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by

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Abstract

A present document summarizes some results of program BASIS implementation by Russian Party during 2002-2006 period. Distribution, biomass and age composition of chum salmon (*Oncorhynchus keta*) in the western Bering Sea in 2002-2006 are discussed in detail. It has been shown that during summer period chum salmon dominates in terms of its biomass among other fish species in the upper epipelagic layer of the western Bering Sea (54-63 % of total fish biomass). Autumn period is characterized by strong interannual variations (13-39 %) of this value.

Material and methods

The present document is based upon data of 6 complex surveys in the western Bering Sea during autumn of 2002, 2003, 2004 and 2006 and during summer of 2003 and 2005. These studies were carried out along the BASIS program implementation by TIRNO-Center. All surveys progressed from south into north with a reversed pattern in 2006. Fig. 1 outlines survey area.

Trawlings are carried out by the standard midwater trawl, model RT/TM 80/396 m fished with four 120 m bridles. Heavy orbicular midwater trawl doors, each one of 6 sq.m, were used. Depending on towing speed the vertical spread of the trawl is 22-46 m and horizontal spread is 34-50 m. At each station the net is towed for 1 hour. The net is towed at about 3.7-5.6 kts with the headrope located at the surface (fixed layer – 0 m), particularly at night. Number of trawl stations per survey ranged between 72 and 113 depending upon year.

The abundance (in millions of individuals) and the biomass (in thousands of tons) of chum salmon were calculated by multiplying the average density (individuals/km^2)

and mass (kg/km^2) for the particular species times area of the biostatistical region. For each station the abundance and the biomass of all the nekton representatives per specified unit of area (individuals/km^2 and kg/km^2) was calculated using the following formula:

$$N(B) = \frac{n(m)}{1.852 \times v \times t \times 0.001 \times a \times k},$$

where N is abundance of particular species (individuals/km^2),

B is biomass (kg/km^2),

n is actual number of particular species caught (individuals),

m is weight of particular species in the catch (kg),

1.852 - number of kilometers in one nautical mile,

v is a speed of trawl towing (knots),

t is duration of the trawling (hrs),

a is a horizontal spread of the trawl (m),

k is a fishing efficiency coefficient

For the mature and immature chum salmon, k was set at 0.3, for the juvenile salmon k was set to be 0.4 (Shuntov, 1986).

Chum salmon were aged based on scale readings. Scale samples for subsequent aging were as follows: summer 2002 – 1773 inds., summer 2003 – 2198 inds., autumn 2003 – 1366 inds., autumn 2004 – 971 inds., summer 2005 – 1550 inds., autumn 2006 – 3489 inds. Of chum salmon

Results and Discussion

Chum salmon distribution in the western Bering Sea

Fig. 2 provides overview of spatial distribution of chum salmon relative abundance (immature and mature chum salmon combined) for 6 surveys during summer autumn season of 2002-2006 period. In this figure and all figures below the order of subfigures

matches seasonal chronology. Early summer is noted for intensive redistribution of chum salmon into the western Bering Sea. In late June-early July chum salmon concentrates in the western part of Aleutian Basin and near Anadyr Bay (Fig. 2, a). Evidently, major concentrations of chum salmon are still located near central part of the Bering Sea and adjacent waters off Aleutian Islands.

In July-August of 2003 chum salmon abundance in the western Bering Sea was substantially higher compared to June-July of 2005 (Fig. 2, b). During 2006 survey chum salmon distribution was similar to that during summer of 2003 (although in 2006 chum salmon densities were lower and more compacted, Fig. 2, c).

During the autumn period the "core" areas of chum salmon aggregations moved towards south. This was slightly evident during early autumn timing of 2002 survey (Fig. 2, d). During the late autumn survey of 2003 major aggregations of chum salmon were located more to the south (western boundary of Aleutian Basin and Shish Ridge, Fig. 2, e). During the autumn of 2004 major aggregations of chum salmon were located more to the south compared to 2003 (despite of the fact that both surveys had similar timing) (Fig. 2, f).

There is a clear differentiation between spatio-temporal patterns of juvenile, immature and mature chum salmon. During the all surveys mature chum salmon concentrated within shelf and shelf break zones (Fig. 3). Also, mature chum salmon abundance was high in adjacent Pacific waters.

