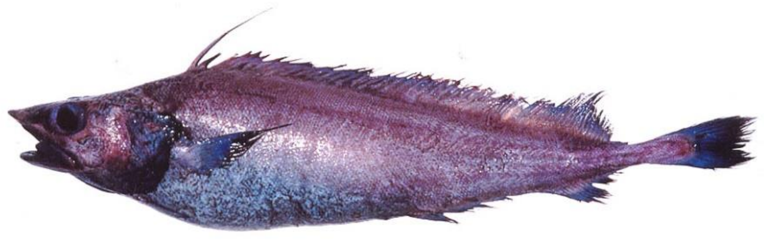

Pacific Flatnose (*Antimora microlepis*, Moridae, Gadiformes) in the North Pacific: an overview of their distribution, genetic diversity, otoliths, and parasites

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INTRODUCTION

The genus *Antimora* (Gadiformes: Moridae) *sensu* Small (1981) and Cohen *et al.* (1990) includes two recognized species, the Pacific flatnose *A. microlepis* (Bean, 1890) and the blue hake *A. rostrata* (Günther, 1878). The latter species are almost cosmopolitan except in the North Pacific, where they are replaced by the former one. Pacific flatnose represent a regular by-catch in deep-sea trawl, longline and trap fisheries and in some areas may occur in considerable amounts (Fitch, Lavenberg, 1968; Eschmeyer et al., 1983; Cohen et al., 1990). For example, on the continental slope of the Sea of Okhotsk their biomass is more than 3 thousand tons or about 1% of the total biomass of the predominant fish species (Dudnik, Dolganov, 1992). The biology of the species under consideration is poorly studied in comparison with blue hake (Svetovidov, 1948; Cohen et al., 1990). In the literature there are only a few publications describing the structure of the otoliths of Pacific flatnose in connection with the taxonomy of morids (Karrer, 1971; Fitch, Barker, 1972), as well as observations from the submersible (Cohen, 1977). A number of papers provide only general information on the spatial and vertical distributions, sizes and age of the species in question (Shuntov, 1965; Fitch, Lavenberg, 1968; Makushok, 1971; Eschmeyer et al., 1983; Allen, Smith, 1988; Cohen et al., 1990; Orlov, 1998; Orlov, Abramov, 2002; Frey et al., 2017).

GOAL

The goal of this poster is to present some results of studies performed during the years 2016-2018 in the framework of the initiative project "Taxonomy, microevolution, distribution, and biology of morid cods *Antimora* spp. (Moridae, Gadiformes, Teleostei) of the World ocean" supported by the Russian Foundation for Basic Research (grant No. 16-04-00516).

RESULTS AND DISCUSSION

Distribution

The range of Pacific flatnose was described by Cohen et al. (1990) in FAO Species Catalogue (Fig. 1) and recently revised by Iwamoto (2010) in IUCN Red List of Threatened Species (Fig. 2). In our opinion, both sources contain some wrong data. The latter map does not display occurrence of the species in the Okhotsk and Bering seas and both maps indicate the occurrence of this species within the entire North Pacific. As our analysis of more than 10,000 records shows (Fig. 3), Pacific flatnose inhabit mostly continental slope from Mexico and Taiwan in the south to the northern Bering Sea in the north. They are very common in the Okhotsk and Bering seas, and in the high seas occur only on seamounts (Emperor seamounts, Hawaiian Ridge, seamounts of the Gulf of Alaska, Bowers and Shirshov underwater ridges).

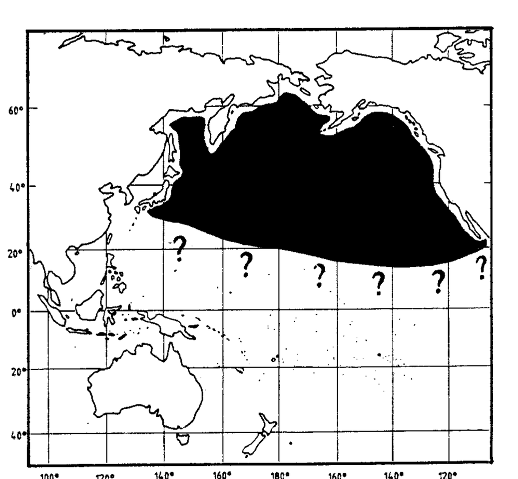

Fig. 1. Distribution of Pacific flatnose *Antimora microlepis* (after Cohen et al., 1990)

