BEHAVIORAL AND BIOCHEMICAL ADAPTATIONS OF JUVENILE PACIFIC SALMON IN THE PERIOD POSTCATADPOMOUSE MIGRATION IN THE OKHOTSK SEA

A.V. Klimov, A.P. Lozovoy, I.V. Zhiganova

Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO),
18, Naberezhnaya Str., Petropavlovsk-Kamchatsky, 683000, Russia
Petropavlovsk-Kamchatsky (e-mail: klimov@kamniro.ru)

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INTRODUCTION

Within their phenotype, salmon are very flexible group of fish with highly variable life policies (Pavlov 1994, Pavlov et al, 2010). Throughout life they periodically replace ecosystem, response to these changes there is an adaptation to different abiotic and biotic environments.

A distinctive feature of all the adaptation period from the other stages of ontogeny of salmon is the transition of the energy budget from surplus to deficit, expressed in the intensive use of food reserves, mainly triacylglycerols (Sidorov 1983). A description of the work is to identify the frequency and recurrence of the content of total lipids and proteins, and to relate these variations to the critical stages in the life of Pacific salmon.

Table 1. Sampling zones

Zone	Time	Place
I	July 2010, 2011	coastal waters of the western Kamchatka
II	September 2011	coastal waters of the western Kamchatka and free waters of the Sea of Okhotsk
III	October-November 2010, 2011	the northern and southern part of the free waters of the Sea of Okhotsk, Kuril Pacific Ocean
IV	February-April 2010, 2011	waters of the Pacific Ocean in the area of subarctic front

MATERIALS AND METHODS

Collection of material was carried out on four zones during the trawl sample takes (Table 1, Fig. 1). The studies were performed on fragments of muscle tissue taken from grilse gone from the rivers into the Okhotsk Sea and came out in the free waters of the Pacific Ocean. For analysis at selected points (Fig. 1) of the trawl catches we took specimens, 5-30 pcs. From each type of hauling, and 50-100 pcs. On a full biological analysis.

The material is a piece of muscle tissue taken in the dorsal fin (along the body from the top of the back to the middle line). Muscle tissue was excised together with subcutaneous fat. Sample weight ranged from 15 to 20 g. Muscle tissue collected during the expedition, was stored at -20 º C. In the laboratory samples were homogenized in a solution of chloroform-ethanol (2:1), and stored until analysis at -20 º C. The lipids were extracted by chloroform-ethanol (2:1) (Folch et al., 1957). The total content of total lipids was determined by the gravimetric method (Kates, 1975).

Non-fat solids weight (IDS) was taken for the contents of protein in muscle tissue, which is known to consist of more than 90% protein in fish (Shulman, 1999).

All analyzed specimens of fish: pink salmon - 209, chum - 192, sockeye – 110.

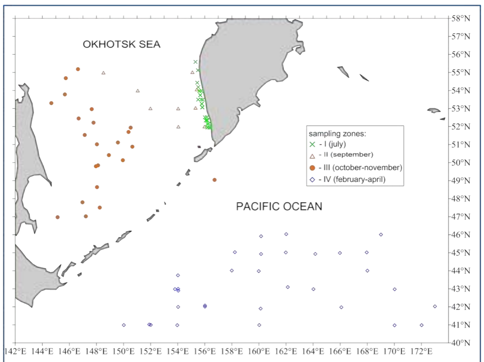

Fig. 1. Map of sampling zones on biochemical analysis

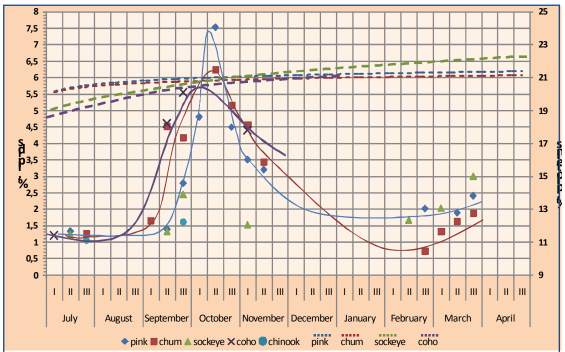

Fig. 2. Seasonal dynamics of total lipids and proteins in the muscle tissue of juvenile Pacific salmon during postcatadromous migrations in the Okhotsk Sea.

RESULTS

In **July** 2010 and 2011 there was a trawl take of grilse at the west coast of Kamchatka. **Analysis of muscle tissue in all species showed low lipid content of not more than 1.6% on average** (Fig. 2). Such lipids observed annually on all stations of the zone I (Fig. 1, Tab. 3-5). This period in the development of Pacific salmon continued all summer, we have identified as an adaptation to the sea. During the adaptation period grilse are not out in the open sea and held mainly in coastal waters (Shuntov, Temnykh 2008).