During all surveys immature chum salmon were concentrated over the deep-water areas (Fig. 3). Chum salmon juveniles were recorded only during the autumn. They highest densities were observed in Anadyr Bay and Navarin region. Also, their catches were high in Olyutorskii and Karaginskii Bays and within Commander Basin.

There was a seasonal trend in percentages of different life stages in catches. During early summer of 2005 mature chum salmon dominated in catches (51-100 %) in all regions, except for basin areas (Fig. 3, a). Mature chum salmon densities in Commander and Aleutian Basins were also high (40-41 % of total chum salmon catch). During late summer of 2003 immature chum salmon dominated the entire area of the western Bering Sea (Fig. 3, b). Only coastal catches had high densities of mature chum salmon.

Percentage of immature chum salmon increased towards autumn (Fig. 3, c-f). During the second decade of October mature chum salmon ceased to be present in catches of Anadyr Bay and Navarin region. Spatio-temporal dynamics of mature chum trawl catches corresponds well to timing of its preanadromous migration.

Intensive offshore migration of juvenile chum salmon is observed in September (Fig. 3, d-f). In the beginning, they start to appear in shelf and shelf break areas (within the survey area), with a gradual spread into deep-water basins.

Chum salmon age composition in the western Bering Sea

Mature chum salmon. During June-July of 2005 the majority of catches of mature chum salmon was composed of age 0.3 individuals (Fig. 4, a). Depending on location their percentage of total catch varied within 57-100 %. Individuals of age 0.3 and 0.4 dominated catches of mature chum salmon. Younger age groups (primarily, 0.2) were of a lower abundance (highest values were observed in Pacific waters 16 %). Within Bering Sea individuals of 0.2 age were observed only in basin areas.

Late summer of 2003 was notes for widely spread dominance of 0.3 and 0.4 chum age groups (Fig. 4, b). During this survey up to 38% of mature chum salmon catch was composed of 0.2 individuals.

In the end of September of 2002-2004 no mature chum salmon were caught in northern parts of survey area. Southern part of survey area was dominated by fish of 0.3 age (primarily deep-water areas). The percentage of 0.4 and 0.2 age groups was high (6-50 % and 3-50 %, respectively). In 2004 age group 0.5 was recorded in the western Aleutian Basin.

The percentage of older age groups of mature chum salmon in Pacific waters off Kamchatka has increased from September (2004 survey, Fig. 4, f) into October (2006 survey, Fig. 4, c). Age group 0.4 constituted majority (43-58 %) of mature chum salmon catches. Bering Sea area was dominated by 0.3 and 0.4 age groups. Mature chum salmon of 0.1 age group were recorded in catches over deep-water basin areas and Pacific waters off Kamchatka.

Immature chum salmon. During June-July of 2005 older age groups dominated immature chum salmon catches (Fig. 4). Their percentage in some areas was as high as

67-100 %. Starting July-August 0.1 and 0.2 dominated catches over deep-water and shelf break areas. During summer of 2003 percentage of 0.1 age groups in these areas ranged within 12-64 %. During autumn surveys of 2002, 2003, 2004 and 2006 this parameter was somewhat higher (11-93 %). In Navarin region and Anadyr shelf 0.2 and 0.3 age groups were dominant.

It can be concluded, that during June-October of 2002-2006 surveys 0.3 was dominant age group of mature chum salmon. This age group was dominant for immature chum salmon during first half of summer. During July-October 0.1 age group of chum salmon was dominant among immature chum salmon in the western Bering Sea.

Chum salmon within nekton communities of the western Bering Sea

During 2002-2006 period percentage of chum salmon biomass from total fish biomass within upper epipelagic layer has varied substantially from year to year (Table). In general, this parameter was higher in summer as compared to autumn. During summer of 2005 and 2003 chum salmon constituted majority of fish species biomass (63 % and 54 %, respectively). Despite of twofold difference in total fish biomass between these two years, percentages of nekton species biomasses remained similar. Only percentages of pink salmon and juvenile Atka mackerel differed between 2005 and 2003. During June-July of 2003 percentage of pink salmon was significantly as the majority of individuals have already left survey areas during anadromous migration.

