Journal of International Scientific Publications: Ecology and Safety

Volume 8, ISSN 1314-7234 (Online), Published at: http://www.scientific-publications.net

INVASIVE SPECIES IN THE FAUNA OF BRYOZOA IN THE BERING AND THE CHUCKCHI SEAS

Valentina I.Gontar

Laboratory of the brackish water hydrobiology, Zoological Institute RAS, Saint Petersburg, Russia

Abstract

First diving expedition of the marine research laboratory of the Zoological Institute RAS was held in the regions of the Providence Bay in the Bering Sea and near the Wrangler Island in the Chuckchi Sea in 1976. Bryozoan collection were identified and analyzed. Peculiarities of geographical locations have determined of coldwater appearance of the Bryozoa fauna with mainly species of Arctic and Pacific origin and few species of Atlantic origin. Species of the real Arctic fauna are immigrants in the Bering Sea after opening of the Bering Strait. Bryozoa as incrusted organisms acquires an importance to the marine biogeography.

Key words. *Fauna, Bryozoa, the Chuckchi Sea, the Bering Sea, invasion, biogeographical composition.*

1. INTRODUCTION

The island of Chukotka is situated in the utmost north-east of territory of the Russia to the East from 180° E. Its north-western border is the Amguem River. Area of the Chukotka is approximately equal 110 000 sq.km, and third part of its area is occupied by flat lands, intermountain depressions and river's valleys, which is consisted of Quaternary sediments.

The most important role in climate plays the geographical position of the Chukotka, which is surrounded by relatively cold seas- the Chuckchi Sea and the Bering Sea, which regulate heat transfer in atmospheric layers near land. In connection with heat exchange the temperatures in coastal regions has observed in winter more high and in summer lower than in inner parts of the Chukotka. All listed factors are determined Polar marine climate in coastal regions of the Chukotka, which is characterized more long-continued winter with small amount of snow and short cool summer.

Average annual temperatures of air in the Chukotka island is negative (the Providence Bay –4,9°C, Vankarem –10,7°). Maximal average monthly temperatures (July-August) fluctuated between +3,6° and +10,5°, and minimal (January-February) from –15,9° to –27,3°. About hardness of climatic conditions testifies also short-term frost-free season - in Vankarem 45 days, In Providence Bay - 68 days.

Features of geographical location of these regions have determined biogeographical compostion of faune of Bryozoa, which is attached animals and represents important object for studying of origin of the Arctic fauna and biogeographical borders in investigated regions of the Chuckchi and Bering seas.

2. MATERIAL AND METHOD

Paper is used of author's data based on collection of the expedition of the Zoological Institute under leadership of professor A,N.Golikov in the Providence Bay (the Bering Sea), in the Wrangel Island and the Cape Schmidt (the Chuckchi Sea) in 1976. Collection of the expedition were obtained for the first time in these regions by quantitative diving method. Bryozoa was found at 22 stations, at depths from 2 to 25 m near Wrangel Island (Gontar, 2009). In the Providence Bay Bryozoa was found at 35 stations, at depths from 2 to 40m (Gontar, 2013).

3. RESULTS

The Chuckchi Sea—the most eastern sea of the Siberian seas is situated along shelf back from the Arctic Circle (Fig.1), and is true Arctic sea with Arctic fauna and flora. Bottom algae meet from the depths 5–8m only. Littoral of the Chuckchi Sea is lifeless and it is characteristic for the Arctic biogeographical subregion (Zenkevich, 1963). Wrangel Island is part of ancient Bering Land Bridge and preserves of unique testimonies of existence of Beringia until now. In faunistic relationship the Chuckchi Sea relatively well studied. The Soviet expeditions during the 30th years of the XX century were particularly fruitful in studying of its fauna (Kluge, 1952, 1962, 2009).

Fig. 1. Map of the Chuckchi Sea and of western part of the Bering Sea.

