Feeding Behavior of Pacific Salmon Juveniles in the Northern Okhotsk Sea during the Summer and Autumn of 1994–2000

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In the epipelagic layer (0–200 m) of the northern part of the Okhotsk Sea, the major nekon species are walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), northern smoothtongue (*Leuroglossus schmidti*), and lesser salmonids and cephalopods (juvenile squids). These species serve as key elements in energy/substance flows (Shuntov et al. 1993; Lapko 1994). Biomass changes of Pacific salmon are caused by their foraging and prespawning migrations. The major species are pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) among Pacific salmon (Lapko 1994). The biomass of Pacific salmon in summer is higher than the biomass of Pacific salmon juveniles in autumn, because most Pacific salmon are prespawning individuals.

In the summer of 1997, juvenile pink salmon (10–20 cm in fork length) preyed upon juvenile fishes and squids in coastal waters (Survey Areas 1–3 and 7), whereas in open waters (Area 6) zooplankton dominated in their diets (Fig. 1). In the Shelikhov Bay (Area 1) Pacific herring was the dominant food item, while in other areas (North Western Kamchatka, Area 7) juvenile walleye pollock and squids were key prey. Juvenile chum salmon (10–20 cm) fed mainly on juvenile walleye pollock and Pacific sand lance (*Ammodytes hexapterus*), while only in the Shelikhov Bay (Area 1) they prefered Hyperiidea (Fig. 1).

In September and October, stomach contents of juvenile pink salmon were variable: Hyperiidea, Pteropoda, Euphausiacea, Copepoda and crabs megalopa were dominant food items. In 1994, juvenile pink salmon consumed 3,161 tons of forage species per day. In 1998–2000, their daily consumption decreased from 952 tons to 35 tons (Fig. 2). This might be explained not only by a decrease in the juvenile biomass, but also by a reduction of the daily ration from 8.5% (in 1998) to 4.5% of body weight (in 2000).

In the September and October of 1994 and 1998, the daily food consumption of juvenile chum salmon ranged

Fig.1. Survey Areas and diet composition (%) of juvenile pink and chum salmon in the epipelagic layer of the northern Okhotsk Sea in summer.

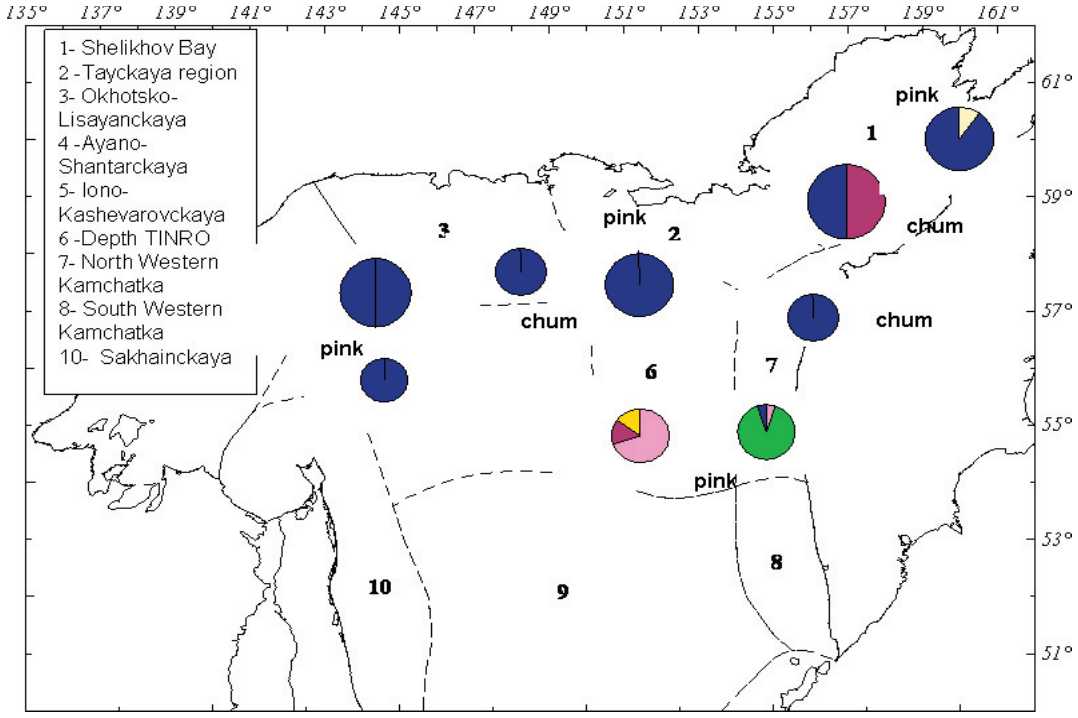

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Fig. 2. Diet composition and daily ration (tons) of juvenile pink salmon in the epipelagic layer of the northern Okhotsk Sea during the autumn of 1994 and 1998-2000.

