# Spatial Distribution and Age Composition of Chum Salmon in the Western Bering Sea in 2002 and 2003

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Abstract: This work was based on data from three epipelagic trawl salmon surveys of TINRO-Centre in the western Bering Sea in July–August 2002 and July–October 2003. We examined spatial distribution, age structure, and body size of chum salmon (*Oncorhynchus keta*). In fall (September and October) 2002–2003, the abundance of immature and maturing chum salmon was highest in the western Aleutian Basin and vicinity. In summer (July and August) 2003, the spatial distribution of chum salmon was more aggregated. Juvenile chum salmon were concentrated in the shelf break areas during the fall after leaving the inshore regions. During the summer and fall immature chum salmon (mostly age 0.1 and 0.2) dominated in the deepwater and shelf break areas. Maturing chum salmon (age 0.3 and 0.4) were prevalent in the shelf areas during summer, while they were almost absent in the western Bering Sea during fall.

Keywords: chum salmon, spatial distribution, age structure, western Bering Sea

## INTRODUCTION

Chum salmon (*Oncorhynchus keta*) is the most widely distributed and the second most abundant species of Pacific salmon. They are distributed in Asia from Korea to the Arctic coast of Russia and in North America from California to the Beaufort Sea. They are also an important part of the inshore fisheries. During 1971–2005 the Russian catches of chum salmon ranged from 8.4 thousand tons to 32.4 thousand tons.

The marine life history of chum salmon has received considerable attention in recent decades. The first investigations were conducted in the middle of the 20th century (Ricker 1964; Smirnov 1975; Birman 1985). At present, there are many studies that address Pacific salmon ecology, including the comprehensive papers by Shuntov (1989), Salo (1991), Shuntov et al. (1993), Sobolevskyi et al. (1994), and Starovoitov (2003). In this paper, we present new data on the spatial distribution, age composition, and size structure of chum salmon in the western Bering Sea.

## MATERIALS AND METHODS

This work is based on three midwater trawl surveys conducted by TINRO-Centre in the western Bering Sea from 2 September to 9 October 2002, from 17 July to 24 August 2003, and from 23 September to 25 October 2003 (Fig. 1). The vertical spread of the net was 31–41 m and the horizontal spread was 38–44 m, depending on towing speed. Trawls were conducted in the subsurface layer during both day and night. All trawls lasted one hour (except at one station) at an average ship speed of 4.6 kt.

The study area was divided into three primary regions: a shelf region (Anadyr Bay, < 150 m depth), a shelf break region (Olutorsky, Koryaksky and Navarinsky shelf breaks, 150–500 m depth) and a deepwater region (Komandor and western Aleutian basins, > 500 m depth) (Fig. 1). Catches of chum salmon were counted, weighed and standardized to individuals per km$^2$. The average density was estimated for three primary regions as: $N = n/(S \cdot k)$, where N is chum salmon abundance per km$^2$, n is chum salmon abundance in the catch, S is trawled area in km$^2$ and k is the catchability coefficient (k = 0.3 for adult and 0.4 for juvenile chum salmon).

For each fish, fork length and body weight were measured, sex and stage of maturity were determined and a scale sample was taken. Scale samples were collected from chum salmon using the method described by Clutter and Whitesel (1956), Knudsen (1985), and Knudsen and Davis (1985). The number of scale samples was 1879 in fall 2002, 2,196 in summer 2003, and 1,531 in fall 2003. Chum salmon were categorized as juvenile (ocean age 0.0), immature (ocean age $\geq$ 0.1, fish will not spawn in this year) and maturing (fish will spawn in this year).

