Molecular genetic study of the population structure as a basis for Pacific cod fishery management in the Russian Far East

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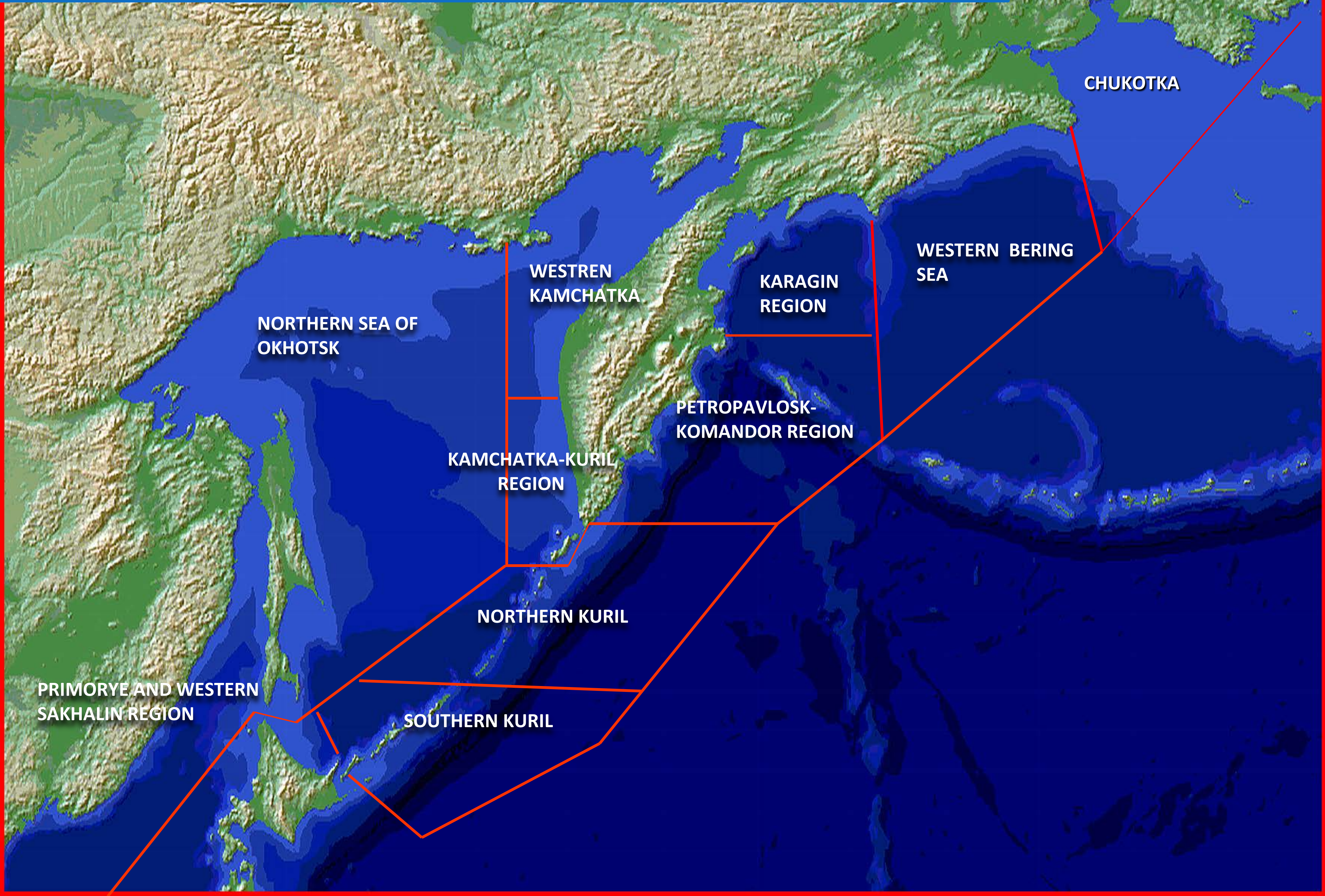
Introduction

- Pacific cod *Gadus macrocephalus (*Tilesius, 1810) is one of the 10 most important fish species in the North Pacific with high catch rates;
- Increasing interest leads to the more intense stock exploitation;
- Unbalanced fishery load on the stocks can be a result of fishery management with no reference to the population structure of the species and can cause overexploitation of the populations;
- There is an urgent need in a complex biological-genetic study in order to reveal the population of Pacific cod.