The expedition of the Zoological Institute of RAS has investigated in the first time of upper shelf zones of the Wrangel Island by diving technique in 1976. Features of geographical location of the Chuckchi Sea define a type of Bryozoa fauna, represented by species of Arctic and Pacific origin and few species of Atlantic origin. The collection of the expedition under leadership of A.N.Golikov included 27 species and subspecies (Table 1), between them two Arctic species (one is circumpolar and other Euroasian in distribution) and all other Boreal-Arctic widespread species (four species are of Pacific origin). The species composition in relationship of biogeographical characteristic in all probability was determined of relatively low depths where these species were met. Two species Hippothoa *hyalina* and *Lichenopora* sp. were marked near the Schmidt Cape. All other species were collected near the Wrangel Island (Rogers Bay, Cape Litke, Cape Hawaii). Finding of new for the fauna of the Chuckchi Sea of amphiboreal species *Einhornia crustulenta baltica*, which inhabits in the Baltic Sea is comparable with earlier registered amphiboreal species *Caulorhamphus spiniferum* and *Parasmittina trispinosa* in the Chuckchi Sea. Kluge (1952) has noted, that the last mentioned two amphiboreal species can be regarded as relicts. Modern migrants of Boreal Pacific fauna has penetrated in the Chuckchi Sea during postglacial time period.

The Bering Sea is one of marginal seas of the Pacific Ocean (Fig.1). It is the largest marine basin of the Russian seas and it is the third sea in extension in the World Ocean. Its area exceeds 2 million square km, the maximal depth of the sea is 4420m, and average depths reach 1598m. The Bering Sea is consist of approximately two equal parts: shallow water northern-eastern part where there are depths less 200m, occupies 45% of area of the sea, and deep depth southern-western with depths more than 200m where the most part is occupied by two depressions. Broad land shelf in width 600-1000км represents inclined submerged flat land, in the limits of which develops specific hydrological and biohydrochemical processes and generates separate water masses. The shelf near Kamchatka and Commander-Aleutian ridge is narrower and its base relief is more complicate. Incoming tides of the Bering Sea generally depend on distribution of tidal waves from the Pacific Ocean. Arctic tide has not almost of influence. In the Bering Sea some types of tides can observe. In the region of the Providence Bay a tide passes as irregular semidiurnal in a height of 1 m.

Thanks to existing classification the Bering Sea is situated in a region of subarctic structure of water masses, which is characterized in general by monotone decrease of salinity with increase of depths and varying changes of temperatures. In total water area of the Sea, excepting of shallow water and the region of the Aleutian ridge, in

all season of the year can trace cold subsurface layer and warm intermediate layer. Maximal value of salinity (33,2-33,3‰) near surface can observe in a region of Blizhny Strait, in western part of deep-water depression and near middle part of the Aleutian ridge and minimal (up to 20-25‰) in land bays of off-shore zone. Desalination of coastal waters reaches its maximum in July. The most coldwater species compositions is confined in central part of shallow water where is distributed water of residual winter cooling with subzero temperatures. On periphery of coldwater biocenoses are placed more warm water biocenoses in which is notable of presence of Boreal Pacific elements (Neyman, 1963; Filatova and Neyman, 1963).

Biogeographical characteristic and problems of zoning of the Bering Sea touched upon many publications. Though a border between Arctic and Boreal subregions in the Bering Sea is still unclear. Different opinions about position of the border were found on analysis of proportion of species number in different animal groups. Some scientists conducted the border between Arctic and Boreal subregions in the limits of the Bering Sea (Vinogradov, 1948; Galkin, 1955; Neyman, 1960, and other), relating the northern part of the Bering Sea to low-Arctic province. Other authors conducted the northern border of the Boreal subregion through the Bering Strait (Ushakov, 1953; Scarlato, 1956) or even in the limits of the Chuckchi Sea (Gorbunov, 1952; Filatova, 1957).

