NPAFC

Doc. 124

Rev. 1

Feeding of Chinook and Coho Salmon in the Northwestern Pacific Ocean

by

A.F. Volkov, V.I. Chuchukalo, A.Ya. Efimkin

Pacific Research Institute of Fisheries and Oceanography
Vladivostok, 690600
Russia

submitted to the

North Pacific Anadromous Fish Commission

by

Russia

April 1995

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Volkov, A.F., V.I. Chuchukalo and A.Ya. Efimkin. 1995. Feeding of Chinook and Coho Salmon in the Northwestern Pacific Ocean. (NPAFC Doc. 124). 12 p. Pacific Research Institute of Fisheries and Oceanography, Vladivostok, 690600, Russia

Feeding of Chinook and Coho Salmon in the north-western Pacific Ocean

Volkov A.F., Chuchukalo V.I., Efimkin A.Ya.

Literature data about feeding of chinook and coho salmon, the greatest species of the far-eastern salmons of genus Oncorhynchus are few. If there are general information about juvenile at early development stages concerning the feeding spectra and identification of major food objects in the different parts of area (Karpenko, 1979; Gorbatenko, Chuchukalo, 1989; Pearcy at al., 1988; Hea- ley, 1991; Sandercock, 1991) then feeding of adult fishes has not been actually described. The characteristic of qualitative composition on the chinook salmon in the waters near the south-eastern Kamchatka is give by A.I.Synkova (1951) while in the Alaska Gulf - by Reid (1961).

The known publications on the problems of feeding of coho salmon during the sea period of life concern also principally its juvenile (Synkova, 1951; Karpenko, 1979; Gorbatenko, Chuchukalo, 1989; Sandercock, 1991) and characterize mainly qualitative composition of food.

In scientific literature, the materials concerning the feed- ing of adult chinook and coho salmon during summer period are practically absent and this is related to that catching of large salmons in the sea by trawls providing the representative samples to study their feeding proved to be possible only after emergence of the powerful trawlers capable to work using large-sized pelagic trawls with speed of not less than 5 knots. In this case, both salmons are caught in single specimens and in no each case.

Of all of far-eastern salmons, the coho has the highest speed of growth: spending in the sea slightly more than year after seaward migration it returns to the spawning having an average mass of slightly more then 3 kg. Thanks to this feature, the coho has become the subject of the most efficient fish-well breeding of juvenile in a number of countries (Japan, Chile) and, in this case, the coho attains after six-month keeping in fish-wells mass of 2 kg.

Correspondingly, a study of such characteristics of the chi- nook and coho feeding under natural conditions as intensity, se- lectivity, regional peculiarities, daily rhythmic and calculation of daily rations are of importance and interest.

Materials and methodology

When carrying out the accounting investigations of salmons within the economic zone of Russia by TINRO, a feeding of chinook

and coho has been studied. Their catches have been performed by trawls 108/528 at speeds about 5 knots within the upper 50-m layer.

The available materials are fairly limited. When carrying out the accounting works concerning the Pacific salmons in the June-August (1991-1993) in the Bering sea, Sea of Okhotsk and Pacific waters near the Kuril Islands and eastern Kamchatka, 159 specimen of large chinook as well as 121 stomachs of juvenile catched in October-December 1986-1987 in the Bering Sea were surveyed. The number of catched and examined specimens coho was also comparatively not high. That of adult specimens of coho was 212: 133 in the Sea of Okhotsk (98 in the waters near eastern Kamchatka), 58 in the Pacific zone off Kuril Islands, 21 in the area of eastern Kamchatka while the number of juvenile was 140 (6 in the Bering sea and area off eastern Kamchatka and 134 in the Sea of Okhotsk). Part of juvenile was caught in the autumn-winter period.

The feeding has been examined using the standard methodology accepted in TINRO and described in "Methodical-manual on the fish feeding examination...", 1974; Manual on examination of fish feeding...", 1961; and "Manual on examination of fish feeding...", 1986.