Fishery regions of Pacific cod in Russian waters



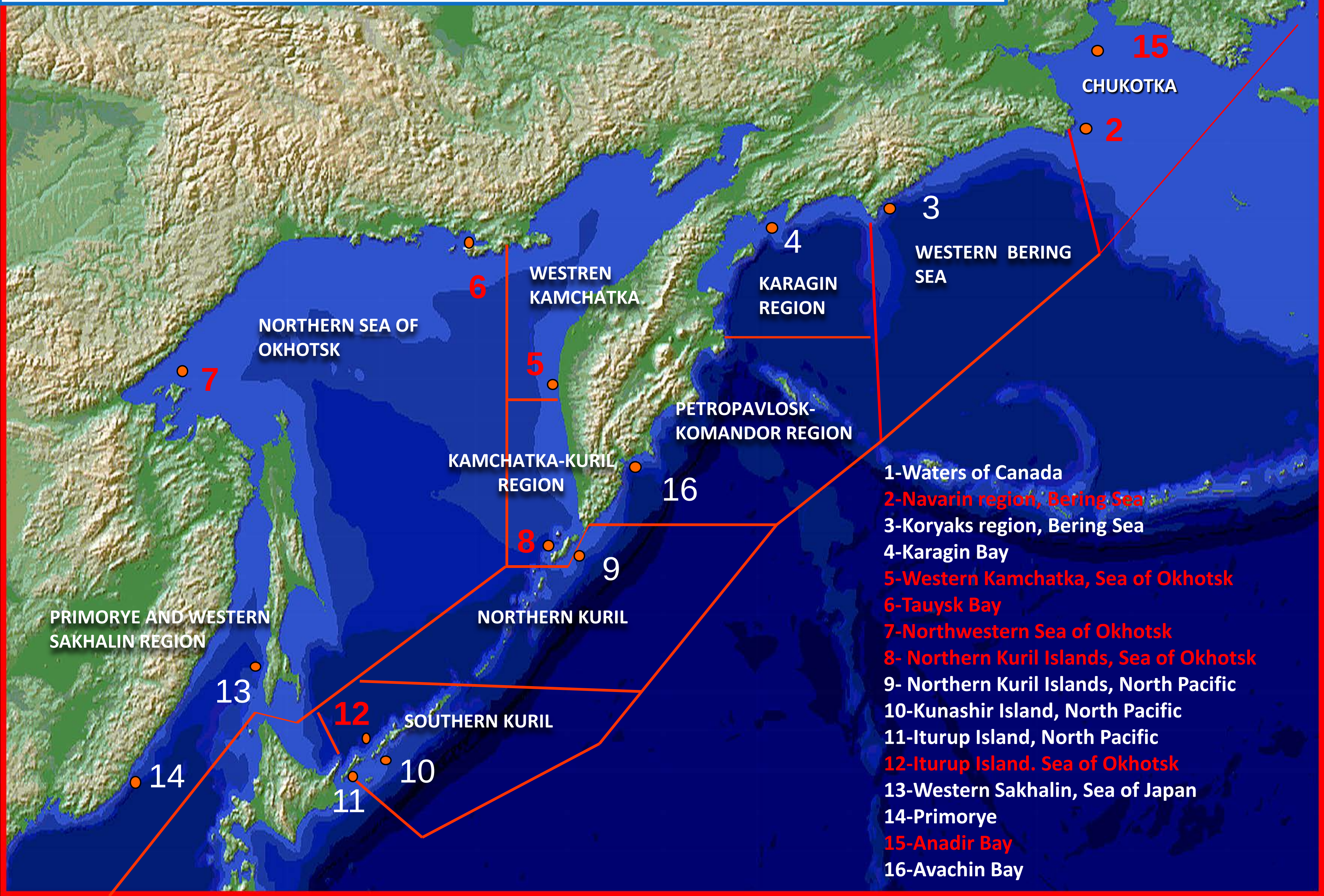
Objective

- The goal of this study is to analyze genetic differentiation of Pacific cod Gadus macrocephalus, reveal its intraspecific structure and develop proposals for TAC settings in accordance with the population structure.

Materials

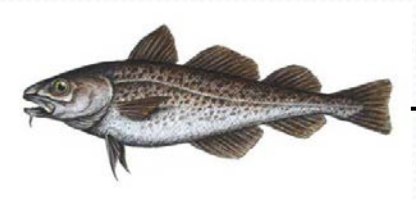
- Samples from 7 regions of the North Pacific: Navarin region of the Bering Sea, Western Kamchatka (Sea of Okhotsk), Tauysk Bay, Northwestern Sea of Okhotsk, Northern Kuril Islands (Sea of Okhotsk), Iturup Island (Sea of Okhotsk), Anadir Bay.