Fig. 2. Distribution of Pacific flatnose *Antimora microlepis* (after Iwamoto et al., 2010)

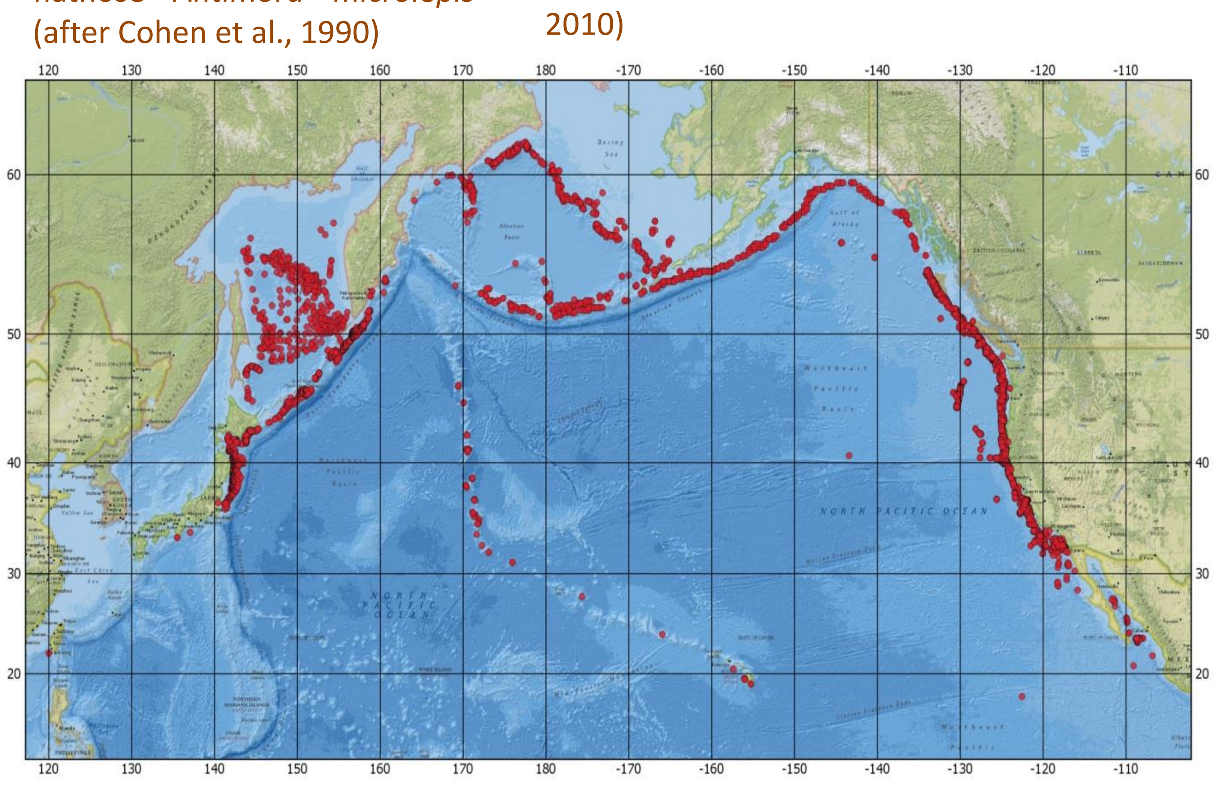

Fig. 3. Records of Pacific flatnose *Antimora microlepis* in the North Pacific

Genetic analysis

With the development of molecular genetic methods, interest in the study of macro - and microevolution processes in fish has increased significantly, including such deep-sea species, as *Antimora* spp. (Oyarzun et al., 1995; Roa-Varóna, Orti, 2009; Smith et al., 2011; White et al., 2011). Until now, however, genetic studies of members of the genus have been limited to the North Atlantic basin (Smith et al., 2011). In this study, tissue samples of 186 individuals from 7 samples from the entire species' range were analyzed using the *CO1* gene (Table. 1). The maximum haplotypic diversity (14 haplotypes, not counting the unique ones) was observed in the sample from British Columbia waters, which has not yet found any reasonable explanation. The haplotype 42 had a highest frequency of occurrence (51.1% for all samples). In addition to this haplotype, considerable frequencies of occurrence were noted for haplotypes 3 (8.1%), 43 (4.8%), 62 (7.5%), and 77 (5.9%). The maximum numbers of unique (rare) haplotypes were found in the sample