Completion of the adjustment period of pink salmon and chum salmon, amid the mass migration to the open waters of the Sea of Okhotsk, is the transition of the energy budget deficit into surplus. This is accompanied by an increase in the growth rate recorded by the accumulation of proteins and active deposition of fat (Tab. 3,4).

Sockeye salmon completing an adaptation period migrates along the coast of western Kamchatka to the north (Erokhin, Shershneva 2007). We have not seen rapid changes in the accumulation of nutrients. Such change in behavior in Pacific salmon occurs in early autumn (Tab. 5).

October, juvenile pink salmon and chum salmon in the Okhotsk Sea were characterized by the highest deposition of fat (Fig. 2). High physical activity against excessive food supply and the optimal temperature for juveniles in the northern Sea of Okhotsk can get surplus energy budget, which, in turn, is reflected in the deposition of nutrients to the tissues, including fat in muscle (Tab. 3,4) (Sidorov 1983, Shulman, Love 1999, Erokhin, Klimov 2010).

In **November**, during the migration of the pink salmon and chum salmon to southern Okhotsk Sea the proportion of lipids in muscle tissue has been declined.

Juvenile *sockeye salmon* taken for analysis in November, in the southwestern part of the Okhotsk Sea **kept a low level of lipids** 1,12-1,84% on average 1.52%. The fish, sized 36-42,5 cm and caught in October, near the southern tip of the Kamchatka Peninsula and the northern Kuril Islands on the Pacific side was the exception (Fig. 1). These fish were increase in the lipid status to 1,06-3,20% at average 1.81%. Judging by the size, this young fish feed in the ocean second year (Tab. 5).

From **November** to **December**, juvenile Pacific salmon migrate to the ocean (Shuntov, Temnykh 2008). Passing the Kuril straits, the young pink and chum salmon begin adapting to the ocean**. During 3-4 months in the ocean young fish are losing up to 80% of lipids accumulated during autumn feeding** (Tab. 3,4).

The content of total lipids in juvenile *sockeye salmon*, did not decrease, but on the contrary, increased in average up to 9% (1.67%), in comparison with young, caught in November (1.52%). We have adopted groups sized 35-40 cm (498-787 g) and 41,5-53 cm (793-1751 g) for fish refeeding in the ocean (Tab. 5).

The protein component of the muscle tissue of Pacific salmon was more static in comparison with the total lipids and the gap of development from fertilization until they reach the ocean, the level of protein in the muscle tissue undergoes two major changes. First, when the energy needs in the embryonic development spend up to 40% protein, and then restore in the river feeding (Sidorov 1983). The second change concerns the slope of young fish in the sea and the adaptation to the sea life (Fig. 2). If the metabolism of lipids and carbohydrates of the juveniles in the sea dominated by catabolic processes, the protein metabolism contrary dominated anabolic, requiring energy for biosynthetic transformations (Varnavskiy, 1991)

Table 3. Biochemical rates of juvenile pink salmon caught in the Sea of Okhotsk in 2010, 2011.
Numerator is the average values, denominator is ranges

Years	2011						2010		2011	
Period	July	September			October		November		February- April	
View sizes length, cm	6-8	14,5-17,5	18-22	23-25	19,5-22,5	22,6-25,5	21-25	25-28,5	24-32	32,5-40,5
Body length AC, cm	7,4 / 6,5-8	16,4 / 14,5-17,5	19,9 / 18-22	23,9 / 23-25	22 / 20-22	23,6 / 23-25	24 / 21-25	26 / 25-28	29 / 24,4-32	35 / 32,6-40,2
Weight, g	3 / 6-8	40 / 25-58	80 / 49-120	133 / 105-156	103 / 65-122	136 / 102-192	128 / 85-148	187 / 152-252	244 / 140-335	428 / 332-684
Protein, % wet weight	22,28	20,21 / 19,09-23,42	19,84 / 18,3-22,38	20,24 / 19,79-21,05	19,62 / 16,92-22,3	19,83 / 16,73-21,73	21,45 / 20,77-22,2	21,91 / 20,49-22,82	19,85 / 15,17-26,94	20,49 / 17,44-24,59
Lipids, % wet weight	1,33	1,8 / 1,18-2,43	1,88 / 1,2-2,97	2,12 / 1,46-2,49	4,8 / 2,09-8,92	5,16 / 2,63-9,6	3,48 / 1,52-5,74	3,99 / 2,49-5,89	1,84 / 1,34-2,19	2,61 / 1,55-4,18

Table 4. Biochemical rates of juvenile chum salmon caught in the Sea of Okhotsk in 2010, 2011.
Numerator is the average values, denominator is ranges

