Dynamics of distribution and relative abundance of three small mesopelagic predatory teleosts in the northwestern Pacific over 40 years

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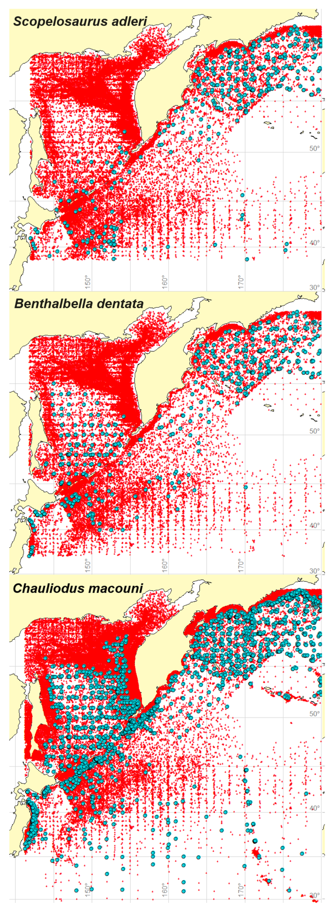

Fig. 1. Capture sites of three small mesopelagic fishes in the northwestern Pacific, 1965-2010. Here and on Figures 2-7, little red crosses indicate stations where particular species was not present.

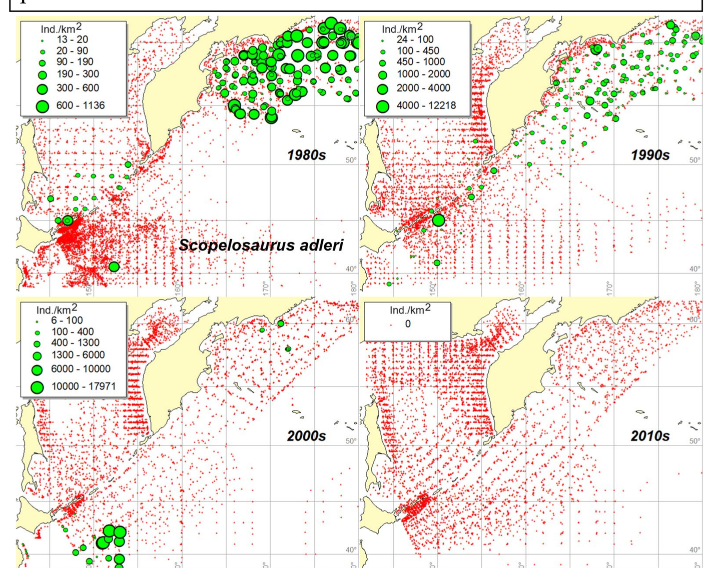

Fig. 2. Decadal changes in the spatial distribution of *Scopelosaurus adleri* in the northwestern Pacific, 1980-2010.

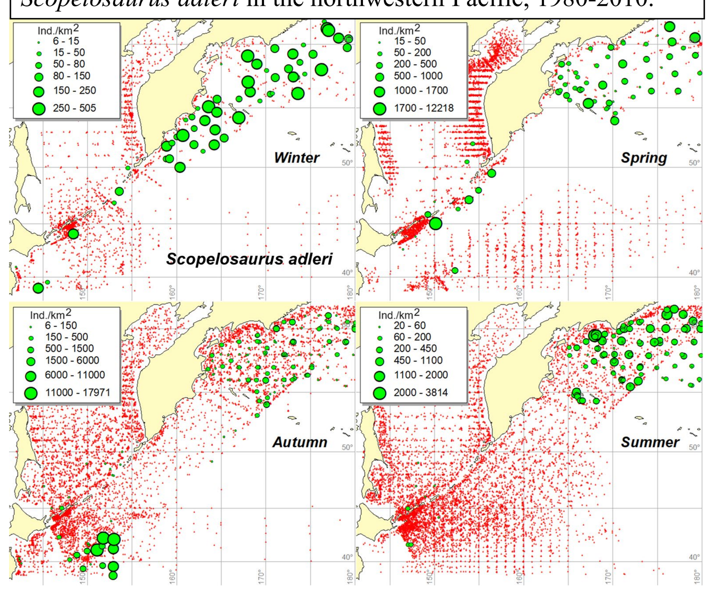

Fig. 3. Seasonal changes in the spatial distribution of *Scopelosaurus adleri* in the northwestern Pacific, 1980-2010.