Biogeographical zonation of the Bering Sea had in paper of A.P. Andriyashev (1939) in detail. «The Anadyr cold spot is extremely essential factor in distribution of the fauna. Rather abrupt faunistic border passes between Boreal and Arctic waters, in so-called the Anadyr faunistic barrier in its southern margin», and the barrier passes through a line: outfall of the Anadyr River – Rumyantsev Cape. «Marine waters to the north of St. Lawrence Island and near coast of Chukotka (till the Bering Strait) are strongly cooled as well. Isotherms of bottom layer between the Bering Strait and St. Lawrence Island are spread unequally. Lower temperatures (till negative near bottom) are observed in the western part of this region, i.e. near coast of Chukotka, whereas eastern and southern-eastern parts of this region have waters of more southern origin with bottom temperatures about 3-5°. These more favorable conditions permit many Boreal species to come up more to the north along American coast than along Asian coast. … Low bottom temperatures of the Anadyr cold spot are divided sharply from more warm water adjacent to south waters, formed in this region of local district of «Polar front» (Andriyashev, 1939). A.P. Andriyashev has considered the Bering Sea in a whole as Boreal subregion, and has separated of northern part of the sea (to the north of the Anadyr faunistic barrier) as northern Beringsea district of subarctic character. «To the south of this border meets great number of Boreal species whereas more to the north of it are common many of Arctic species. … With warm waters of a current near American coast some of north Pacific species penetrate through the Bering Strait in the Chuckchi Sea» (Andriyashev, 1939). A.P. Andriyashev has noted as well, that: «the greatest value for biogeographer has sedentary species of marine benthos living in the limits of continental shelf and having of small amplitude of temperature fluctuations. These species can serve for principal biogeographical conclusions» (Andriyashev, 1939). Bryozoa is represented by attached to substrate colonies and has in this opinion a considerable interest for marine biogeography.

In the Bering Sea, glacial regime of which is considerably more favorable than in the Chuckchi Sea, in shallow water of the Gulf of Anadyr, where the depths are from 20–40 to 60–80 m, the relatively deep water Providence Bay occupies suitable geographical location has played earlier and plays so far an important role in the investigation of the Eastern Arctic. The Providence Bay is almost in whole or partly free from ice from May until October. Ice comes off in the beginning of June and water during summer can warm up only till +2-3°C. Data of Bryozoa fauna was almost absent.

In collection of diving expedition of the Zoological Institute 32 Bryozoa species and subspecies were found in the first time in the Providence Bay (Table 1). Previously only species *Serratiflustra serrulata* (Busk) was met in this Bay (Kluge, 1961). In biogeographical relationship the fauna of Bryozoa had coldwater appearance and was represented of Arctic species. (7% from common number of registered species); Boreal-Arctic species (59%), with one of them of Atlantic origin, with all other Boreal-Arctic species of Pacific origin. Boreal-Arctic circumpolar widespread species and high Boreal-Arctic species composed of 10% of common number. And finally there was a group relatively coldwater Boreal species in the fauna which is different in their origin: widespread Boreal of Pacific origin (10%); amphiboreal (7%) and amphipacific (7%) species. Two species *Einhornia crustulenta baltica* (Borg) (amphiboreal) and *Flustrellaria whiteavesi* Norman (Arctic) were marked in the first time in the Bering Sea. Maximal role in the Bryozoa fauna at different depths of the Providence Bay played Boreal-Arctic species and these were widespread or circumpolar species, or species of Pacific origin. Arctic species was represented by two circumpolar species.

Table 1. List of Bryozoa species in the Providence Bay and near the Wrangel Island.