Samples of Pacific cod for genetic study



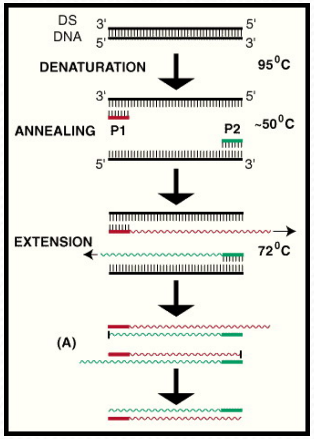
1-Waters of Canada
2-Navarin region, Bering Sea
3-Koryaks region, Bering Sea
4-Karagin Bay
5-Western Kamchatka, Sea of Okhotsk
6-Tauysk Bay
7-Northwestern Sea of Okhotsk
8- Northern Kuril Islands, Sea of Okhotsk
9- Northern Kuril Islands, North Pacific
10-Kunashir Island, North Pacific
11-Iturup Island, North Pacific
12-Iturup Island. Sea of Okhotsk
13-Western Sakhalin, Sea of Japan
14-Primorye
15-Anadir Bay
16-Avachin Bay

Methods

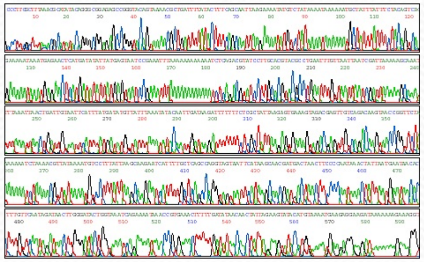


Pieces of muscle or pectoral fin

Extraction of DNA



PCR amplification



Sequence analysis

Data processing

Methods

- **Genetic markers**
  - Microsatellites
    - Loci, initially sequenced and tested on Atlantic cod, Gmo3, Gmo34, Gmo19, Gmo8 (Miller et. al., 2000), PGmo 32 (Jakobsdottir et al., 2006) as well as own Pacific cod locus Gma106 (Canino, 2005)
  - Gene of cytochrome b
    - New universal primers were specially designed for this study and used for PCR of cytochrome b gene
  - Control region of mtDNA

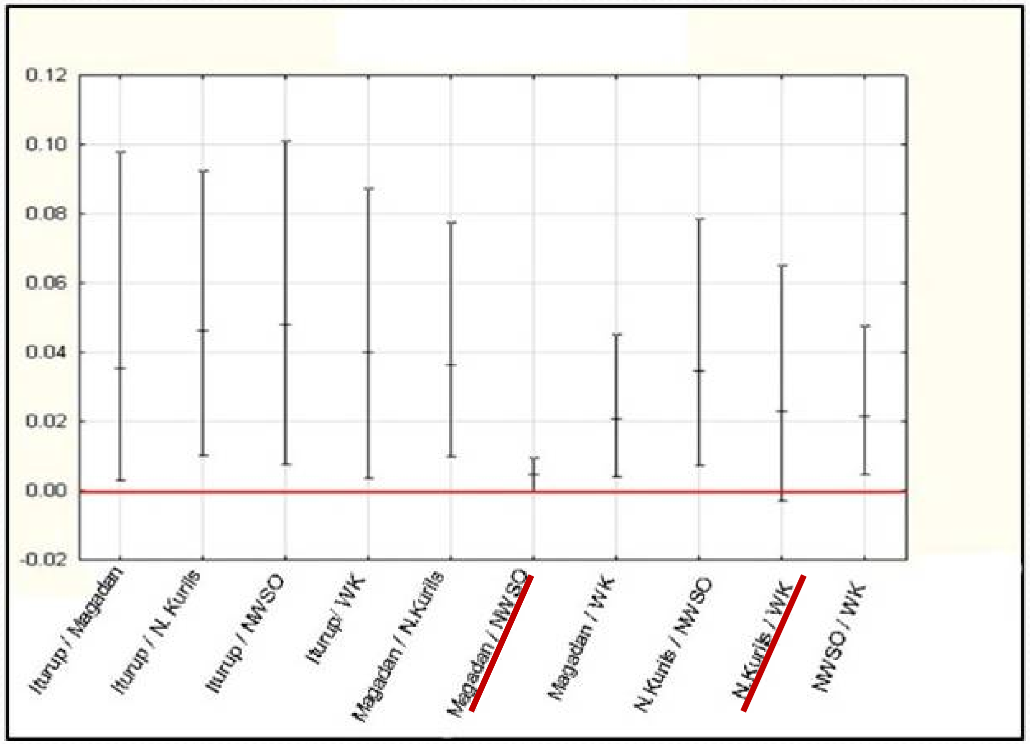
Results

- **Microsatellites**
  - High polymorphism of loci
  - Average number of alleles per locus is 22