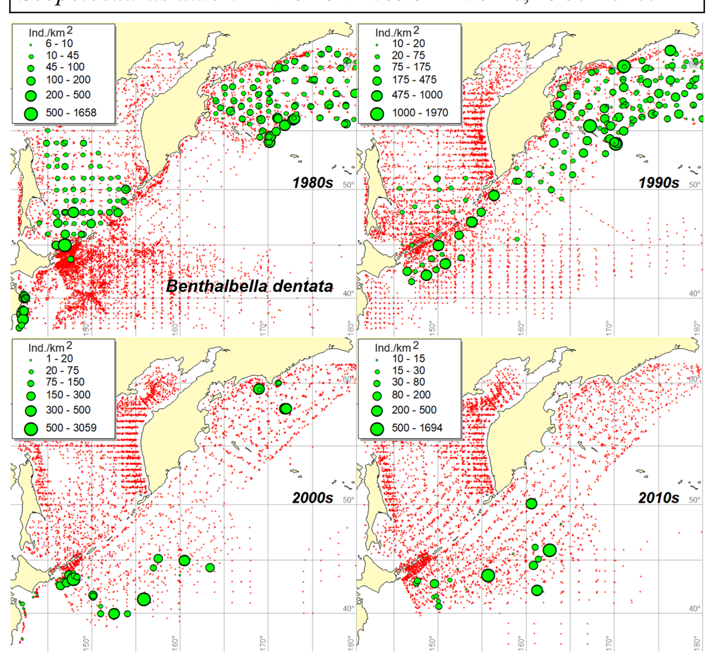

Fig. 4. Decadal changes in the spatial distribution of *Benthalbella dentata* in the northwestern Pacific, 1980-2010.

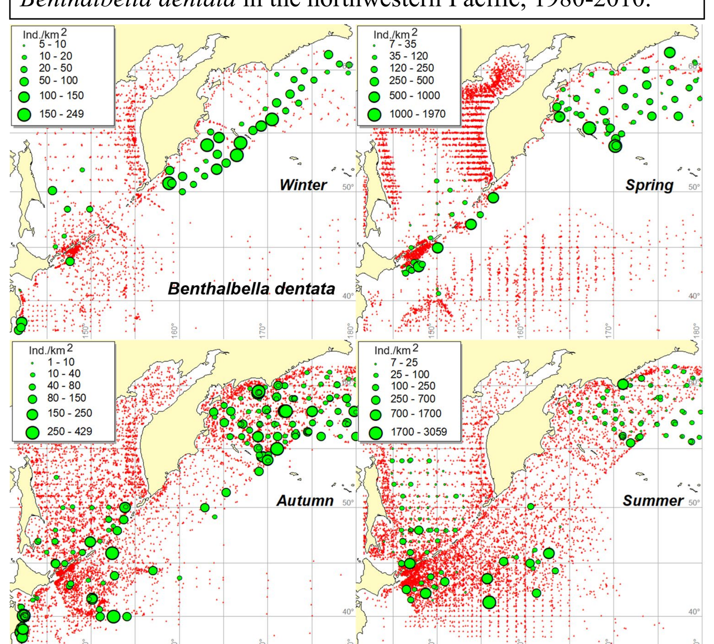

Fig. 5. Seasonal changes in the spatial distribution of *Benthalbella dentata* in the northwestern Pacific, 1980-2010.

Introduction

Pelagic predators play an important role in marine ecosystems, occupying the top position in food webs and accumulating intake of energy and organic matter produced by organisms of lower trophic levels. Until now, studies of pelagic predators have focused mainly on large aquatic animals, such as sharks, tuna, billfishes, marine mammals and some others, while notably less attention was paid to small predatory mesopelagic fishes. In the northwestern Pacific, among the small predatory meso- and bathypelagic fishes, three species are the most common and abundant. These are longfin waryfish *Scopelosaurus adleri*, northern pearleye *Benthalbella dentata,* and Pacific viperfish *Chauliodus macouni*, which play an important role in food chains, occupying an intermediate position between apex predators and non-predatory planktonic and nektonic animals. Despite the great ecological role and frequent occurrence in catches of scientific midwater trawl surveys, information on the distribution and abundance dynamics of these species in the northwestern Pacific is rather limited and mostly outdated.