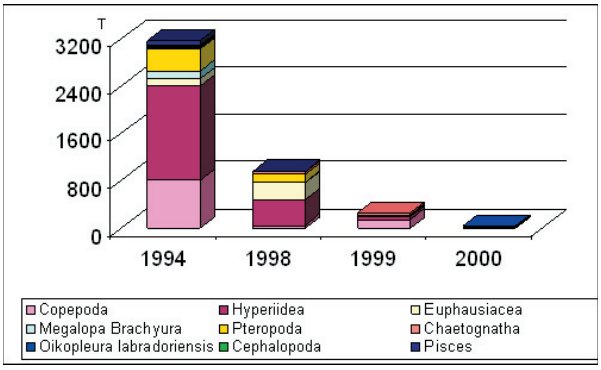


Fig. 3. Diet composition and daily ration (tons) of juvenile chum salmon in the epipelagic layer of the northern Okhotsk Sea during the autumn of 1994, 1998 and 2000.

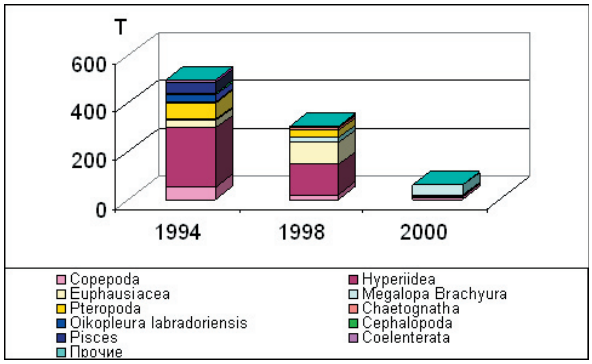


Fig. 4. Diet composition and daily ration (tons) of juvenile sockeye salmon in the epipelagic layer of the northern Okhotsk Sea during the autumn of 1994, 1998 and 2000.

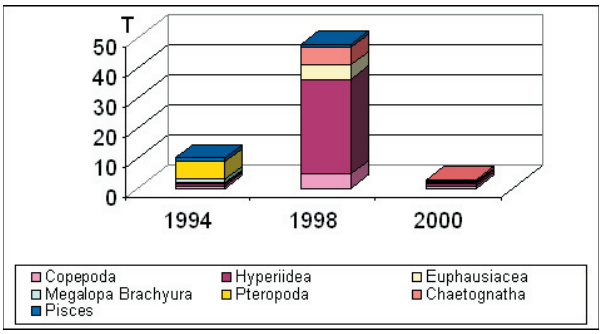


Fig. 5. Diet composition and daily ration (tons) of juvenile coho salmon in the epipelagic layer of the northern Okhotsk Sea during the autumn of 1994, 1998 and 2000.

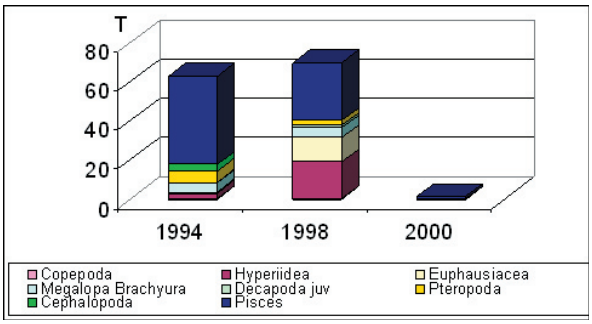
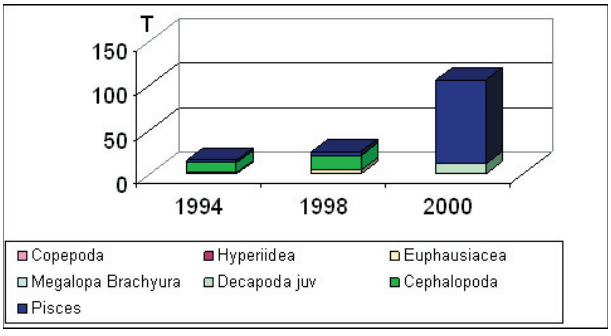


