrowers and important bioturbators (Murina, 1984). They are mainly deposit feeders, although some species may also filter feed (Murina, 1984). To date, 12 species of sipunculans have been reported from the Arctic Ocean and adjacent seas (Kędra and Murina, 2007). Studies of Sipuncula have been concentrated mainly in the Atlantic sector of the Arctic, including around Greenland and in Svalbard fjords, with the Barents and deep Nordic Seas having received most of the scientific attention (Theel, 1905; Wesenberg-Lund, 1930, 1933, 1934, 1937, 1938, 1955; Murina, 1977; Kedra and Murina, 2007). Murina (1977) is the only monograph dealing with sipunculans in the Arctic seas, yet it is available only in Russian.

The northern Bering and Chukchi Seas are among the most productive marine ecosystems in the world. Specifically, the high productivity of these seas is primarily due to high water column production (up to 570 g C m⁻² yr⁻¹; Springer et al., 1996), limited

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zooplankton grazing, and therefore tight benthic-pelagic coupling of organic matter (Dunton et al., 1989; Grehmeier and McRoy, 1989; Iken et al., 2010). A combination of these processes leads to high benthic biomass, abundance, and diversity of long-lived benthic organisms (Grebmeier et al., 2006; Bluhm et al., 2011). Sipunculans are found among the dominant macrofaunal species in the region in terms of both biomass and abundance, especially in the northern Chukchi Sea (e.g., Grebmeier et al., 2006). However, in most marine ecological research sipunculan speciesspecific studies are not conducted. The only description of Bering and Chukchi Sea sipunculan fauna are in Russian (Murina, 1977, 1985) and are based on studies conducted 40 years ago. Murina (1977) showed a decreasing gradient in sipunculan diversity toward the north; 11 species and subspecies were found in the subarctic southern Bering Sea, along the Aleutian islands (all previous names are after Murina, 1977): Golfingia (Golfingia) muricaudata (previously, Golfingia appendiculata), G. margaritacea (previously, Golfingia margaritacea, Golfingia mawsoni), G. vulgaris, Nephasoma (Nephasoma) minutum (previously, Golfingia improvisa), N. diaphanes diaphanes (previously, Golfingia minutum), N. diaphanes corrugatum (previously, Golfingia schuettei), N. eremita (previously, Golfingia eremita), Phascolosoma agassizii agassizii (previously, Phascolosoma japonicum), Phascolion lutense, P. strombus strombus (previously, Phascolion strombi), and Apionsoma murinae (previously, Golfingia murinae). Four species, G. vulgaris, G. margaritacea, N. eremita (previously, G. eremita), and P. strombus strombus (previously, P. strombi), were found in the northern Bering Sea around Saint Lawrence Island. Finally, only three species were found in the Chukchi Sea, Golfingia margaritacea, N. diaphanes diaphanes (previously, G. minuta), and P. strombus strombus (previously, P. strombi), around Wrangel Island (Table 1). The only other publication from the Chukchi Sea reports four species (G. vulgaris vulgaris, N. abyssorum abyssorum, N. lilljeborgi, and P. strombus

strombus; Table 1; Murina, 1985). Recent research conducted during the Russian-American Long-term Census of the Arctic (RUSALCA) program in 2004 revealed six sipunculan species in the Chukchi Sea (taxonomic nomenclature as in Cutler, 1994). Golfingia vulgaris vulgaris, G. margaritacea, Nephasoma disphanes diaphanes, N. lilljeborgi, N. abyssorum abyssorum, and Phascolion strombus strombus (Table 1, V. G. Murina, National Academy of Sciences of Ukraine, personal communication).

The main aim of this chapter is to present a synopsis of the composition and distribution of the Sipuncula in the waters of the northern Bering and Chukchi Seas based on our own field samples and published data.