Goal

The goal of this presentation is to identify changes in the spatial distribution and catch rates of the three most common small mesopelagic predatory fishes (*S. adleri, B. dentata*, and *C. macouni*) in the northwestern Pacific based on the analysis of long-term data obtained during Soviet/Russian scientific midwater trawl surveys.

Material and Methods

Two databases created at the Pacific Branch of the Russian Federal Research Institute of Fisheries and Oceanography (TINRO, Vladivostok, Russia) were used for this work.

1. Raw data were extracted from the extensive TINRO database "Marine Biology" (Database 2000; Volvenko 2015a, 2015b, 2016). These are compiled data from all scientific, exploratory, and commercial fishing cruises in the region (Fig. 1). Many of them are not suitable for quantitative assessments of fish abundance since they do not contain information on trawling speed, opening of trawl mouth, or even the type of trawl used. Only pelagic hauls made by mid-water trawls in the eastern hemisphere (longitude up to 180°) were selected for the quantitative analysis.

2. Cleaned and verified data were taken from another database "Trawl macrofauna of the northern Pacific pelagic zone 1979-2009" (Volvenko & Kulik 2011; Volvenko et al. 2014) supplemented with the data from recent trawl surveys conducted by TINRO through 2010. This database contains only carefully checked and edited data from selected scientific cruises with all technical parameters of fishing gear necessary for calculating fish density in specimens per square kilometer (Figs. 2-7).

The frequency of occurrence of a species (%) was calculated as the number of its captures divided by the total number of hauls within study area and multiplied by 100. The abundance of a species, as Catch Per Unit Effort – CPUE (ind./km^2), was calculated using the formula (Volvenko 1998, 2000): $CPUE=n/(1.852 \cdot v \cdot t \cdot (a/1000))$, where n is the number of fish in the catch (ind.), v – trawling speed (knots), t – hauling duration (hours), a – horizontal opening of the trawl mouth (m), 1.852 – number of kilometers in a nautical mile, 1000 – number of meters in a kilometer.

Main Results

In *S. adleri* and *B. dentata*, the northern boundary of distribution remained almost unchanged until the 2000s, while in the latter species it subsequently shifted by 10° south, and in *C. macouni* it remained virtually unchanged until the 2010s (Fig. 8). The southern distribution boundary of *S. adleri* remained almost unchanged until the 2000s, while its changes in *B. dentata* and *C. macouni* occurred in antiphase. There were no significant seasonal changes in the northern distribution boundary of three species considered, which was at approximately 60°N during the year. The southern boundary of *S. adleri* and *B. dentata* distributions shifted slightly to the north in spring and winter and to the south in autumn, while in *C. macouni* it shifted noticeably to the north in summer and autumn. Over the long term, the occurrence of all species increased until the 1990s, after which it decreased to minimum values in the 2010s (Fig. 9). The occurrence of all three species in catches was minimal in summer, and maximal in autumn for *B. dentata* and in winter for the other two species.

The maximum value of the average catches of *S. adleri* was recorded in the 2000s, while in the other two species in the 1990s (Fig. 10); their minimum in all three species occurred in the 2010s. In *C. macouni*, the maximum average catches were recorded in spring, while minimum in summer. In *S. adleri* and *B. dentata*, the minimum was recorded in winter, while the maximum in autumn and summer, respectively.