During the autumn period 2004 and 2006 were noted for peak abundances of chum salmon (respectively, 39 % and 34 %) (Table). During August-October of 2006 chum salmon biomass amounted to 391 th. t (highest estimate for autumn period). In 2006 in addition to chum salmon, sockeye salmon (13 %), mesopelagic fishes (14 %) and other fish species (24 %) were highly abundant.

Autumn of 2004 was noted for lowest estimate of chum salmon abundance estimate for the western Bering Sea (146 th. t, 39 % of total fish species biomass) (Table). The low fish species abundance estimates in 2004 (resulting in high percentage of chum salmon biomass) are linked to incomplete survey coverage in 2004 (Anadyr shelf remained uncovered by survey grid) and low abundance of mesopelagic fish species

(northern smoothtongue and northern lampfish). Biomass of other Pacific salmon species remained at the level of long-term averages (39 %).

During autumn period of 2002 and 2003 percentage of chum salmon biomass was lowest (13 % and 18 %, respectively) (Table). In 2002 its biomass was at a relatively high level– 335 th. t. However, the percentage of chum salmon biomass decrease in 2002 was due to high biomass estimates of mesopelagic fishes, juvenile walleye pollock and Atka mackerel. During autumn of 2003 walleye pollock abundance estimates for the western Bering Sea were even higher. This also resulted in lowered percentage of chum salmon biomass.

Jellyfish biomass in upper epipelagic layer of the western Bering Sea was quite high during years of research, exceeding in some years cumulative fish species biomass. During 2002-2006 significant portion of nekton biomass was attributed to squid species.

Starting from late summer, immature individuals were dominant among other maturity stages of chum salmon (Table). Their percentage increased in autumn. During early summer percentages of immature and mature chum salmon biomasses were approximately equal. Biomass of juvenile chum salmon was insignificant during all years of research.

It can be concluded, that during summer period chum salmon dominates among other fish species (54-63 % of cumulative fish species biomass) in the upper epipelagic layer of the western Bering Sea. During autumn period chum salmon are still highly abundant, but percentage of their biomass fluctuates significantly from year to year (13-39 %). During summer-autumn period immature individuals dominate chum salmon catches.

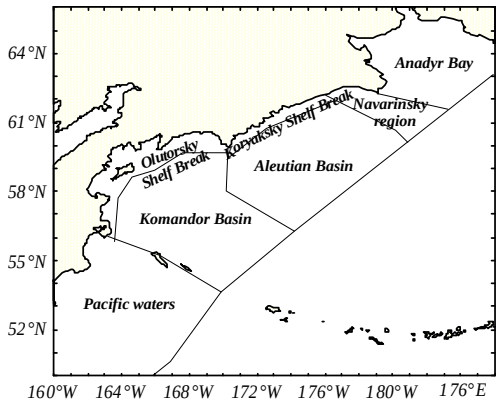

Fig. 1. Map of the study area in the western Bering Sea.