MATERIAL AND METHODS

Material was collected during seven cruises: one by U.S. Coast Guard Cutter Healy (HLY0702) in 2007, cruises 2009 and 2010 undertaken as part of the Chukchi Sea Offshorn Monitoring in Drilling Area (COMIDA) Chemistry and Benthan (CAB) program (COMIDA09, COMIDA10), studies funded = Shell Production and Exploration (SHELL) in 2009 (SHELL) and 2010 (SHELL10) undertaken as part of the COMIDA Call cruises, and two during the annual Canadian Coast Guard San Sir Wilfrid Laurier (SWL) cruises in 2010 (SWL10) and 2011 (SWL11) to the northern Bering and Chukchi Seas, Altogether 263 stations were sampled from 61°N in the northern Bering See northward to 76°N in the Chukchi Sea (Figure 1). Samples was collected with a Van Veen grab (0.1 m2 catch area) with four licates (except during SHELL cruises, when only single grabs were taken). Sediment grabs were washed on a 1 mm sieve screen box and recovered biological material was fixed in a 10% buffer formaldehyde and seawater solution. All the organisms were sorted in the laboratory at the Chesapeake Biological Laborators

TABLE 1. Sipuncular species found in the northern Bering and Chukchi Seas. A plus (+) indicates a species was found in a particular study; a dash (—) indicates it was not.

Species	This study	Murina (1977)	Murina (1985)	Murina (pers. comm.
Golfingiidae				
Golfingia margaritacea	+	+		+
Golfingia vulgaris	+	4	+	+
Nephasoma abyssorum abyssorum	_	_	+	+
Nephasoma diaphanes corrugatum	+	2. 2		_
Nephasoma diaphanes diaphanes	0.00	2+		+
Nephasoma eremita	59+3		-	-
Nephasoma lilljeborgi	-) s		+
Phascolionidae				
Phascolion strombus	+	+	+	140

University of Maryland Center for Environmental Science, and apunculan specimens were identified to species or lowest possible taxonomic level. Worms were postfixed with 50% propanol. Specimens in photographs were fixed immediately after sampling with 70% ethanol. Over 700 samples were analyzed, and 2,141 spunculan specimens were found and identified.

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vers onc erec ater All taxonomic nomenclature follows Cutler's (1994) iden-Scations. The examined specimens are archived at the Chesaeake Biological Laboratory, University of Maryland Center for Environmental Science (Solomons, Maryland, USA).

RESULTS

Sipunculan specimens were found at only 37% of the stations (97 of 263 stations; Figure 1). At most of the stations only a single or a few specimens were found; however, in some areas punculans were very abundant (maximum of 1,745 individuals m⁻²) and among the most dominant taxa. Especially rich sere samples collected in upper central Barrow Canyon, around tanna Shoal, and along the Russian coast of Chukotka (northest of Bering Strait in the Chukchi Sea).

PHYLUM SIPUNCULA

CLASS SIPUNCULIDEA

ORDER GOLFINGIIFORMES

FAMILY GOLFINGIIDAE

Genus Golfingia Lankester, 1885

Golfingia margaritacea (Sars, 1851)

Remark. This species is considered a subspecies in Cutler (1994).

MATERIAL. 1,557 specimens on mud, sand, gravel, and rocky bottoms, from depths of 29–130 m, with the highest numbers in the Barrow Canyon and Hanna Shoal (Figure 2).

DESCRIPTION. Large sipuncular worms, up to 250 mm, but usually about 150-200 mm; small specimens and juveniles common (3-20 mm). Trunk cylindrical, up to 150 mm in length and 5-15 mm wide (large specimens); introvert less than half of the trunk length, no hooks. Individual wet-weight

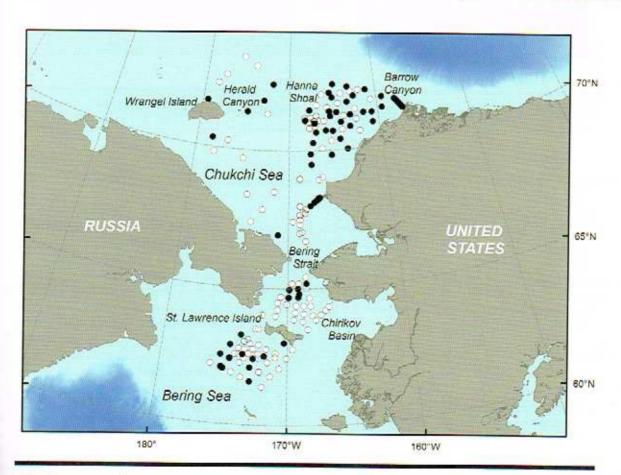


FIGURE 1. Location of sampling stations. Black dots represent stations where sipunculan specimens were found.