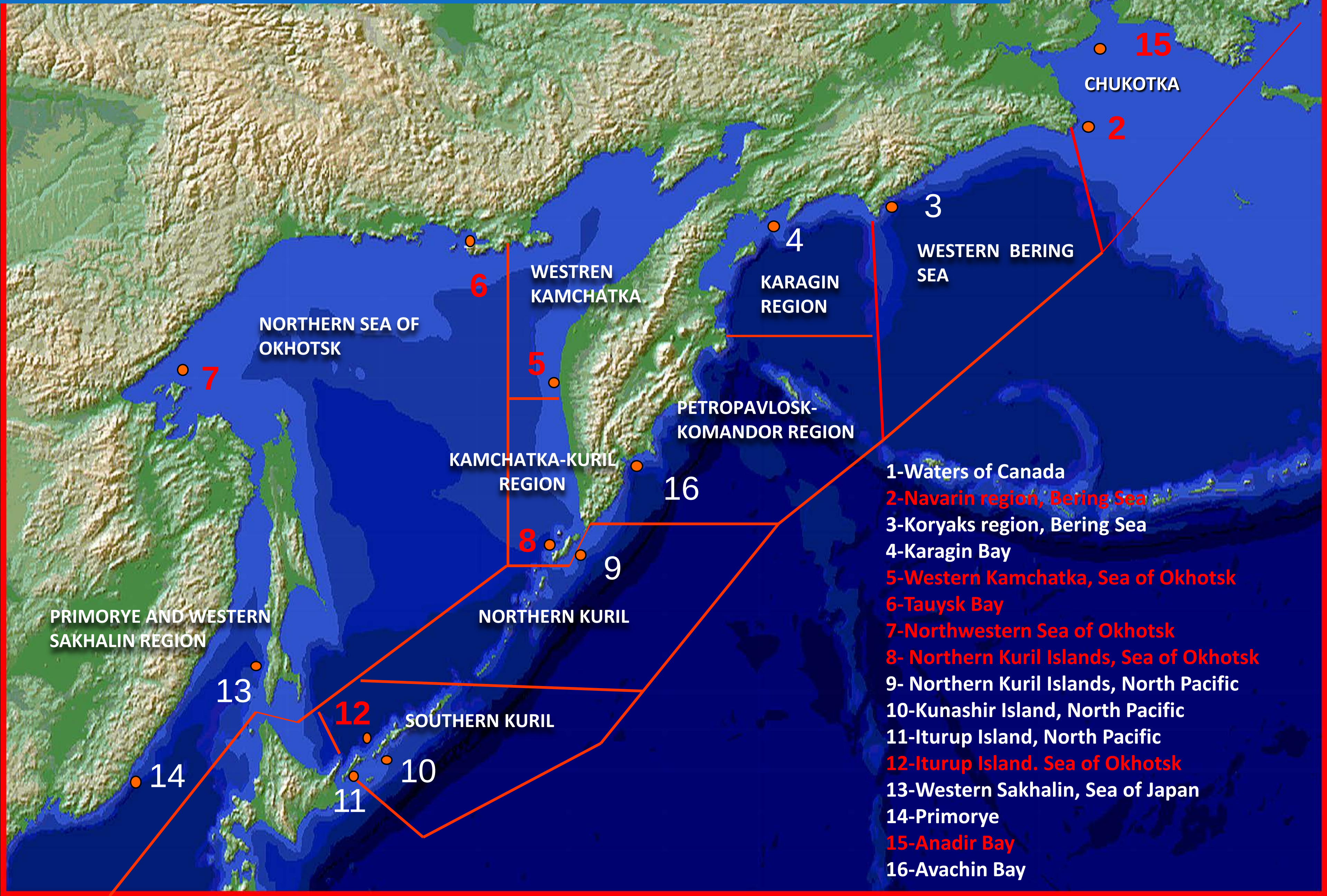
Locus	Quantity of alleles
Gma106	13
Gmo19	30
Gmo3	2
Gmo34	26
Gmo8	52
pGmo32	9

Results

- **Microsatellites**
  - Pairwise comparison of Theta-P values showed significant differentiation between studied samples, except for the two pairs of samples (Tauysk Bay/Northwestern Sea of Okhotsk and the Northern Kuril Islands/Western Kamchatka).