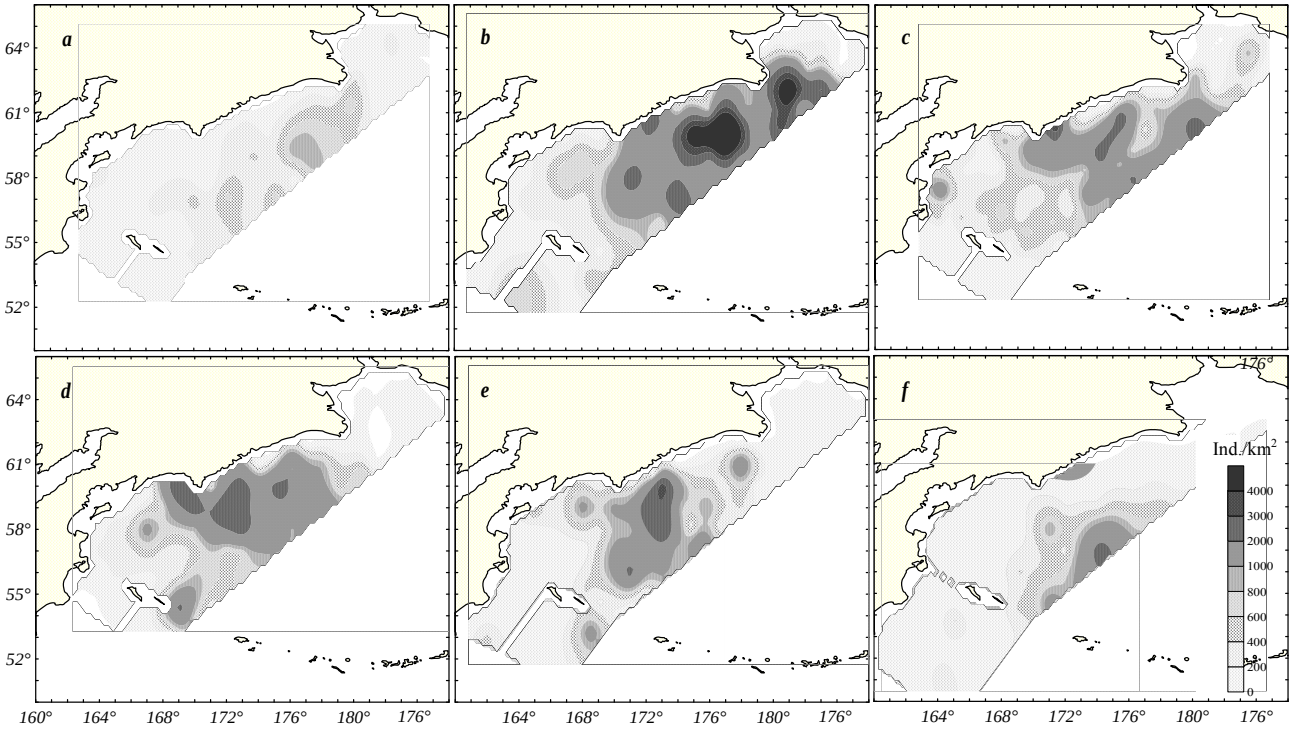

Fig. 2. Spatial distribution of density of mature and immature chum salmon in the western Bering Sea and adjacent Pacific waters in June-July, 2005 (a), July-August, 2003 (b), August-September, 2006 (c), September-October, 2002 (d), 2003 (e), 2004 (f)