Years	2010	2011							2010	2011
Period	July	July	September				October		November	February-April
View sizes length, cm	6-9	5-11	13-17,5	18-20	20,5-24,5	25-30	20-25	25-27,5	20-23,5	24-32
Body length AC, cm	7 / 6-8,7	8 / 5-11	16 / 13-17,5	19 / 18,0-20	22,5 / 20,5-24,5	27 / 25-30	22,4 / 20-25	26 / 25-27	22 / 21-23	25 / 22,8-28,7
Weight, g	3 / 2-6	6 / 2-14	44,7 / 28-62	77,3 / 58-109	129,6 / 88-188	222,1 / 186-340	121 / 84-178	196 / 162-232	124 / 102-215	158 / 112-217
protein, % wet weight	20,22 / 18,80-22,13	19,97 / 19,3-20,65	19,97 / 17,09-21,53	20,97 / 19,14-22,97	21,50 / 19,37-23,12	22,01 / 20,81-23,87	20,16 / 17,45-22,53	20,48 / 19,13-21,23	22,36 / 21,79-23,29	21,28 / 18,84-25,08
lipids, % wet weight	1,56 / 0,96-2,25	1,26 / 1,04-1,59	1,38 / 1,04-1,88	1,93 / 1,2-3,52	3,15 / 1,37-5,91	5,01 / 2,74-7,97	4,02 / 1,54-7,34	5,52 / 3,31-8,5	4,01 / 2,22-6,09	1,71 / 0,95-3,12

Table 5. Biochemical rates of juvenile sockeye salmon caught in the Sea of Okhotsk in 2010, 2011.
Numerator is the average values, denominator is ranges

Years	2010		2011				2010		2011		
Period	July		July		September		November		February- April		
View sizes length, cm	6,5-14	14,5-18,5	7,5-12,5	13,0-16,0	17-19,5	20-23,5	23-26,5	33-42,5	21,5-30	35-40	41,5-53
Body length AC, cm	10 / 6,7-13,9	16 / 14,6-18,2	10 / 7,9-12,5	14 / 13-15,7	18,5 / 17-19,5	21,2 / 20-23,5	25 / 24-26	37 / 33-42	28 / 21,5-30,4	38 / 35,3-40	48 / 41,5-53,4
Weight, g	13 / 3-34	43 / 32-66	12 / 5-22	32 / 23-44	74 / 50-87	111 / 87-145	166 / 146-192	571 / 384-848	226 / 92-308	634 / 498-787	1270 / 793-1751
protein, % wet weight	20,30 / 19,02-21,30	20,30 / 18,18-23,12	20,40 / 18,62-22,04	20,41 / 19,08-21,87	19,98 / 19,26-22,10	20,29 / 19,59-21,41	23,08 / 22,54-23,53	23,15 / 22,19-24,44	23,94 / 22,25-25,62	21,55 / 20,77-22,46	21,51 / 20,43-22,14
lipids, % wet weight	1,17 / 0,49-1,81	1,53 / 0,48-2,12	1,18 / 0,64-1,79	1,22 / 0,78-1,66	1,43 / 1,01-2,75	1,77 / 1,04-2,85	1,52 / 1,12-1,84	1,81 / 1,06-3,20	1,67 / 0,62-2,08	2,5 / 1,1-4,57	2,99 / 1,43-4,76

DISCUSSION

The first year of life in the sea world has been divided into three stages: early life in the sea- adaptation to the sea (June-August), intensive autumn feeding (September-October), and out to the ocean - the adaptation to the ocean (November ~April).

The process of migration of juvenile salmon accompanied by significant energy spending with a corresponding reduction of main energy, the lipids in the body of the fish(three times or more). Adaptation to the new conditions of juvenile also accompanied by increased spending ingested energy during the early stages of coastal foraging. At the same time, much of the spending are protein synthesis, they act as guarantors of a quick going out of the press of various predators which are new significant threat in such environment. In connection with this, we did not observe a decline in the content of proteins nor during the transition, nor during the sea stage.

According to the available data set, the duration of the adaptation of the marine period includes all summer months. The boundary of the actively replenish of fat reserves and energy potential is, apparently, in August, followed by a strong increase in total calories and lipid content in pink salmon and chum salmon except sockeye. During foraging at the coast, sockeye salmon have very few changes in lipid content in the muscle and it is still low in comparison with chum and pink salmon's level. **Going out to the sea for chum and pink salmon, judging by their reduced lipid level (to 80%), plays a very important role in ontogeny, comparable with early marine adaptation period, which is not true of salmon, for which the lipid content is not fall, but conversely it increases average on 9%.**

CONCLUSION

Analyzing the above material, we see two different strategies for the development of offshore feeding areas and different strategies of biochemical adaptation. On the one hand, pink salmon and chum salmon, which master the vast sea areas, actively put on weight, and then during the migration to the ocean they spend most of the accumulated nutrients, on the other hand sockeye, which puts on weight only in coastal waters and it keeps a low level of lipids, beginning from going out to sea and ending by going to the ocean.

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