Samples of Pacific cod for genetic study



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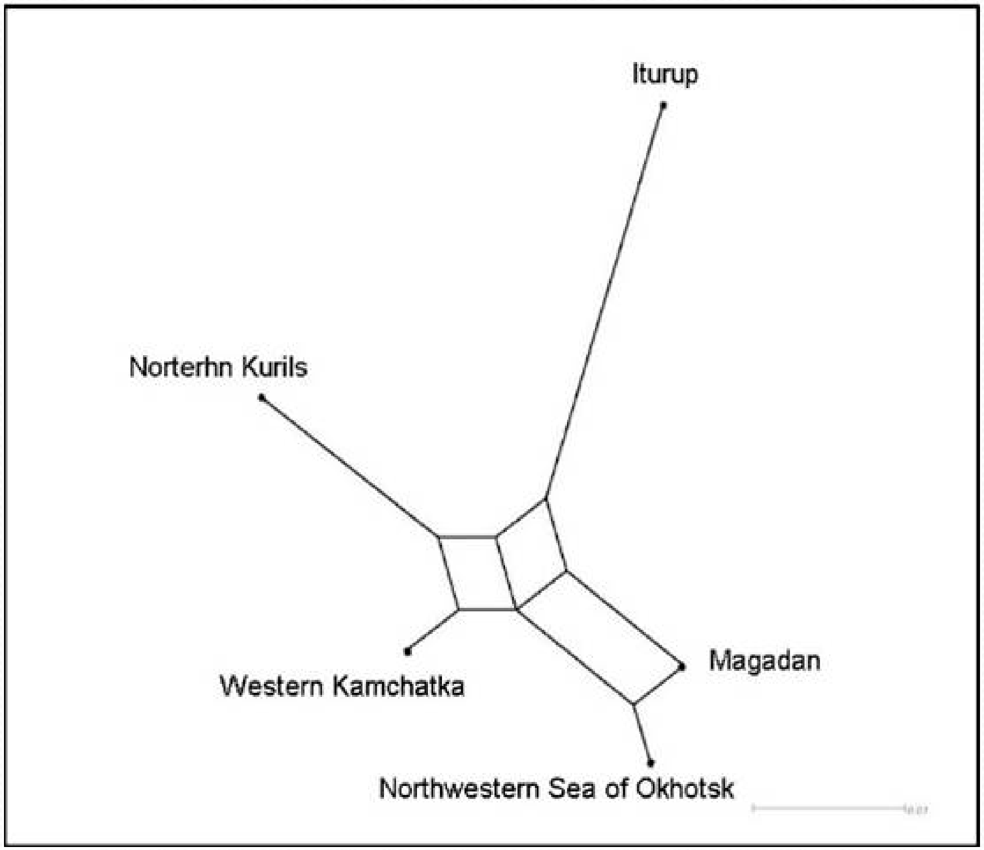
15-Anadir Bay
16-Avachin Bay