Providence Bay	**Wrangel Island**	**Biogeographical characteristic**
Eucratea loricata (L.)	*Eucratea loricata* (L.)	Boreal-Arctic, widespread, circumpolar
Einhornia crustulenta baltica (Borg)	*Einhornia crusrulenta baltica* (Borg)	Amphiboreal
Tegella armifera (Hincks)	*Tegella armifera* (Hincks)	High Boreal-Arctic, widespread, circumpolar
Tegella spitzbergensis (Bidenkap)		Boreal-Arctic, widespread, circumpolar
Tegella anguloavicularis Kluge	*Tegella anguloavicularis* Kluge	Boreal-Arctic, Pacific origin
	Septentriopora nigrans (Hincks)	Boreal-Arctic, widespread, circumpolar
Tegella sp.	*Tegella sp.*	
	Callopora sp.	
Flustrellaria whiteavesi Norman		Arctic, circumpolar
Cauloramphus sp.	*Caulorhamphus sp.*	
Carbasea carbasea (Ellis et Solander)	*Carbasea carbasea* (Ellis et Solander)	Boreal-Arctic, widespread, circumpolar, Atlantic origin
Serratiflustra serrulata Busk	*Serratiflusra serrulata* Busk	High Boreal-Arctic, circumpolar
Flustra sp.	*Flustra sp.*	
Flustra sp.n		
Chartella papyracea (Ellis et Solander)		Amphiboreal
Dendrobeania levinseni (Kluge)		Boreal-Arctic, Pacific origin
Dendrobeania fruticosa (Packard)	*Dendrobeania fruticosa* (Packard)	Boreal-Arctic, widespread
Scrupocellaria elongata (Busk)	*Scrupocellaria elongata* (Busk)	High Boreal-Arctic, circumpolar
	Scrupocellaria scabra (Van Beneden)	Boreal-Arctic, widespread, circumpolar
Scrupocellaria sp.		
	Escharella sp.	
Smittina mucronata (Smitt)		Boreal-Arctic , Euroasian, Pacific origin
Smittina sp.		
	Smittina concinna belli (Dawson)	Boreal-Arctic
	Porella minuta (Norman)	Boreal-Arctic, Atlantic origin
	Cystisella saccata (Busk)	Boreal-Arctic, circumpolar, Pacific origin
Cystisella saccata beringia Kluge	*Cystisella saccata beringia* Kluge	Boreal-Arctic, circumpolar, Pacific origin
Arctonula Arctica (M.Sars)	*Arctonula Arctica* (M. Sars)	Boreal-Arctic, circumpolar,

		Pacific origin
Hppopodina sp.n.		
Hippoporina reticulatopunctata (Hincks)		Boreal-Arctic, circumpolar, Pacific origin
	Stomachetosella cruenta (Busk)	Boreal-Arctic, widespread
	Stomachetosella sp.	
Myriozoella crustacea (Smitt)		Boreal-Arctic, circumpolar, Pacific origin
Hippothoa hyalina (L.)	*Hippothoa hyalina* (L.)	Boreal-Arctic, widespread
	Escharoides jacksoni rostrata (Kluge)	Arctic
Rhamphostomella bilaminata sibirica Kluge		Boreal-Arctic, Pacific origin
Rhamphostomella scabra (Fabricius)		Boreal-Arctic, circumpolar, Pacific origin
Cellepora sp. плох.сохр.		
Ellisina levata (Hincks)		Amphipacific
Eurystomella zavjalovensis (Kubanin)		Boreal, widespread, Pacific origin
Aplousina major Osburn		Amphipacific
Bowerbankia composita Kluge	*Bowerbankia composita* Kluge	Amphiboreal
Bowerbankia Arctica Busk		Arctic, circumpolar
Bowerbankia sp.		
Flustrellidra gigantea (Silen)		Boreal, widespread, Pacific origin
Flustrellidra cervicornis (Robertson)		Boreal, widespread, Pacific origin
Flustrellidra corniculata (Smitt)	*Flustrelldra corniculata* (Smitt)	Boreal-Arctic, widespread, circumpolar
	Alcyonidium disciforme Smitt	Arctic, circumpolar
Alcyonidium mytili Dalyell	*Alcyonidium mytili* Dalyell	Boreal-Arctic, widespread, circumpolar
Alcyonidium gelatinosum (L.)	*Alcyonidium gelatinosum* (L.)	Boreal-Arctic, widespread, circumpolar
	Alcyonidium gelatinosum pachydermatum Kluge	Arctic
Alcyonidium sp.	*Alcyonidium* sp.	
Lichenopora sp.	*Lichenopora sp.*	
	Crisa denticulata (Lamarck)	Boreal-Arctic, Atlantic origin
	Crisia sp.	