Fig. 6. Diet composition and daily ration (tons) of juvenile chinook salmon in the epipelagic layer of the northern Okhotsk Sea during the autumn of 1994, 1998 and 2000.



between 494 and 304 tons, whereas in 2000 it was 27 tons (Fig. 3). Fifty percent of the daily diet of juvenile chum salmon (10–30 cm) was composed of Hyperiidea, while consumption of Euphausiacea was lower. Pteropoda were a dominant food item in 2000. Nekton constituted about 40% of the diet in 1999. Like juvenile pink salmon, the biomass of juvenile chum salmon decreased and the daily diurnal ration decreased from 7.3% (in 1994) to 4.2% (in 2000).

In the autumn of 1994, Pteropoda, crabs megalopa and juvenile walleye pollock were dominant food items of juvenile sockeye salmon (*O. nerka*)(15–30 cm). Juvenile sockeye salmon biomass increased in 1998 and the consumption of forage species totaled 47.5 tons per day, with Hyperiidea being the most dominant (67.7%)(Fig. 4). In 2000 it was significantly lower (2.9 tons) with Copepoda and Hyperiidea being dominant food items. In 1994 and 2000 the daily ration was lower (2.2% and 3.9% of body weight, respectively) compared to 1998 (4.8%).

During summer and autumn, juvenile coho salmon (*O. kisutch*)(20–35 cm) and juvenile chinook salmon (*O. tshawytscha*)(20–30 cm) fed on juvenile walleye pollock, Pacific sand lance, capelin, Pacific herring, and Pleuronectidae, as well as upon juvenile squids (Figs. 5 and 6). Zooplankton constituted up to 20–25% of food weight in diet of juvenile coho salmon. Major prey groups were Euphausiacea, Hyperiidea, Copepoda and crabs megalopa. In waters of the western Kamchatka, juvenile chinook salmon consumed primarily juvenile squids (63.4%). For juvenile coho and chinook salmon, feeding activity was observed during the daytime period. Minimal feeding occurred in the morning. In 1998 average daily rations of juvenile coho and chinook salmon was 5.1% and 4.5% of body weight, respectively.

Fish species were basic food components of juvenile masu salmon (*O. masou*) (20–30 cm), with capelin,

Table 1. Diet composition (% of food weight) of juvenile masu salmon in the epipelagial of the northern Okhotsk Sea during summer and autumn.

	Summer	Autumn					
	1997	1994	1998				2000
	Areas 6–7	Areas 5–7	Area 10	Area 5	Area 7	Area 8	Area 8
Folk length of fish (cm)	20–35	20–30	30–40	30–40	25–35	25–35	25–35
Copepoda	-	3.0	-	-	0.1	-	-
Neocalanus plumchrus	-	2.8	-	-	0.1	-	-
N. cristatus	-	0.2	-	-	-	-	-
Hyperiidea	-	-	-	-	-	2.6	8.0
Themisto japonica	-	-	-	-	-	2.6	6.0
Primno macropa	-	-	-	-	-	-	2.0
Euphausiacea	-	9.2	-	-	-	0.9	-
Thysanoessa raschii	-	1.1	-	-	-	0.9	-
T. longipes	-	8.1	-	-	-	-	-
Megalopa, Zoea Brachyura	-	32.5	-	-	9.7	-	-
Cephalopoda	-	10.8	-	-	-	-	6.0
Pisces	100.0	44.5	100.0	100.0	90.2	96.5	86.0
Theragra chalcogramma	60.0	44.5	-	-	-	39.0	50.0
Mallotus villosus	-	-	-	-	34.0	-	-
Ammodytes hexapterus	40.0	-	-	-	-	-	-
Pleuronectidae larvae	-	-	100.0	-	51.2	-	-
Pisces larvae	-	-	-	-	-	57.5	-
Pisces unidentified	-	-	-	100.0	5.0	-	36.0
Stomach fullness index ($^0/_{000}$)	284	61	68	27	234	157	176

Table 2. Diet composition (% of food weight) of juvenile Dolly Varden in the epipelagial of the northern Okhotsk Sea during summer and autumn.

