Spatial Distribution and Features of Biology of Pacific Sleeper Shark
_Somniosus pacificus_ in the North Pacific

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Abstract — The results of the investigations of spatial and vertical distribution of Pacific sleeper shark _Somniosus pacificus_ in the North Pacific Ocean conducted for many years are presented. In addition, the size distribution and features of biology of the species are studied. The largest abundance of the species is registered in the Bering Sea, western Gulf of Alaska, eastern Aleutian Islands, and Pacific waters of northern Kuril Islands and southeastern Kamchatka. The species is the most abundant near the bottom at the depth from 200 to 700 m and in the pelagic waters at a depth of 100–200 m. The average depths of the catches of Pacific sleeper shark substantially change over the year reaching minimum values in June and maximum values in December. Vertical daily migrations (to the water column at night and to the bottom during the day) are registered. The catches are represented by fish 26–352 cm in length, and sharks 100–200 cm in length prevail. The males are noticeably smaller than the females. In general, condition of the fishes decreases and feeding intensity increases with growth. Food composition substantially changes with the increase of body length: consumption of squids decreases and consumption of crustaceans, fishes, and fishery wastes increases. The food composition is slightly different in the females and males.

Keywords: Pacific sleeper shark _Somniosus pacificus_, distribution, body length, body weight, condition factor, food composition, North Pacific

INTRODUCTION

Pacific sleeper shark _Somniosus pacificus_, the endemic species for the North Pacific Ocean (Roedel and Ripley, 1950; Parin, 1971; Pinchuk, 1972), is usual in the lower shelf and continental slope. The species is distributed from South Japan (Shikoku Island), Taiwan, and Mexican waters (southern end of Baja California Peninsula) in the south to the southern part of the Chukchi Sea in the north, including the northern Sea of Japan, Okhotsk, and Bering seas, Gulf of Alaska, and waters of British Columbia and Oregon and Washington states (Lindberg and Legeza, 1959; Clemens and Wilby, 1961; Hart, 1973; Dolganov, 1983; Compagno, 1984; Fedorov et al., 2003; Benz et al., 2004; Wang and Yang, 2004; Yano et al., 2007), as well as (most likely) the East Siberian and Beaufort seas (Mecklenburg et al., 2002). The species is distributed in the continental margin, but it can be found above seamounts located not far from the coastal zone (Lundsten et al., 2009). At present, commercial exploitation of the species is not intensive (Compagno, 1990). Restricted fishery has been conducted previously off California (Walford, 1935). In the representatives of the species, vitamin A content in the liver is higher than that in other species of deepwater sharks (Higashi et al., 1955). For this reason, a restricted commercial fishery has been conducted before in the North Pacific Ocean (Zolotova, 1978). According to the generally accepted opinion, Pacific sleeper sharks have a negative impact on commercial fishery: they destroy the traps used for sablefish _Anoplopoma fimbria_ fishery in the northeastern Pacific Ocean (Anderson et al., 1979), and they reach a large abundance in the trawls used for Alaska pollock _Theragra chalcogramma_ fishery in the Bering Sea (Orlov, 2005). Despite increasing abundance of the species in Russian and American waters registered in recent years (Wright and Hulbert, 2000; Borets et al., 2001; Glebov et al., 2003; Starovoitov et al., 2004; Courtney and Sigler, 2007), the data on spatial distribution of the shark are fragmentary, and they are restricted to the western Bering Sea and Kuril and Kamchatka waters of the Pacific Ocean. In addition, the materials on the biology of the species are fragmentary and not numerous (Bright, 1959; Anderson et al., 1979; Tanaka et al., 1982; Ebert et al., 1987; Orlov, 1999; Orlov and Moiseev, 1999; Yang and Page, 1999; Glubokov, 2004;
shark in the western Bering Sea have been published recently (Wischniowski, 2008; Courtney and Foy, 2012). Shaufler et al., 2005; Chuchukalo, 2006; Sigler et al., 2006; Yano et al., 2007; Wischniowski, 2008; Courtney and Foy, 2012).