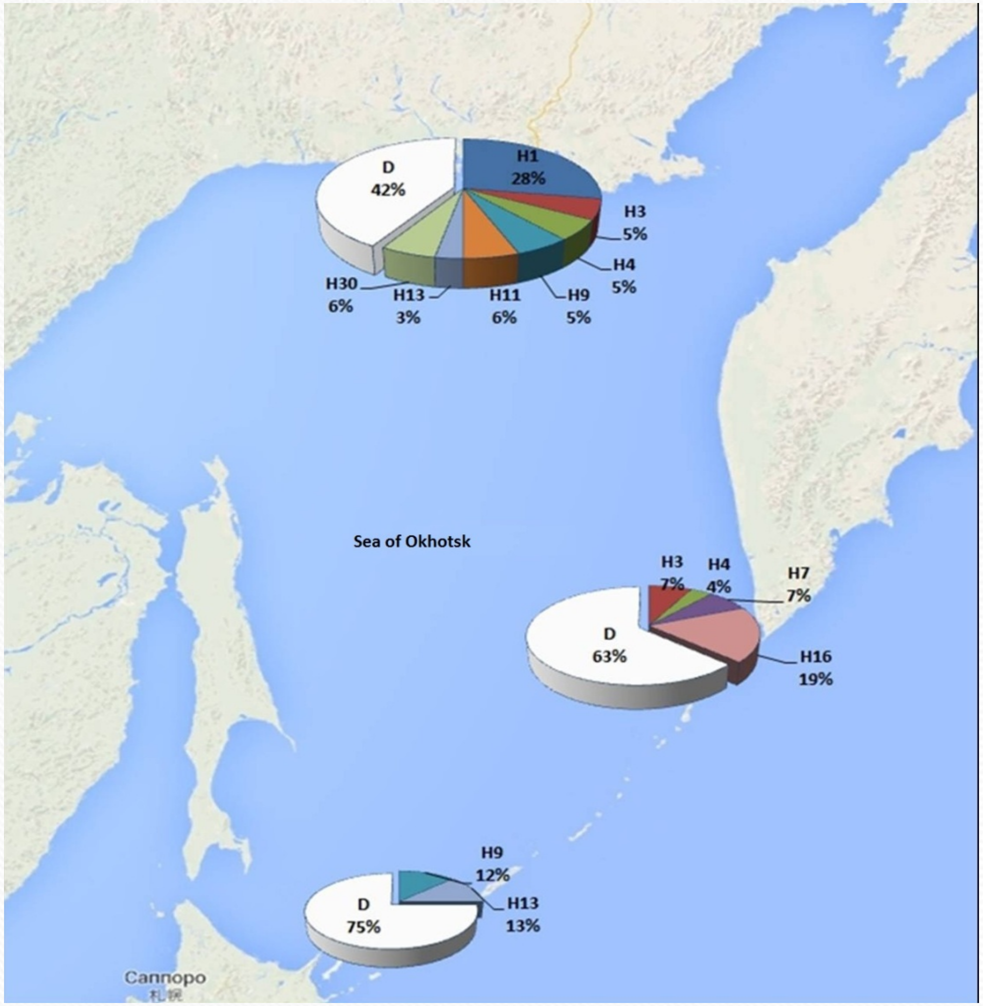
Results

- **Microsatellites**
- Samples from the Northwestern Sea of Okhotsk and Tauysk Bay (Magadan) are most related to each other
- Samples from Western Kamchatka and Northern Kuril Islands are relatively closely spaced
- The most distant from each other are samples from Iturup Island waters and Northwestern Sea of Okhotsk.



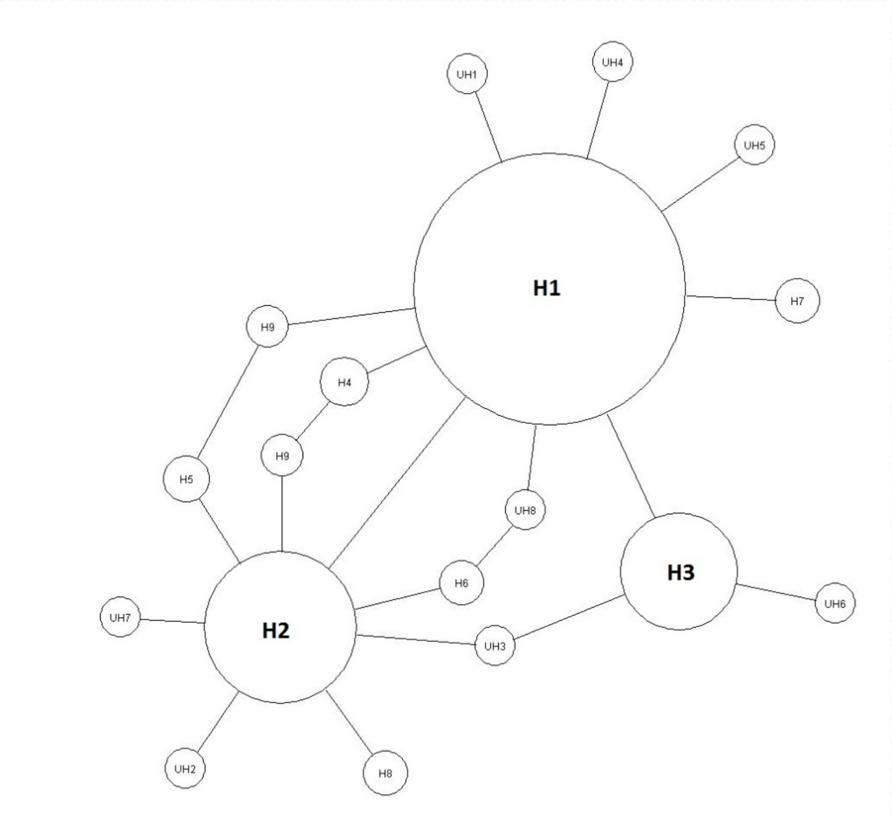
Results

- **Gene of cytochrome b**
- 47 haplotype: 9 haplotypes appeared in more than one fish, all other haplotypes ("D") are presented singly, i.e. they are unique.
- The greatest number of unique haplotypes ("D") was found in the samples from the Iturup Island waters - 75%, and the lowest - in the samples from Tauysk Bay - 42%.