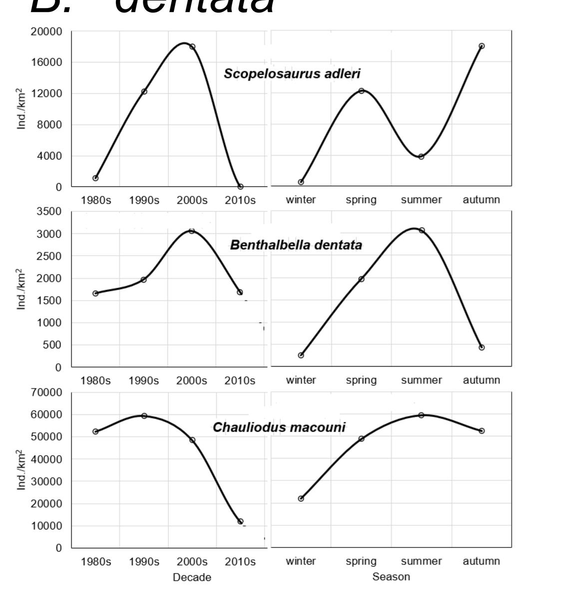

Fig. 11. Decadal (left) and seasonal (right) changes of maximum densities of three small mesopelagic predatory fishes in the northwestern Pacific.

The absolute maximum catches of *S. adleri* and *B. dentata* were recorded in the 2000s, and in *C. macouni* in the 1990s. (Fig. 11), while the minimum in all three species in 2010. The minimum catches of all species were recorded in winter, while the maximum catches of S. adleri were recorded in autumn, and those of the other two species in summer.

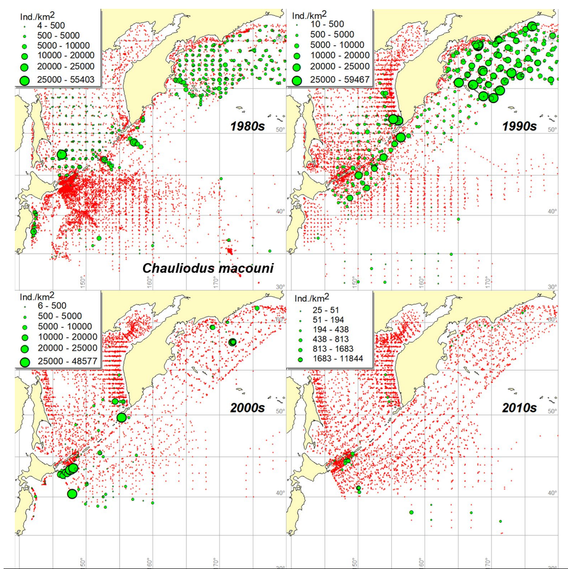

Fig. 6. Decadal changes in the spatial distribution of *Chauliodus macouni* in the northwestern Pacific, 1980-2010.

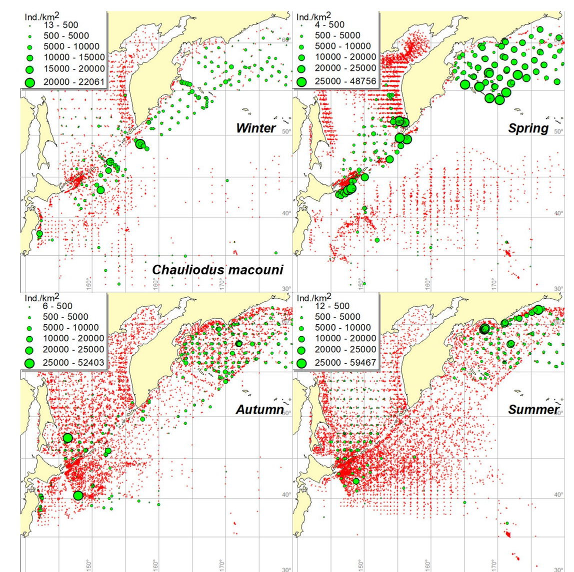

Fig. 7. Seasonal changes in the spatial distribution of *Chauliodus macouni* in the northwestern Pacific, 1980-2010.