The maps of spatial distribution of Pacific sleeper shark in the western Bering Sea have been published recently (Atlas..., 2006). They are based on the surveys of the TINRO-Center conducted over many years with the use of GIS technology. The data are summarized using 1 × 1-degree trapezoids of small elementary allotments of average (for many years) densities of the hydrobionts suitable for the presentation. However, only general patterns of species distribution are illustrated in the maps. In addition, the maps include the information on the catches of the sharks with midwater trawls only in epipelagic and mesopelagic waters, and the features of their distribution near the bottom remain unknown. Finally, the maps are restricted to the western Bering Sea, and the spatial distribution of Pacific sleeper shark within its entire range in the North Pacific is not represented.

The goal of this study is the synthesis and analysis of the materials collected over many years on the spatial and vertical distribution, size composition, and features of biology of Pacific sleeper shark in the North Pacific Ocean.

**MATERIALS AND METHODS**

The material of this study is based on the trawl samples and commercial catches with different gears in the North Pacific Ocean from 1960 to 2008. Researchers from the following institutions participated in the study: Pacific Research Fisheries Center (TINRO-Center), Vladivostok; Alaska Fisheries Science Center (AFSC), Seattle, Washington; Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Moscow; Sakhalin Research Institute of Fisheries and Oceanography (SakhNIRO), Yuzhno-Sakhalinsk; and Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO), Petropavlovsk-Kamchatsky. In this study, the information on the catches, including Pacific sleeper sharks, is represented.

In total, the data on 7990 catches of Pacific sleeper sharks with different gears (mid-water trawls (2732), bottom trawls, long-lines, gill nets, and traps (5258)), including 1290 catches with depth registration, were analyzed. All trawl catches were adjusted to a standard trawling duration (1 h). All catches with registered depths and horizons of the trawling were tentatively divided into bottom (with the same depth and horizon of the trawling) and pelagic (with the difference between the sampling depth and trawling horizon if this difference reached 10 m or more). The data on the following catches of Pacific sleeper shark were used in the study: 11 with bottom gill nets (SakhNIRO), 825 with bottom and mid-water trawls (TINRO-Center), 255 with bottom trawls (VNIRO, SakhNIRO, and KamchatNIRO), 214 with bottom trawls (AFSC), and 6685 with bottom long-lines, traps, and bottom and mid-water trawls (American scientific observers onboard fishing vessels).

The analysis of size composition of the fish was based on the measurement of the total body length (TL) of 910 specimens, including 110 females and 102 males. Among these females and males, the body weight was determined in 44 and 54 specimens, respectively. Data on these fishes were also used for the analysis of sex ratios in different size groups. To describe a relationship between the body length and body weight (n = 905 for both sexes), in addition to length and weight measurements of individual specimens, the materials of the catches represented by two individuals of the species were used. In the latter case, average body length and weight was calculated based on the range of the data. The same material was used for the analysis of the condition factor.

Food composition was analyzed based on 155 specimens of Pacific sleeper shark 79–423 cm TL (empty stomachs were found in 25 specimens) collected in the western Bering Sea and Pacific waters of northern Kuril Islands and southeastern Kamchatka. To determine the index of significance of a food component, the normalized frequency of its occurrence (adjusted to 100%) was applied. For comparative analysis of food composition, the data on 85 males and 68 females with food in their stomachs were used.

The maps illustrating the spatial distribution of the fish were created with SURFER 8 (Golden Software, 2005) software.

**RESULTS AND DISCUSSION**

**Spatial Distribution**

Based on our data, Pacific sleeper shark is distributed mainly in the margin of the continental slope. Pelagic (Fig. 1a) and bottom (Fig. 1b) catches are located in the same regions, and the species is the most abundant along the continental slope of the Bering Sea from Cape Navarin to Bristol Bay. The catches are rare in pelagic areas located far from the coastal zone, and only single catches are registered in deepwater basins of the Okhotsk and Bering seas. Based on bottom catches (with the exception of the regions with a large abundance of species, which are mentioned above), Pacific sleeper shark is usual in southern Aniva Bay off Sakhalin, in Pacific waters of northern Kuril Islands and southeastern Kamchatka, in the Olyutorsky and Navarintsky areas of the Bering Sea, and in the western Gulf of Alaska around Kodiak Island.

Spatial distribution of Pacific sleeper shark in the North Pacific Ocean is investigated comparatively well only in Russian waters of the western Bering Sea and in Kuril and Kamchatka waters (Orlov, 1999; Orlov and Moiseev, 1999; Glubokov, 2004; Atlas..., 2006).