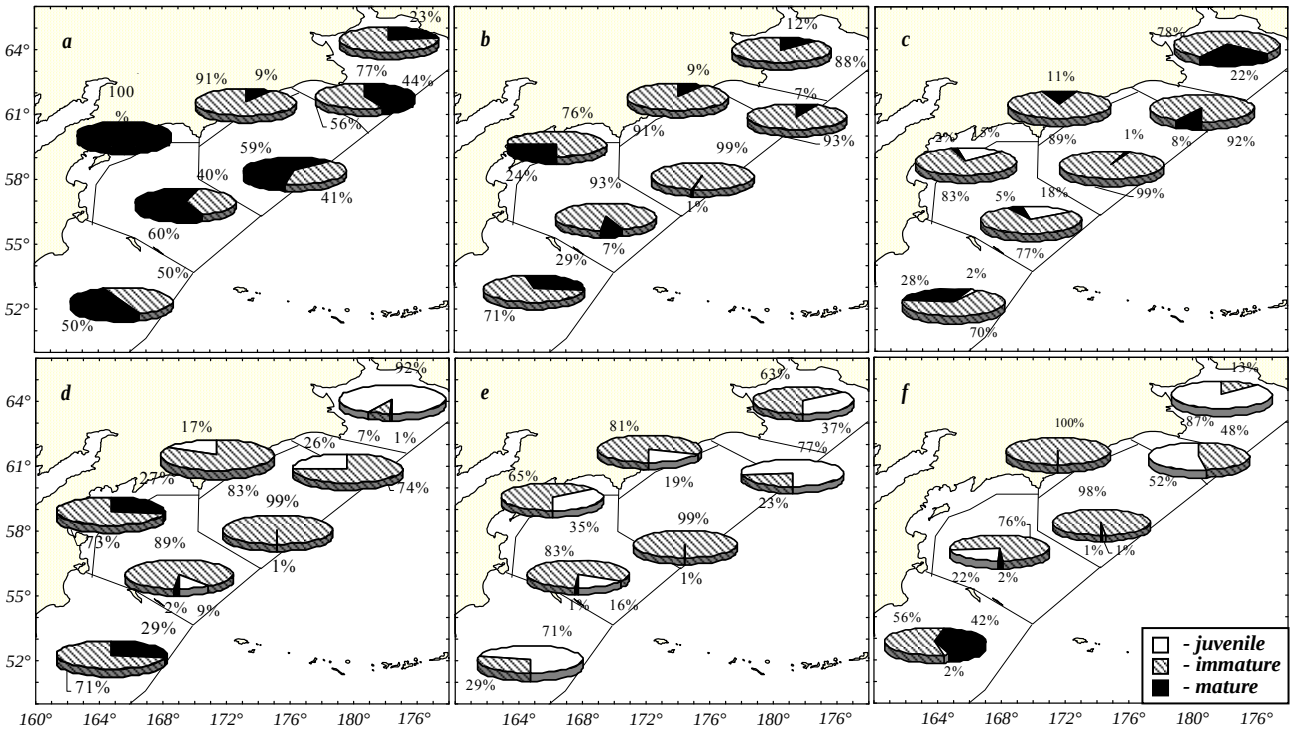

Fig. 3. Ration (by number) of juvenile, mature and immature chum salmon in the western Bering Sea and adjacent Pacific waters in June-July, 2005 (a), July-August, 2003 (b), August-September, 2006 (c), September-October, 2002 (d), 2003 (e), 2004 (f)