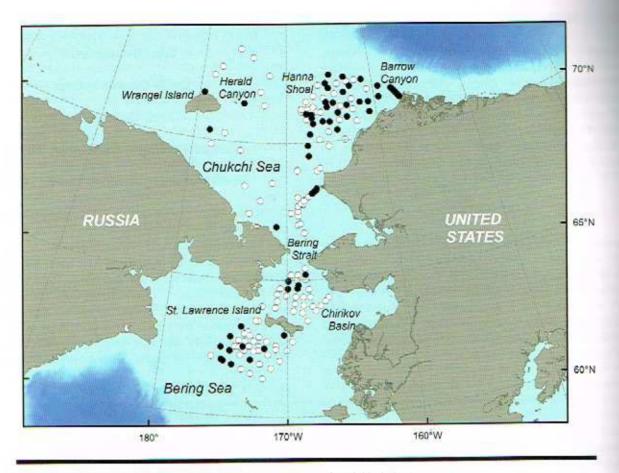


FIGURE 2. Location of stations where Golfingia margaritacea was found (black dots).

formalin-preserved animals reached 22.68 g. Four retractor muscles, with the anterior pair more dorsally placed than posterior ventral pair. The ventral pair usually originated in the middle third of the trunk and the dorsal pair in the anterior third, but specimens with more posterior placement of the retractor muscle were also found. Skin gray or grayish white to dark gray, sometimes brown. Skin sometimes covered with small papillac. Two nephridia, short and free from the body wall. Large variation in morphology, with up to about 100 tentacles, although this number is found only in large specimens (Figure 3A).

DISTRIBUTION. This is a widely distributed coldwater and cosmopolitan species occurring in all sectors of the Arlantic, Arctic, and Antarctic Oceans (80°N to 78°S) and north of 30°N and south of 30°S in the Pacific. However, it is not known to be in the Indian Ocean (Curler, 1994). Its depth range is 1–5,300 m, but it is usually found at depths less than 300 m (Cutler, 1994). It is found in all Arctic seas, including in the Barents Sea (Garbul and Anisimova, 2012), around Svalbard (Kędra and Murina, 2007), in the Canadian Arctic (Frank, 1983), and in the East Siberian, Laptev, and Okhotsk Seas (Murina, 1977). It has been reported from both the Bering and Chukchi Seas (Marina, 1977, 1985, pers. comm.).

Golfingia vulgaris vulgaris (De Blainville, 1827)

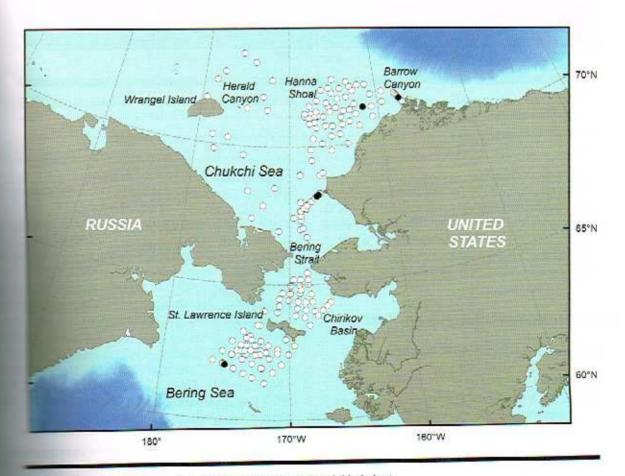
MATERIAL. 13 specimens on mud, sand, gravel, rocky bottoms, from depths 43–130 m. COMIDA09: state (st.) 29 (Hanna Shoal), COMIDA10: st. 50 (Barrow Canges SWL11: st. 2 (south of Saint Lawrence Island), st. 24, 25 (south eastern Chukchi Sea; Figure 4).

DESCRIPTION. Large, cylindrical worm, with true up to 100 mm, usually about 20–45 mm. Introvert shorter the trunk with simple, dark, scattered hooks (up to 30–40 posterior ventral pair. Ventral pair originating in the middle of the trunk, and the dorsal pair arising posterior to anus gray and dark gray, both ends of the trunk dark and heavily pillated. Two short nephridia, open anterior to the anus.

DISTRIBUTION. This is a cold-water and cospolitan species occurring primarily in the northeastern Atlanta



TRE 3. Photos of (A) Golfingia margaritacea, tentacles, and (B) Phascolion strombus, close-up of skin and holdfast papillae. Specimens preserved ethanol.



Location of stations where Golfingia vulgaris was found (black dots).