## RESULTS AND DISCUSSION

Immature and maturing chum salmon densities in the deepwater and shelf regions were similar in fall 2002 and fall

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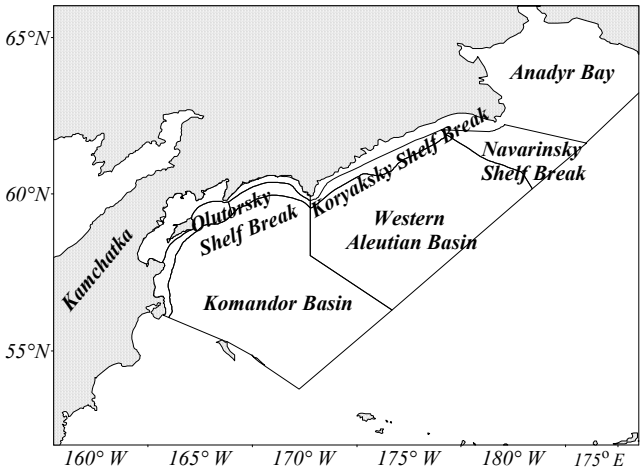


**Fig. 1.** Map of the study area in the western Bering Sea.

2003 (Table 1). In the shelf break region immature and maturing chum salmon were more numerous in 2002. Juvenile chum salmon were more abundant in fall 2003 compared to fall 2002, excluding the shelf region. In 2003, fish concentrated in deep water and shelf break zones. In 2002, they were most abundant on the shelf. This difference may be explained by the later dates of the survey in fall 2003. Juvenile chum salmon tended to move from the shelf to deepwater areas after downstream migration.

In summer 2003, immature and maturing chum salmon concentrated in the deepwater and shelf break regions (Table 1). Juvenile salmon were absent from the trawl catches, because they foraged in inshore regions outside of the study area. The density of immature and maturing chum salmon was greater in the summer than in the fall. Their abundance was the highest in the deepwater regions in fall and summer 2002–2003 and on the shelf break in summer 2003 (Table 1, Fig. 2). Within the deepwater zone they were more aggregated in the Aleutian Basin.

In fall, immature chum salmon dominate, especially in the Komandor and Aleutian basins (Fig. 4a, c); the percentage of maturing chum salmon was low. In summer, catches of maturing fish were higher, but they dominated only in the northern part of Anadyr Bay (Fig. 4b). Despite this dominance, chum salmon density in this region was low (Table 1). Thus, most of chum salmon catches in summer 2003 consisted of immature fish. There was likely more intensive migration of immature chum salmon to the western Bering Sea in summer 2003. In summer 2003 maturing chum salmon dominated in shelf and shelf break areas (Fig 4b). Their abundance ranged from 34 to 306 ind/km$^2$. Maturing chum salmon density was lower in the deepwater regions. In fall 2002 maturing chum salmon were observed at almost every location in the survey area. The highest density was in the Aleutian Basin (156 ind/km$^2$; Fig. 4b). In contrast, in fall 2003 maturing chum salmon abundance was low, and they occurred only in the deepwater regions (Fig. 4c).

The highest concentrations of juvenile chum salmon were confined mainly to the Olutorsky region, the northwestern Komandor Basin and Anadyr Bay (Fig. 3). In the deepwater regions of the Bering Sea the catches of juveniles were low. Consequently, they concentrate in the continental shelf break regions during the fall after leaving the inshore regions. A relationship between juvenile spatial distribution and surface temperature was observed. It is assumed that chum salmon avoid sea temperatures < 5–6°C (Azumaya et al. 2005). In 2002, juvenile chum salmon were widely distributed in Anadyr Bay. In 2003, however, they were caught only in southeastern Anadyr Bay (Fig. 3).

Juvenile chum salmon moved further from shore as they grew. As a result, their average length in the inshore regions was less than in offshore regions (Fig. 3). The mean fork length of juvenile chum salmon was also different in the southwestern regions compared to northeastern regions, mainly as a result of the differences in times of trawl surveys. The survey began in September in the southwestern Bering Sea and was completed in October in the northwestern Bering Sea.