4. CONCLUSION

Recent migrants of Boreal Pacific fauna, which was found near the Wrangler Island (Boreal-Arctic species of Pacific origin), have penetrated in the Chuckchi Sea during post glacial time. Presence of only Boreal-Arctic species of Atlantic origin and two Arctic species in the Providence Bay testifies about penetration of fauna of the Chuckchi Sea to the Bering Sea. Limited areal of these species in the Pacific marine waters gives a base for proposal that species of autochtonic glacial marine fauna are migrants in the Bering Sea of recent time period. During glacial time the Arctic species could not penetrate in the Pacific Ocean, as well the Pacific species could not reach the Arctic Ocean, because on a place the northern part of the Bering Sea and part of the Chuckchi Sea has been situated Beringia land. In the Post glacial time only as a result of boreal transgression has opened the Bering Strait. Relatively warm water conditions during that time period could not help of wide spreading of the Arctic migrants which has found appropriate conditions for life in the northern coldwater part of the Bering Sea (region of the Anadyr coldwater spot). It should emphasize the presence of Boreal-Arctic, amphiboreal and amphipacific species in the fauna of the Providence Bay that testifies about an influence of the Boreal fauna in this region. Notably it should mark that species *Einhornia crustulenta baltica*, which as in the fauna of the Chuckchi Sea near the Wrangler Island has met in the first time and is relict species.

According to opinion of Andriyashev (1939) and our opinion as well (Gontar, Naumov, 1994, 2004) «correct bigeograhical characterstic for species and fauna in whole cannot give without detailed faunistic analysis and mainly without ascertainment of basic features of history of fauna development and its origin. For correct determination for instance of Arctic species it is necessary to find out genetic ties of the species with autochthonic fauna of the Arctic seas, because occurrence any species in stable negative temperatures do not completely define the species to reckon it among category of Arctic species, in like manner it cannot on the base of hardness only or “Arctic” conditions of life in any basin to consider its fauna as true Arctic fauna. Many species in the Okhotsk sea live very often at whole-year subzero temperatures (for instance, region of so-called the Shantar sea), and had not close genetic relationship with authentic Arctic fauna and originated in specific conditions this local этой местной «Arctic» from authentic Boreal Pacific fauna. … Faunistic dividing is dominant, through which we recognize essentially history of origin of fauna, when formal biogeographical dividing of fauna in Arctic, sub-Arctic, Boreal and so on, is certain abstraction; the last generally is reflected distribution of fauna is depending on recent environments, showing up similarity and differences in this relationship between various faunistic regions» (Andriyashev, 1939).

REFERENCES

Andriyashev A.P. (1939) Outline of zoogeography and origination of the Pisces fauna of the Bering Sea and adjacent waters. Ocherk zoogeografii I proiskhozhdeniya fauny ryb Beringova moray I sopredelnykh vod. L.: Izd-vo LGU. 187 p.[In Russian]

Vinogradov L.G. (1948) About zoogeographical zonation of the Far Eastern seas. O zoogeographicheskom rayonirovanii dalnevostochnych morey. // Izvestiya TINRO. T.28. P.162-164.[In Russian]

Galkin Yu.I. (1955) Gastropoda Trochidae of the Far Eastern and Northern seas of the USSR. Bryukhonogie molluski Trochidae dalnevostochnykh b severnykh morey SSSR (family Trochidea). //In.:Opredeliteli po faune SSSR. M.: Izd-vo AN SSSR. 542 p. [In Russian]

Gontar V.I. (2009) Bottom fauna of the Chuckchi Sea. Донная фауна Чукотского моря. //Vestnik ecologii, lesovedeniya I landshaftovedeniya. (Sibirskoye otdeleniye RAN). №10. P.140–156. [In Russian]

Gontar V.I. (2013) Bryozoa of the Providence Bay of the Bering Sea. Mshanki (Bryozoa) bukhty Provideniya Beringova morya.// In.: Earth: Life in Biodiversity. London:IASHE. P.46-49.[In Russian]

Gontar V.I., Naumov A.D. (2004) Colonization of marine bottom animals as a tool of biological invasion. Rasseleniye morskich donnykh zhivotnykh kak mechanism biologicheskoy invasii. //In: Biologicheskiye invazii v vodnykh I nazemnykh ecosystemakh. Chapter 2.8./ Ed. A.F.Alimov, N.G.Bogutskaya (red.). M.;Spb.:Tovarishchestvo nauchnykh izdaniy KMK i ZIN RAN. P. 207-214.[In Russian]