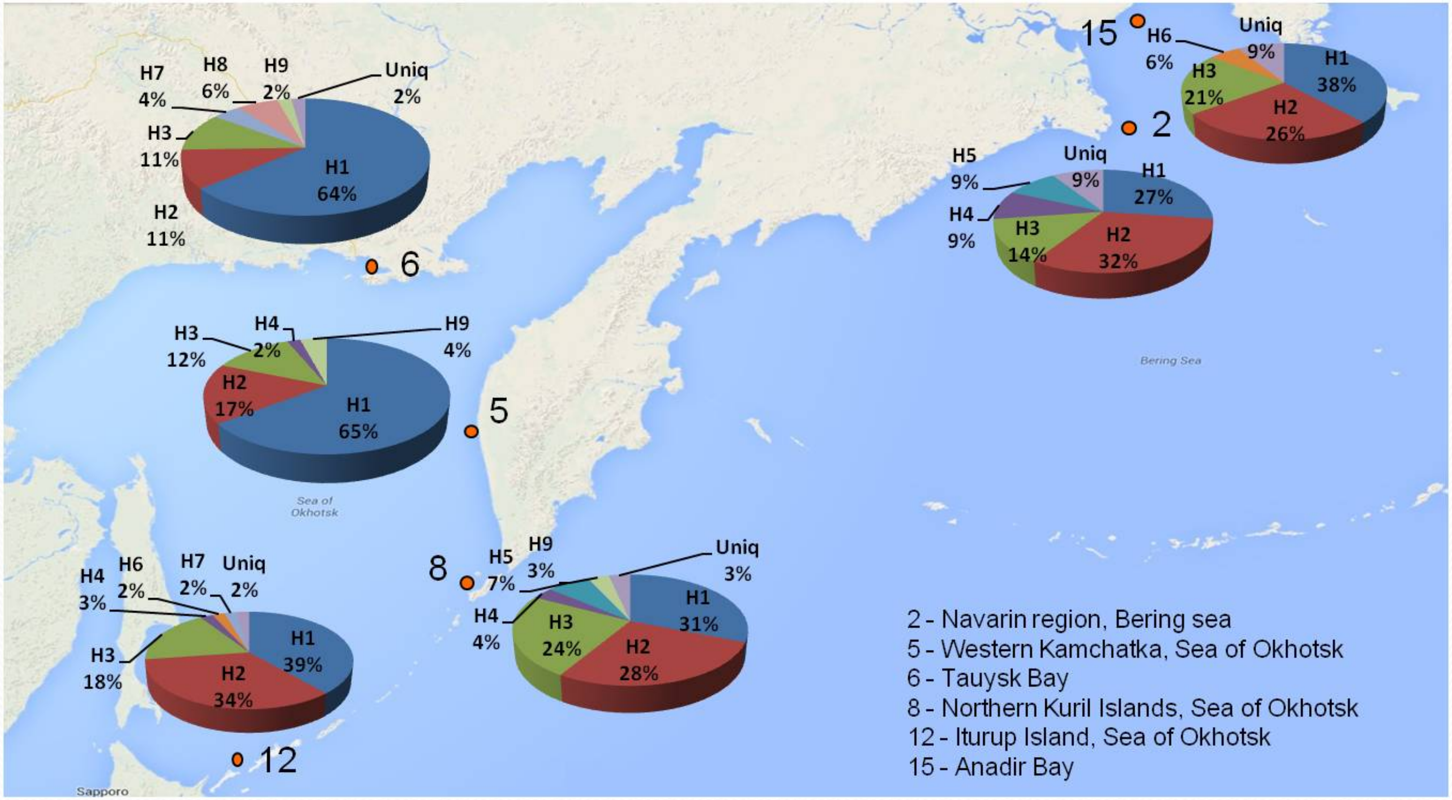
Results

- **Control region of mtDNA**
- Total 227 samples
- 3 main haplotypes: H1, H2 and H3.