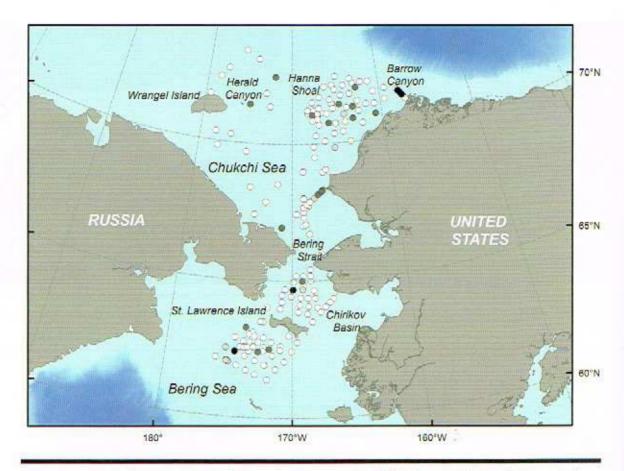


FIGURE 5. Location of stations where Nephasoma diaphanes corrugatum (black dots), Nephasoma diaphanes diaphanes (dark gray dots), or both (light gray dots) were found.

Ocean, including around Greenland, Scandinavia, and the British Isles, but it is absent in the western Atlantic Ocean (Cutler, 1994). Its depth range is 5–2,000 m, but it is usually found at depths of 10–500 m (Cutler, 1994). It was found in the Barents Sea (Garbul and Anisimova, 2012), Svalbard (Kedra and Murina, 2007), and the Karsk and Okhotsk Seas (Murina, 1977). It is reported from the whole Bering Sea and rarely in the Chukchi Sea (Murina, 1977, 1985, pers. comm.).

Genus Nephasoma Pergament, 1940

Nephasoma diaphanes diaphanes (Gerould, 1913)

MATERIAL. 67 specimens on mud, sand, and silt, often in foraminiferan tests, from depths of 38-130 m. COMIDA09: st. 3, 11, 27, 31, 50, 51 (Hanna Shoal), COMIDA10: st. 15, 1013, 1014, 1015 (Hanna Shoal), HLY0702: st. 8, 23, 25, 29 (south of Saint Lawrence Island), RUSALCA: st. 7, 20 (southeastern Chukchi Sea), st. 143 (west of Wrangel Island), st. 148 (north of Wrangel Island), SWL10: st. 14, 15 (south of Saint Lawrence Island), st. 23 (Chirikov Basin), SWL11: st. 4 (south of

Saint Lawrence Island), st. 10, 17 (Chirikov Basin), st. 22, 23, 25 (southeastern Chukchi Sea; Figure 5).

DESCRIPTION. Small, slender worm, 1–5 mm. Small, scattered hooks up to 5–20 µm, short, rounded tentaclar lobes. Two retractor muscles, originates in various locations. Skin transparent and thin, with small papillae. Often in foramiferan tests.

DISTRIBUTION. It is a cosmopolite species with wideranging vertical distribution (Cutler, 1994). It is the most common sipunculan in deep-sea communities (Cutler and Curle 1987). In Arctic waters it has been reported from Svalbard, Barents Sea, the Karsk Sea, and the Okhotsk Sea. This specinhabits silt, sand, and mud and is often found in foraminiferentests, small polychaete tubes, and mollusk shells (Cutler, 1994). It is reported from the southern Bering Sea (Murina, 1977) and Chukchi Sea (Murina, pers. comm.).

Nephasoma diaphanes corrugatum N. Cutler and Cutler, 1986

MATERIAL. 64 specimens found on mud, sand, segravel, and rocky bottoms, from depths of 43–130 m, COMIDA

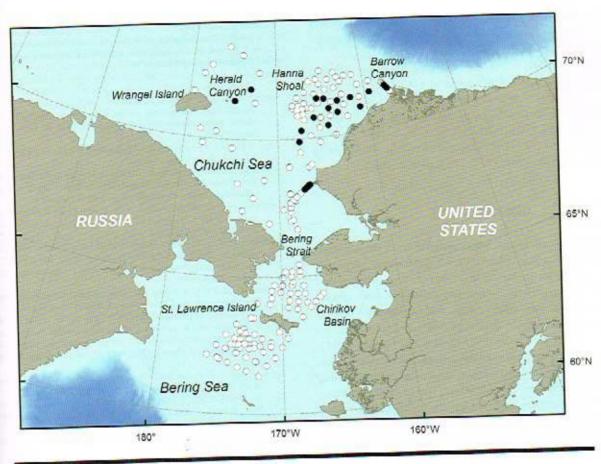


FIGURE 6. Location of stations where Phascolion strombus was found (black dots).