Gorbunov G.P. (1952) Bivalvia of the Chuckchi Sea and the Bering Strait. Dvustvorchatye mollyuski (Bivalvia) Chukotskogo morya I Beringova proliva. // In: Krayniy Severo-Vostok SSSR / P.V.Ushakov (red.). M.;L.:Izd-vo AN SSSR. T. 2. P.216-278.[In Russian]

Zenkevich L.A. (1963) Biology of Seas of the USSSR. Biologiya morey SSSR. M.: Izd-vo AN SSSR.740 p.[In Russian]

Kluge G.A. (1952) Bryozoa of the Chuckchi Sea and the Bering Strait. Mschanki (Bryozoa) Chukotskogo morya i Beringova proliva.// In: Krayniy Severo-Vostok SSSR / P.V.Ushakov (red.). M.;L.:Izd-vo AN SSSR. T. 2. P.138–168. .[In Russian]

Kluge G.A. (1961) List of species of Bryozoa of the Far Eastern seas of the USSR. Spisok vidov mschanok (Bryozoa) Dalnevostochnykh morey SSSR.// In.: Issledovaniya dalnevostochnykh morey SSSR. M.;L.:Izd-vo AN SSSR. T.VII. P. 118-143. .[In Russian]

Kluge G.A. (1962) Bryozoa of the northern seas of the USSR. Mshanki severnykh morey SSSR. M.;L.:Izd-vo AN SSSR. 584 p. [In Russian]

Kluge G.A. (2009) Ecology and distribution of Bryozoa in the Barents and Siberian seas. Ecologiya b raspredeleniye vshanok v Barenzevom b sibirskich moryakh. /Gontar V.I. (red.). Sankt Peterburg:Izd-vo Lulu, Inc. 216 p.[In Russian]

Neyman A.A. (1960) Quantitative distribution of benthos in eastern part of the Bering Sea. Kolichestvennoye raspredeleniye bentosa v vostochnoy chasti Beringova moray.//Zoological journal. T.39. Vyp. 9.P.1281-1292.[In Russian]

Neyman A.A. (1963) Quantitative distribution of benthos in the shelf and upper horizons of slope of eastern part of the Bering Sea. Kolichestvennoye raspredeleniye bentosa na shelfe I verkhnikh gorizontakh sklona vostochnoy chaste Beringova Morya // Trudy VNIRO. T.48. P.455-459. [In Russian]

Scarlato O.A. (1956) To biogeography of the Far Eastern seas as example of Bivalvia. K biogeografii dalnevostochnykh morey na primere dvustvorchatykh molluskov. //In: Trudy problemnogo I tematicheskogo soveshchaniya Zoologicheskogo Instituta AN SSSR. L.: Izd-vo AN SSSR. P.83-92. [In Russian]

Ushakov P.V. (1953) Fauna of the Sea of Okhotsk and conditions if its existence. Fauna Okhotskogo moray I usloviya ee sushchestvovaniya. M.:Izd-vo An SSSR. 460 p. [In Russian]

Filatova Z.A. (1957) Zoogepgraphical zonation of the northern season distribution of Bivalvia. Zoogeograficheskoye rayonirovaniye severnykh morey po rasprostraneniyu dvustvorchstykh molluskov. //Trudy Instituta okeanologii AN SSSR. T.23. P.195-215.[In Russian]

Filatova Z.A.., Neyman A.A. (1963) Biocenoses of the bottom fauna of the Berig Sea. Biocenozy donnoy fauny Beringova moray. // Oceanology. № 3, Vyp. 6. P. 1079-1084. [In Russian]

Gontar, V.I. & Naumov A.D. (1994) The spreading of benthic animals of the shelf of the Northern Eurasia. 1994.// In: Studies on Ecology and Palaeoecology of benthic communities. /R.Mateucci et al., (eds.). Boll.Soc. Paleont. Ital., Spec.Vol., Mucchi, Modena. P.153-156, 2 text-fig.