The age composition of chum salmon was different

**Table 1.** Density (ind/km$^2$) of chum salmon in the different regions of the western Bering Sea. Imm/mat = immature and maturing fish; N = number of stations.

| | | Fall 2002 | | Fall 2003 | | Summer 2003 | Fall 2002–2003 | |
|---|---|---|---|---|---|---|---|---|
| | | Juvenile | Imm/mat | Juvenile | Imm/mat | Imm/mat | Juvenile | Imm/mat |
| Deep water | average | 53 | 1,000 | 208 | 982 | 1,737 | 130 | 991 |
| | range | 0–1,428 | 23–2,911 | 0–4,473 | 0–4,749 | 105–144,404 | 0–4473 | 0–4,749 |
| | N | 45 | | 44 | | 42 | 89 | |
| Shelf break | average | 45 | 395 | 111 | 81 | 2034 | 78 | 238 |
| | range | 0–203 | 0–3,019 | 0–520 | 0–254 | 87–8,714 | 0–520 | 0–3,019 |
| | N | 10 | | 10 | | 11 | 20 | |
| Shelf | average | 101 | 8 | 3 | 4 | 458 | 50 | 6 |
| | range | 0–1,003 | 0–58 | 0–39 | 0–37 | 0–4,201 | 0–1,003 | 0–58 |
| | N | 18 | | 19 | | 18 | 37 | |