	1992		1994		1997	
	Area 7	Area 8	Areas 7–8		Area 3	
Folk length of fish (cm)	30–40	30–40	20–30	30–40	20–30	30–40
Copepoda	1.7	-	-	-	-	-
Themisto japonica	79.3	52.9	76.3	89.0	-	-
Primno macropa	-	-	1.1	2.5	-	-
Thysanoessa longipes	-	-	20.0	-	-	-
Thysanoessa sp.	0.6	1.5	-	4.0	-	-
Megalopa Brachyura	16.6	0.7	-	1.5	-	-
Limacina helicina	0.1	11.6	0.1	0.1	-	-
Clione limacina	-	-	2.5	1.4	-	-
Chaetognatha	-	33.3	-	-	-	-
Hemilepidotus sp.	-	-	-	1.5	-	-
Theragra chalcogramma	1.7	-	-	-	100.0	-
Insecta	-	-	-	-	-	100.0
Stomach fullness index ($^0/_{000}$)	123	89	116	90	407	42

Table 3. Daily consumption (thousand tons) of forage species of nekton in the epipelagical northern Okhotsk Sea during summer–autumn period of 1997–2000.

	Theragra chalcogramma	*Clupea pallasii*	*Mallotus villosus*	*Leuroglossus schmidti*	Salmonidae	Cephalopoda (squids juv.)	Other fish species	Total th. tons	Total %
Plankton, total	135.7	92.3	34.7	13.1	0.8	2.1	4.1	282.7	91.7
Euphausiacea	66.9	37.7	16.3	4.4	0.2	1.2	0.9	127.5	41.4
Hyperiidea	25.2	9.8	2.4	2.6	0.3	0.7	0.9	41.9	13.6
Copepoda	27.9	35.7	11.6	5.3	0.0	0.1	0.3	80.9	26.2
Chaetognatha	1.0	1.0	2.0	-	0.0	0.0	0.0	4.1	1.3
Other zooplankton	14.7	8.1	2.4	0.8	0.2	0.1	2.0	28.3	9.2
Nektobentos and bentos, total	5.2	0.3	0.0	0.0	0.0	-	1.4	6.9	2.2
Nekton, total	15.5	1.0	0.2	0.0	0.8	0.1	1.0	18.7	6.1
Squid	0.6	0.1	0.0	0.0	0.1	0.1	0.2	1.1	0.3
Fish	14.9	1.0	0.2	0.0	0.7	0.0	0.8	17.6	5.8
Ground total	156.4	93.6	34.9	13.1	1.6	2.2	6.5	308.3	100.0
% of total consumption	50.8	30.4	11.3	4.2	0.5	0.7	2.1	100.0	

juvenile walleye pollock and Pacific sand lance being most dominant (Table 1). However, in the autumn of 1994, crab magalopa were also dominant in food items of juvenile masu salmon. In summer, a significant amount of hyperiids were observed in their diet. Hyperiids were also dominant food items for Dolly Varden (*Salvelinus malma*)(Table 2). Euphausiids, pteropods and megalopa crabs were significant parts of their diet. Dolly Varden had a similar feeding as juvenile pink and sockeye salmon, because they fed mainly on hyperiids.

In summary, walleye pollock and Pacific herring were major consumers of zooplankton and nekton in epipelagic layer (0-200 m) of the northern Okhotsk Sea (Table 3). Among Pacific salmon, pink and chum were most abundant. In the late 1990s, the daily food consumption decreased both in juvenile pink salmon (from 3.2 in 1994 down to 1.0 thousand tons in 1998) and juvenile chum salmon (from 0.5 down to 0.3 thousand tons). Although juvenile pink and chum salmon had a high diurnal ration in autumn, their share in the overall biomass of nekton species in epipelagic layer was insignificant. A share of food consumed by Pacific salmon was as low as 0.5% in autumn and 0.6% in summer among the total food consumption (Kuznetsova 2005), because large salmon migrated for spawning. In summer, a significant share of juvenile Pacific salmon diet was attributed to nekton, while in autumn, Pteropoda, Euphausiacea, Hyperiidea, Copepoda and crabs megalopa were dominant food items. Predatory salmon species consumed primarily squids and fishes. Pacific salmon, due to their low biomass and short period of stay in the northern Okhotsk Sea, do not play significant role in the total food consumption.

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