from the Gulf of Alaska (40.0%) (probably due to its small size) and in the sample from the Emperor Seamounts (21.7%). If we consider the distribution of haplotypes on the map of the North Pacific (Fig. 4), it is noteworthy to increase the share of the main haplotype 42 in the direction from north to south. So, its share steadily increased from 30.0% in the Gulf of Alaska to 62.5% in the waters of California, and from 39.1% in the waters of Sakhalin to 57.1% in the Pacific waters of Japan. It is also possible to note a high proportion of haplotype 3 off the Asian coast (waters of Japan and Sakhalin – 14.3-16.0%) and the Emperor Seamounts (17.4%) and its low occurrence off the American coast (0.0-5.4%).

Table 1. Composition of *CO1* haplotypes in various Pacific flatnose *Antimora microlepis* samples

Area	Haplotypes																	
	2	3	42	43	61	62	63	64	67	68	70	71	72	73	74	77	89	unique	total
Emperor Seamounts & Hawaii	1	4	9	2		1										1		5	23
Gulf of Alaska			3	1		1										1		4	10
SE Sakhalin		4	12	2	1	1	2	2										1	25
California		2	30	2		2		1	1							4		6	48
Oregon & Washington			12	1		5											1	3	22
British Columbia		2	17	1	1	3			1	1	1	1	2	1	1	3	1	1	37
Honshu, Japan		3	12			1										2		3	21
Total	1	15	95	9	2	14	2	3	2	1	1	1	2	1	1	11	2	23	186