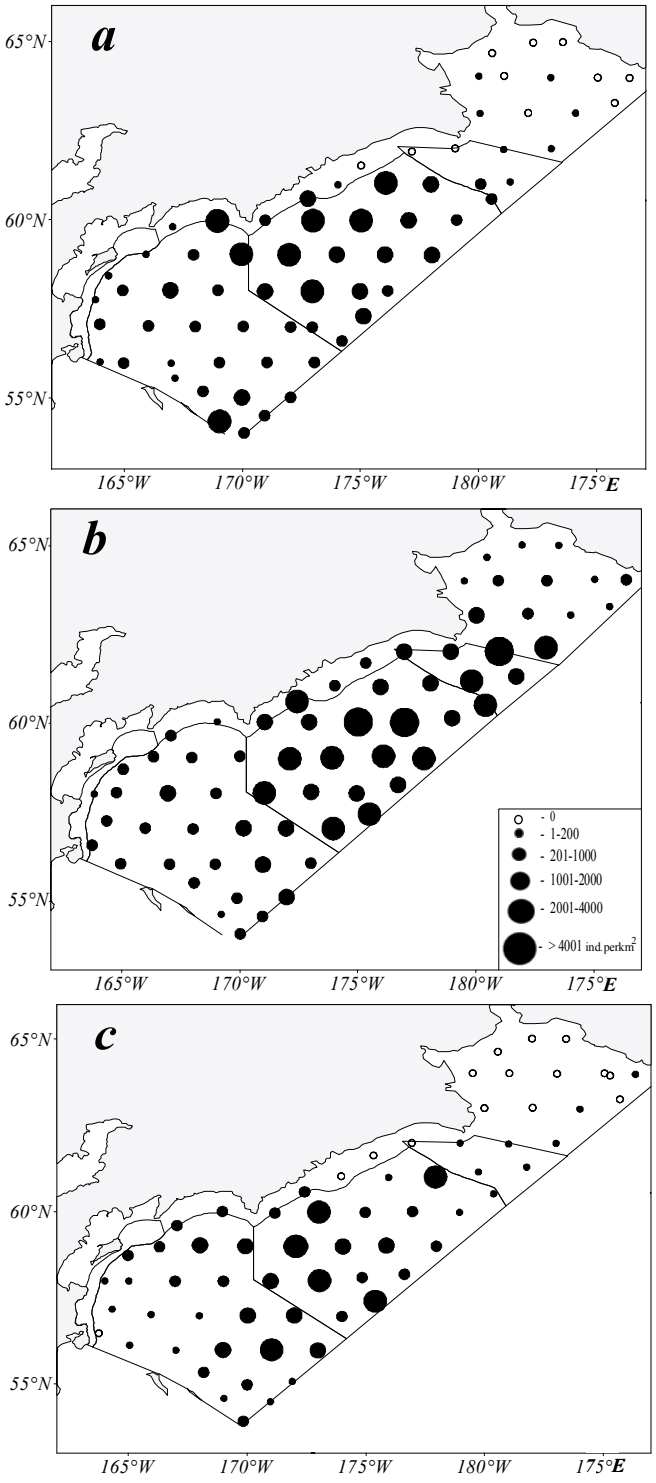


**Fig. 2.** Density distribution of trawl catches of immature and maturing chum salmon in fall 2002 (a), summer 2003 (b), and fall 2003 (c).

among regions, seasons and years. In fall, age 0.2 fish dominated in the deepwater zone. Their percentage varied from 45 to 79% in different regions in 2002 and from 23 to 88% in 2003. Juvenile chum salmon foraged in the Komandor

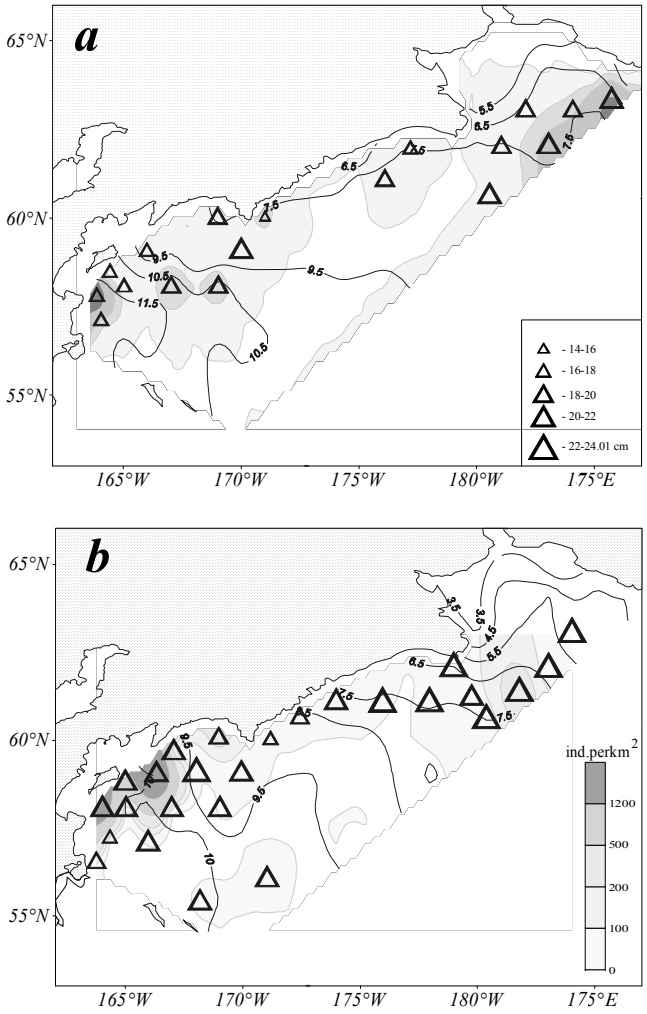


**Fig. 3.** Surface temperatures (lines), and density distribution (contour) and average fork length (triangles) of juvenile chum salmon in the western Bering Sea in fall 2002 (a) and 2003 (b).

Basin, and the Aleutian and Koryaksky shelf breaks. Their percentage was < 13% in the fall of 2002, while it was higher and fluctuated from 13% (Koryaksky shelf break) to 42% (Aleutian Basin) in the fall of 2003.