Results

- **Control region of mtDNA**

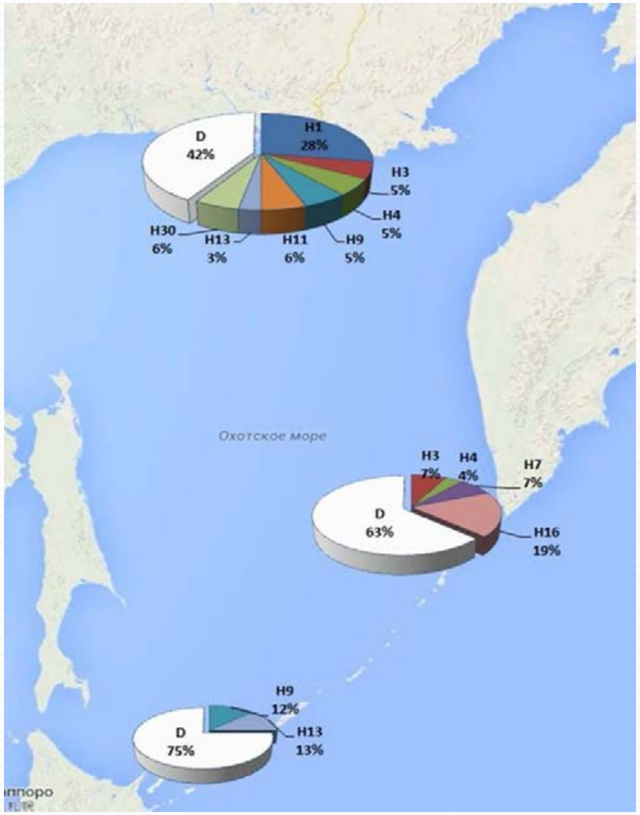


Results

Gene of cytochrome b

Haplotype H1 only in Tauysk Bay

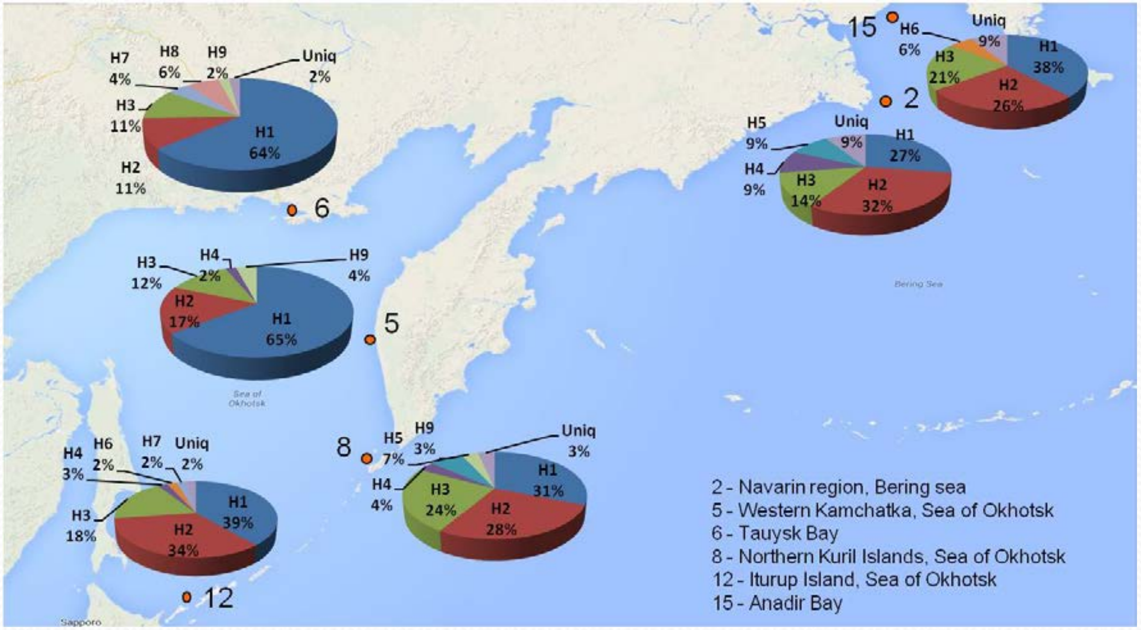
Haplotype H16 only off the Northern Kuril Islands (H16)



Control region of mtDNA

Haplotype H8 only in Tauysk Bay (H8)

Haplotypes H5, H6 only in Northern, Southern Kuril Islands and Northern Bering Sea



Discussion

- Population of Pacific cod is polymorphic and steady for a long period of time;
- Pacific cod from the Sea of Okhotsk is heterogeneous and can be subdivided into at least three major groups - the cod of the northern and northwestern parts of the Sea of Okhotsk, cod of the eastern Sea of Okhotsk and cod of the southern Sea of Okhotsk;
- Despite the established fact of mainly local migrations of Pacific cod the data shows a large-scale drift of genetic material between the North Asian and North American coastal waters of Pacific ocean;
- Further molecular genetic studies are needed for development of adequate and efficient measures for sustainable Pacific cod fisheries in different regions of Pacific Ocean.

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Thank you for your attention!