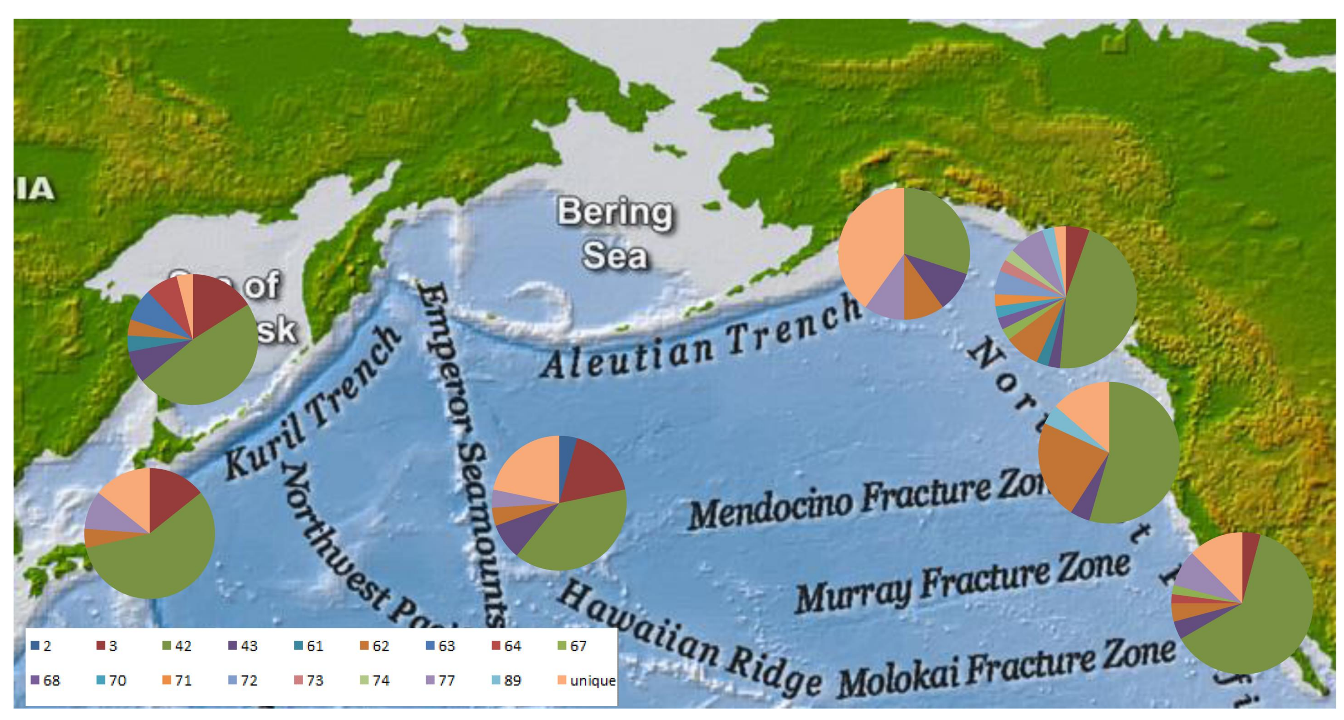

Fig. 4. Distribution of *COI* haplotypes in Pacific flatnose *Antimora microlepis* samples from various parts of species' range.

Otoliths

To study the intraspecific relationships of individuals of *A. microlepis* 704 outlets of four samples from different parts of their species' range were studied (23 otoliths of fish from the waters of the Pacific coast of Honshu, Japan; 24 otoliths of fish from the waters of Southeast Sakhalin, 601 otoliths of fish from US West Coast, 28 otoliths of fish from British Columbia waters of and 28 otoliths of fish from waters of the Emperor Seamounts). The total length and body weight of the fishes were measured. The length of otoliths was measured using an electronic caliper with 0.01 mm accuracy. The weight of otoliths was determined using electronic scales with 0.001 g accuracy. The data obtained were subjected to statistical analysis by the Principal Components method using PAlaeontological Statistics (PAST ver. 3.14 software; Hammer et al., 2001) software. Ratios between fish length of and otolith length, fish length and otolith weight, fish weight and otolith length, fish weight and otolith weight, otolith length and an otolith weight were used for comparative analysis of samples.

The results obtained (Fig. 5) showed that the sample from the Pacific waters of Japan is the most isolated from all others, which may be due to specific habitat conditions. A sample from the Emperor Seamounts also seems a bit separated with partial overlap with samples from southeastern Sakhalin, British Columbia, and US West Coast. The separation of this sample may be related to the isolation of the Emperor Seamounts from the continental slope of both Asian and American coasts. No differences were found between samples from southeastern Sakhalin, British Columbia and US West Coast despite the significant geographical distance, which may be due to similar habitat conditions on both coasts.

At the same time, the analysis of relationships between the length and weight of otoliths (Fig. 6) shows that the values of linear and power coefficients of the studied samples are markedly different from each other. Formulas of these relationships have the following form (W = body weight, g; TL = total length, cm; R^2 = correlation coefficient).

British Columbia: $W = 1.554 \times 10^{-5} TL^{3.508}$ ($R^2 = 0.953$),
US West Coast: $W = 1.923 \times 10^{-4} TL^{2.583}$ ($R^2 = 0.869$),
Southeastern Sakhalin: $W = 6.698 \times 10^{-5} TL^{3.022}$ ($R^2 = 0.929$),
Emperor Seamounts: $W = 1.090 \times 10^{-4} TL^{2.793}$ ($R^2 = 0.787$),
Pacific waters of Japan: $W = 3.474 \times 10^{-4} TL^{2.326}$ ($R^2 = 0.973$).

Thus, the data obtained do not allow to make unambiguous conclusions about the intraspecific relations of *A. microlepis* on the basis of the study of their otoliths.