In the summer of 2003, the predominant age group in the Aleutian and Komandor basins and the Koryaksky shelf break was 0.1 (44%, 59%, and 61%, respectively). Age 0.2 and 0.3 fish were found in the shelf regions. Immature chum salmon (mostly age 0.1 and 0.2) dominated in the deepwater and shelf break areas especially in the Komandor and Aleutian basins during the summer and fall. Maturing chum salmon (age 0.3 and 0.4) dominated in the shelf and shelf break areas during summer, but maturing fish were nearly absent in the western Bering Sea during fall. Similar distributions were observed earlier (Sobolevskyi et al. 1994; Starovoitov 2003; Sviridov et al. 2004).

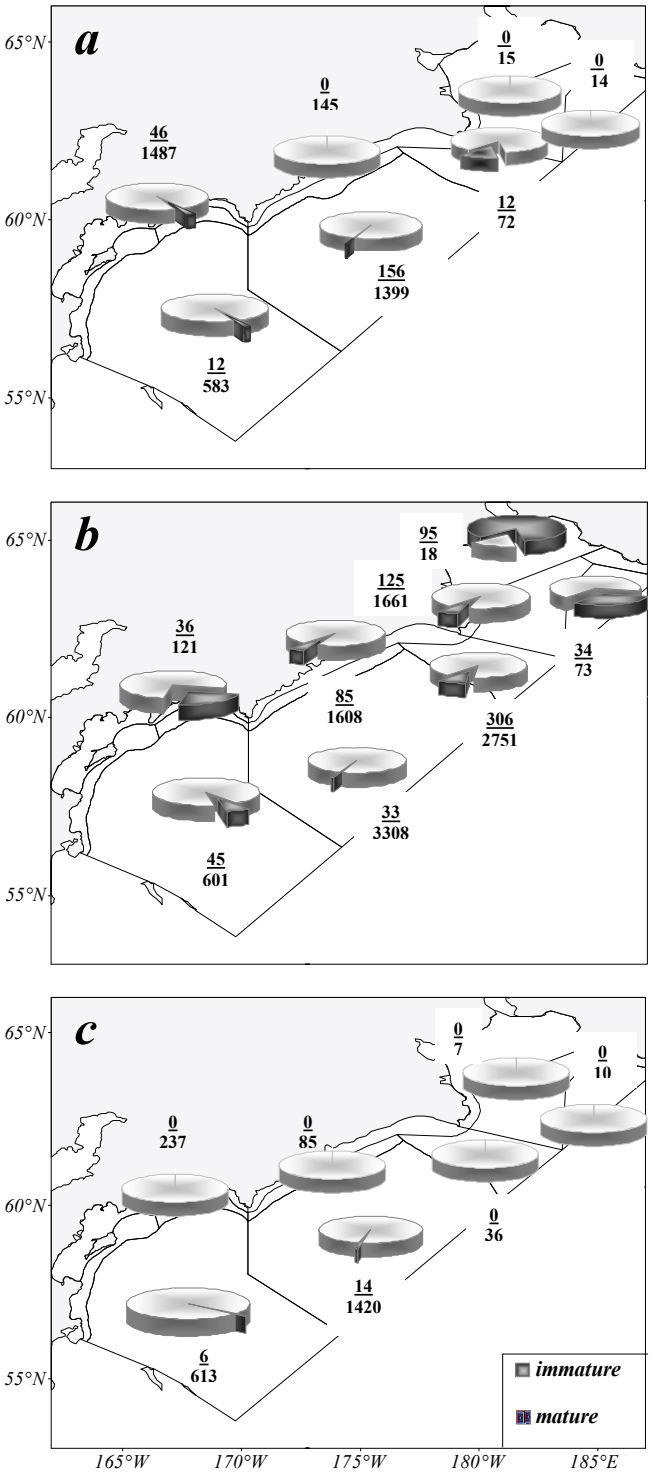


**Fig. 4.** Percent and average density (ind/km$^2$) of maturing (nominator) and immature (denominator) chum salmon in the western Bering Sea in fall 2002 (a), summer 2003 (b) and fall 2003 (c).

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