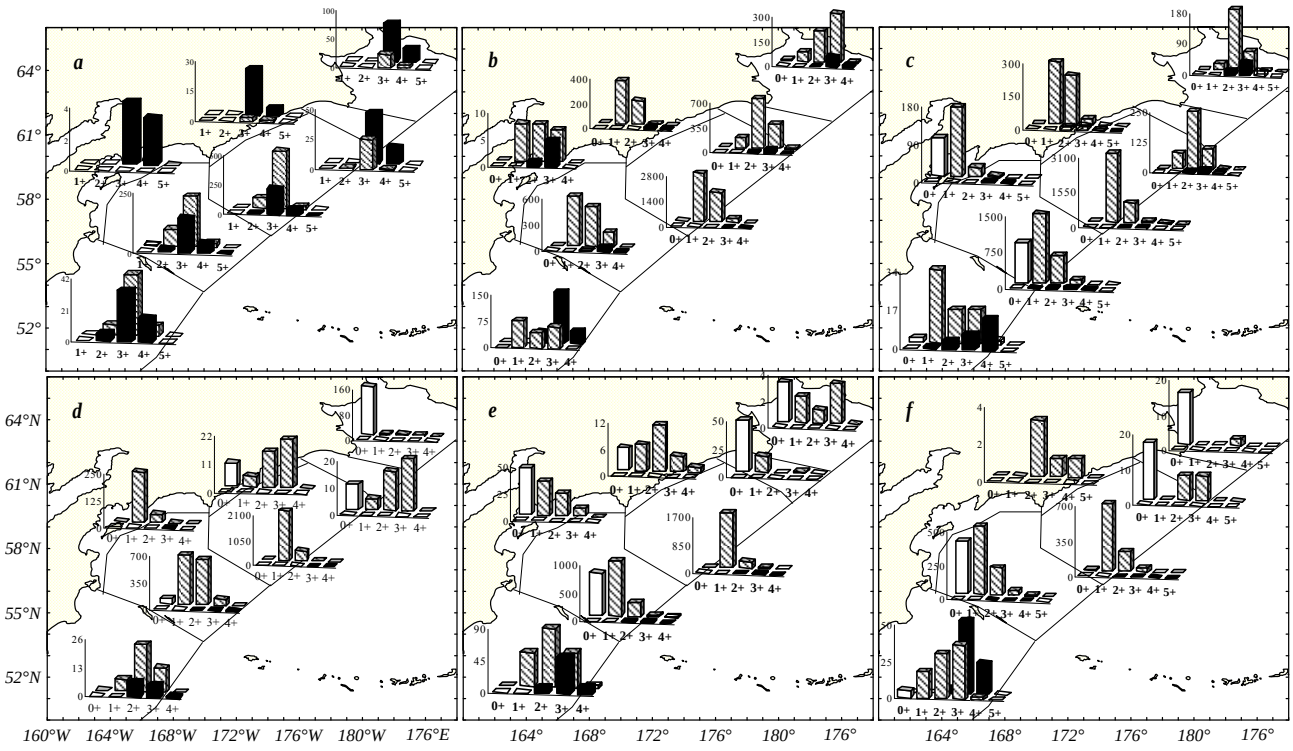

Fig. 4. Age composition of chum salmon in the western Bering Sea and adjacent Pacific waters in June-July, 2005 (a), July-August, 2003 (b), August-September, 2006 (c), September-October, 2002 (d), 2003 (e), 2004 (f)

Table. Biomass (th. t) and ratio (%) of different nekton species and groups of species and macroplankton in upper epipelagic layer of the western Bering Sea during 2002 - 2006.

Species	June 17-July 21, ***2005***		July 15-August 24, ***2003***		August 24-October 12, ***2006***		August, 31-October 9, ***2002***		September, 14-October 25, ***2003***		September 26-October 23, ***2004***	
	th.t	*%*	*th.t*	*%*	*th. t*	*%*	*th. t*	*%*	*th. t*	*%*	*th. t*	*%*
Chum:	294.0	54.2	684.5	63.0	391.2	34.4	335.0	13.4	260.2	18.3	145.7	39.2
mature	*149.1*	*27.5*	*90.0*	*8.3*	*46.0*	*4.0*	*15.9*	*0.6*	*10.8*	*0.8*	*11.3*	*3.0*
immature	*144.9*	*26.7*	*594.5*	*54.7*	*343.3*	*30.2*	*316.8*	*12.7*	*246.3*	*17.3*	*132.8*	*35.7*
juvenile	-	-	*0.01*	+	*2.0*	*0.2*	*2.2*	*0.1*	*3.1*	*0.2*	*1.6*	*0.4*
Pink salmon	94.9	17.5	18.7	1.7	51.8	4.6	26.1	1.0	15.8	1.1	20.1	5.4
Sockeye salmon	37.2	6.9	84.3	7.8	147.6	13.0	180.5	6.7	92.6	6.5	111.0	29.8
Chinook salmon	37.7	6.9	51.3	4.7	13.05	1.1	20.0	0.8	26.8	1.9	11.6	3.1
Coho salmon	0.1	+	3.50	0.3	3.64	0.3	2.4	0.1	4.26	0.3	1.5	0.4
Walleye pollack	31.1	5.7	30.0	2.8	25.8	2.3	464.4	17.9	710.0	49.9	2.4	0.7
Pacific herring	3.3	0.6	10.2	0.9	49.5	4.4	24.3	0.9	10.7	0.7	25.4	6.8
Pacific capelin	3.2	0.6	2.7	0.2	1.6	0.1	171.4	6.6	195.2	13.7	0.6	0.2
Pacific sandlance	0.5	0.1	18.6	1.7	+	+	14.1	0.5	0.17	+	-	-
Northern smoothtongue	9.3	1.7	18.5	1.7	87.1	7.7	24.0	1.5	53.8	3.8	10.7	2.9
Arctic cod	-	-	6.07	0.6	+	+	0.22	+	5.14	0.4	-	-
Atka mackerel	3.6	0.7	119.7	11.0	14.0	1.2	281.5	11.1	13.3	0.9	25.7	6.9
Mesopelagic fishes	0.16	+	17.7	1.6	78.2	6.9	604.4	38.9	17.6	1.2	5.3	1.4
Other fishes	27.9	5.1	20.3	1.9	272.4	24.0	32.5	0.6	18.6	1.3	11.7	3.2
All fish species	542.8	100	1086.0	100	1135.8	100	2180.9	100	1424.1	100	371.8	100
Squids	273		198		123		161		334		176	
Jellyfishes	646		773		1742		980		996		1663	