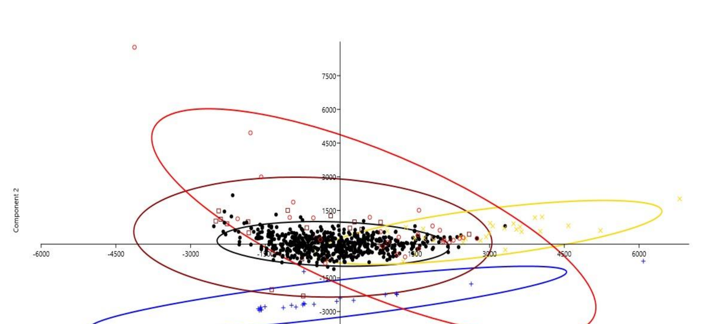

Fig. 5. Results of Principal Component analysis of six samples of Pacific flatnose *Antimora microlepis* otoliths from various parts of the species' range.

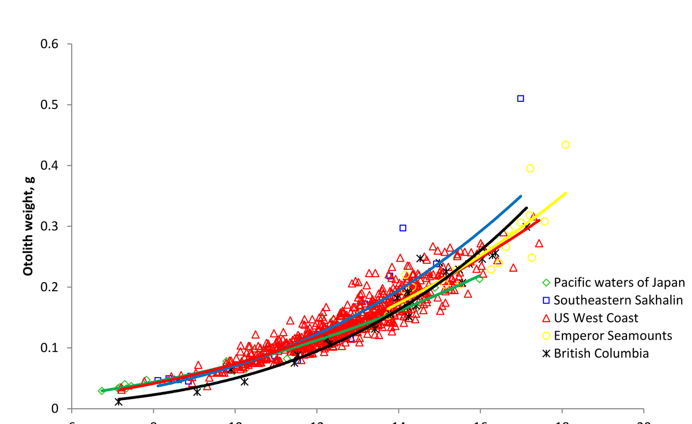

Fig. 6. Relationships between length and weight of Pacific flatnose *Antimora microlepis* otoliths from various parts of the species' range.

ACKNOWLEDGEMENTS

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Parasites

The study of the involvement of *Antimora microlepis* in the parasitic cycles was carried out using three samples: the Southeastern Sakhalin, the Pacific waters of Japan and British Columbia – in total 61 individuals. A total of 12 species of parasites were identified (Cestoda – 2, Nematoda – 3, Trematoda – 4, Copepoda – 2, Monogenea – 1). The greatest infection with helminths both by diversity, and by indicators of intensity and extensiveness of invasion was revealed in the western part of the range (Japan and Sakhalin). This species were mostly infected by *Anisakis* sp., *Dinosoma* sp., *Lecithophyllum* sp., *Choricotyle* sp. and *Sarcotaces* sp. The six species of helminths (*Hysterothylacium* sp., *Acarophis* sp., *Dinosoma* sp., *Lecithophyllum botryophoron*, *Lepidapedon* sp., *Nybelinia* sp. and *Scolex* pl.) were recorded for the first time. Composition of parasites off Japan and Sakhalin Island found the most similar, while off the British Columbia area, both species diversity and level of infection were much smaller. The main reason of this observation is apparently associated with a lower diversity and abundance of intermediate hosts in the latter area. Of particular interest from the point of view of the prospects for the use of *A. microlepis* for the production of food or technical products is the infection by *Sarcotaces* sp. That was observed off Sakhalin and in the waters off Japan. The massive presence of this mesoparasite in the muscles of the host leads to almost full replacement of the host musculature by tissues of the parasite.

Table 2. Species composition of parasites found in different Pacific flatnose *Antimora microlepis* samples.

Group	Species	SE Sakhalin (25 inds.)	Japan (25 inds.)	British Columbia (11 inds.)
Nematoda	*Anisakis* sp.	X	X	
	Acarophis sp.	X	X	
	Hysterothylacium sp.			X
Trematoda	*Dinosoma* sp.	X	X	
	Lecithophyllum spp.	X	X	
	Lepidapedon sp.	X		
Cestoda	*Nybelinia* sp.	X	X	
	Scolex pl.	X	X	
Copepoda	*Parabrachiella* sp.	X	X	X
	Sarcotaces sp.	X	X	
Monogenea	*Choricotyle* sp.	X		X