51 (Barrow Canyon), COMIDA10: st. 50 (Barrow Canyon), 20702: st. 8 (south of Saint Lawrence Island), RUSALCA09: 148 (Herald Canyon), SWL2010: st. 14, 15, 16 (south of Saint Lawrence Island), 20, 21 (Chirikov Basin), SWL2011: st. 3 (south Saint Lawrence Island), 23 (Chirikov Basin), 29, 31, 32, 33 (Chirikov Canyon; Figure 5).

DESCRIPTION. Small, slender worm, 1–5 mm. Small, erred hooks (5–25 µm), short, rounded tentacular lobes. retractor muscles, originating in various locations. Skin translucent to opaque, heavily papillated at both ends of the Papillae on the posterior end of the body darker than on arrounding skin.

DISTRIBUTION. This is a widely distributed species a broad latitudinal range from the Atlantic and Pacific (Cut-1994). Found at depths from 80 to 7,000 m (Cutler, 1994; Decci-Papadopoulou et al., 1999) at sandy silt or clay bottom.

Nephasoma eremita (Sars, 1851)

MATERIAL. 1 specimen, gravel bottom, 130 m, mDA10: st. 50 (Barrow Canyon).

DESCRIPTION. Trunk 22 mm, introvert the same as trunk's, no hooks, short tentacles. Single pair of

retractor muscles arising from the middle of the trunk. Skin dark, no papillae.

DISTRIBUTION. This species is often found in the Arctic, North Atlantic, and Antarctic but is rare in the eastern Pacific (Curler, 1994). Its depth range is 20–2,000 m. It is found in the Barents Sca (Garbul and Anisimova, 2012), around Svalbard (Kędra and Murina, 2007), in the Chukchi, Bering, and Okhotsk Seas (Murina, 1977), and in the East Siberian Sca (Murina, pers. comm.).

FAMILY GOLFINGIIDAE

Genus Phascolion Théel, 1875

Phascolion strombus strombus (Montagu, 1804)

MATERIAL. 439 specimens found on mud, sand, gravel, and rocky bottoms, from depths of 34–130 m, with the highest numbers in the southwestern (Russian coast) and southeastern (Alaskan coast) Chukchi Sea and Barrow Canyon (Figure 6).

DESCRIPTION. Variable body shape, often in gastropods shells and *Pectinaria* tubes. Trunk up to 20 mm, introvert longer than the trunk. About 20 tentacles around the mouth and scattered, clawlike hooks. At the trunk base holdfast papillae with chitinized borders (Figure 3B).

DISTRIBUTION. This is a common north Atlantic and Arctic species, with a depth range of 1–4,030 m, but it prefers shallow habitats. It is found in the Barents Sea (Garbul and Anisimova, 2012), Svalbard (Kędra and Murina, 2007), Canadian Arctic (Frank, 1983), and East Siberian, Laptev, and Okhotsk Seas (Murina, 1977). It is reported from the whole Bering and Chukchi Seas (Murina, 1977, 1985, pers, comm.).

CONCLUSIONS

Previously, seven species were recorded from the northern Bering and Chukchi Seas. Murina (1985, pers. comm.) reported two other species in the Bering and Chukchi Seas: Nephasoma abyssorum abyssorum and Nephasoma lilljeborgi. Both species have bathyal to abyssal depth range, and in Murina's reports these species were found at depths of 300 and 150-830 m, respectively (Cutler and Cutler, 1987; Kedra and Shields, 2011). This study focused only on shallow shelves; the deepest station sampled was in Barrow Canyon (130 m), and all other sampling stations ranged between 29 and 80 m. Nephasoma diaphanes corrugatum has not been reported before. However, the reason may be a result of taxonomic nomenclature confusion: this species was introduced in 1986, two years after the last of Murina's papers on the Pacific Arctic were published. However, according to the newest taxonomic classification, this species was found previously in the southern Bering Sea (identified as Golfingia schuettei). On the basis of the present work and Murina's work (1977, 1985, pers. comm.), we can list eight sipunculan taxa that are present in this area (Table 1).

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