Seasonal Distribution and Migrations of Pacific Cod *Gadus macrocephalus* (Gadidae) in the Northwestern Part of the Sea of Japan and Adjacent Water Areas

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Received December 12, 2009

Abstract—On the basis of materials collected in 32 expeditions in the northwestern part of the Sea of Japan from 1984 to 2009, seasonal and interannual dynamics of biomass of Pacific cod *Gadus macrocephalus* stock was analyzed. Seasonal variation of spatial and bathymetric distributions of this species is considered. The conclusion of the existence of seasonal migrations of cod along the continental coast is substantiated.

DOI: 10.1134/S0032945211020093

Keywords: Pacific cod, migrations, spatial distribution, Sea of Japan.

Pacific cod *Gadus macrocephalus* (Gadidae) is an elittoral wide-boreal species distributed in the northern part of the Pacific Ocean. Its range extends as a vast arc from the northern part of the Yellow Sea via the Sea of Japan, the Sea of Okhotsk, and the Bering Sea and further southeastwards it extends along the coasts of North America to Santa Monica Bay in California. The northern boundary of the range runs along the Bering Strait; the southern boundary is the Sea of Japan, from the southern coast of Korea (approximately up to 35°30′ N); in the west it is up to Honshu Island near Cape Hinomisaki (approximately up to 35°30′ N) in the east (Andriashev, 1954; Chang Ik Zhang, 1984; Mishima, 1984; Borets, 1997; Sheiko and Fedorov, 2000).

Published descriptions of distribution and migrations of the Sea of Japan cod largely concern the areas off the coasts of Korea, Japan, or western Sakhalin (Chang Ik Zhang, 1984; Mishima, 1984; Kim Sen Tok, 1998).

The cod that inhabits the commercial subzone of Primorye has remained poorly studied up to the present time. Some issues of its biology were considered in recent publications (Dovin, 2004; Kalchugin, 2004; Kalchugin et al., 2004). The distribution and scheme of seasonal migrations of cod in the northwestern part of the Sea of Japan were first described in the paper of Moiseev (1953). The materials accumulated up to the present time allow us to make considerable supplements and corrections in this scheme.

The purpose of this study was to generalize long-term data of trawl surveys and information from published sources to reveal regularities of seasonal variation of spatial distribution and migrations of cod in the northwestern part of the Sea of Japan and adjacent water areas.

MATERIAL AND METHODS

Studies were performed in the Sea of Japan within the western part of the Russian exclusive economic zone and territorial waters, including the Primorye commercial subzone and the north of Tatar Strait in the western-Sakhalin commercial subzone. The paper is based on materials of bottom trawl surveys (19 expeditions) and pelagic trawlings (13 expeditions) performed from 1984 to 2009. For the convenience of description of distribution dynamics, this water area was divided into three arbitrary areas: the northern part of Tatar Strait, the northwestern part of the sea, and Peter the Great Bay (Fig. 1). As a boundary between the northern part of Tatar Strait and the northwestern part of the sea, coordinate 49° N was taken. Peter the Great Bay from the southwest is separated by the boundary of the exclusive economic zone and territorial waters and is separated from the east by coordinate 133° E.

Distribution density was calculated from the materials of bottom and pelagic trawlings performed from 1984 to 2009 (Table 1):

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d_i = \frac{M_i}{v_i \times t_i \times p_i \times K_{fe} \times 1.852 \times 0.001}
\]

where \(d_i\) is cod density distribution according to data of \(i\)-trawling, kg/km² or ind./km²; \(M_i\) is actual catch of the cod of \(i\)-trawling, kg or ind.; \(v_i\) is trawling rate of \(i\)-trawling, knots; \(t_i\) is duration of \(i\)-trawling, h; \(p_i\) is horizontal opening of the trawl (arbitrarily taken to be 1/2 of the length of the lead line), m; 1.852 is coefficient of...