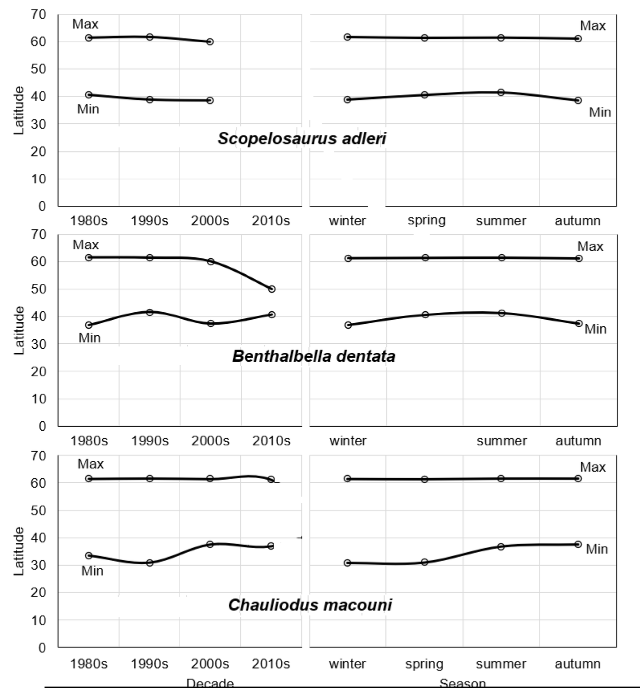

Fig. 8. Decadal (left) and seasonal (right) changes of the northern and southern borders of captures of three small mesopelagic predatory fishes in the northwestern Pacific.

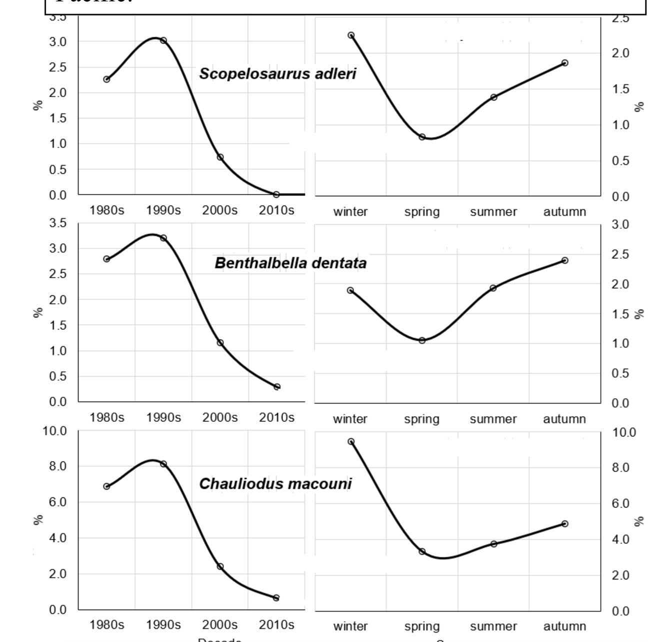

Fig. 9. Decadal (left) and seasonal (right) changes of frequency of occurrence of three small mesopelagic predatory fishes in the northwestern Pacific.

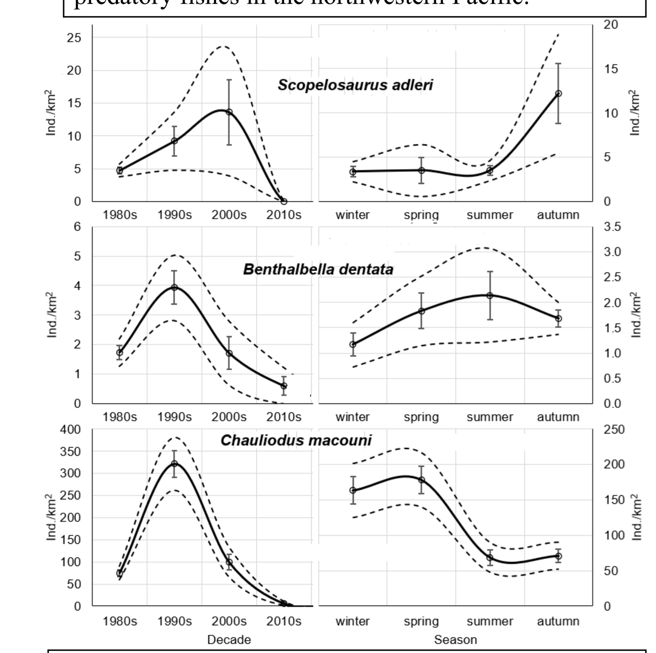

Fig. 10. Decadal (left) and seasonal (right) changes of mean densities of three small mesopelagic predatory fishes in the northwestern Pacific. Whiskers – standard errors, dashed lines – 95% confidence interval.