The samples (complete sample include 25 stomachs of the some length size class but because the salmons are rarely in such amo- unts in the trawling harvests, all of samples, from 1 to 25, have been processed) have been taken with consideration of fish sizes (with a step of 10 cm) from each catch by industrial trawls. The stomachs have been processed immediately after the dissection of fishes without preliminary fixing.

The degree of digestion has been determined by 5 stages while the stomach fullness by 5-ball scale. After that, a total mass of the stomach content for entire sample, species composition of food, importance of mass species and other standard parameters - general and particular indices of fullness (IF) etc. - have been defined.

Discussion of results

Chinook salmon.

At the autumn-winter period, a feeding spectrum of chinook juvenile of 20-40 cm in length is fairly narrow. A base of ration is composed of juvenile squids, and euphausiids (Thysanoessa longipes and Th. inermis) and a share of fingerlings of walleye pollack and capelin is also essential. Copepods, hyperiids, larvae of prawns and crabs are of secondary significance. The daily ration of chinook salmon juvenile calculated using a method of Yu.M. Yurovitsky

(1962) proved to be similar and fairly high in both cases for this season - 3.8-3.9% of fish mass.

The stomach fullness of adult chinook salmons varied greatly. Maximum stomach fullness (376 $^{o}/_{ooo}$) in our materials was noted for male of 78 cm in length catches in the waters near the western Kamchatka in 1992. Food consisted of juvenile of the northern squid (65%) and herring (35%). The stomach of the greatest chinook from the Bering Sea (length is 105 cm, mass is 23.7 kg) was empty and beaks of squids were found in the digestive tract. In the stomach of chinook of 105 cm in length and 16.5 kg in mass from southern Sea of Okhotsk, 4 specimens of sardine were and the fullness index was 255 $^{o}/_{ooo}$.

Great chinook can also feed solely by plankton. So, in summer 1991, a stomach of chinook of 69 in length was crowded by euphausiids Th. Longipes and the fullness index was 168 $^{o}/_{ooo}$.

When the chinook feeds on euphausiids and squids, maximum filling of stomachs is noted by night (11 p.m.-01 a.m.) when these animals rise to surface. Newlyswallowed fish can be found practically at all times except for smoothtongues which appear in the epipelagiale and therefore, in stomach of chinooks only by night (23 p.m.-02 a.m.).

Due to limited volume of materials, it is quite difficult to calculate the daily rations for adult chinook, however, rough computations for chinook which fed only on plankton show that they can be about 3.5% of body mass while, when feeding on fishes and squids, they are probably less.

In the Bering Sea and waters near eastern Kamchatka in summer 1991, chinook ate largely squids (Gonatus madokai and Gonatopsis borealis) as well as butterfly sculpin and immature pollacks. In 1993, here, euphausiids, herrings and sand lances have predominated (Table 1). It is known (Reid, 1961) that in the Alaska Gulf, herrings and squids also predominate in feeding of chinook.

In 1993, a share of euphausiids in feeding of chinook an other species of salmons (in particular, sockeye and Dolly varden) in the Bering Sea and waters near the eastern Kamchatka has appre- ciably increased.

In the Pacific waters near the Kuril Islands, euphausiids and squids, immature lords and japanese anchovy have prevailed in feeding of large chinook. In 1993, as compared with 1991, sardine - ivasi has disappeared from diet of chinook that was related to abrupt decrease of this number but a share oh japanese anchovy and lord has increased (Table 1).

In the southern Sea of Okhotsk, in different years, the pronounced differences have been noted in feeding chinook: in 1991 fed

mainly nekton (sardine-ivasi, Japanese anchovy and, to lesser degree, squids) while, in 1993, euphausiids Th. longipes predominated in ration of chinook.

Data of feeding of chinook in the waters near western Kamchatka are only available for 1992 and it indicates that in this area, the squids have dominated in diet (58%) and shares of her- ring (20%) and Atka mackerels (16%) were also high.

Coho salmon

Similar to all of the Pacific salmons, coho shows in feeding a large plasticity and composition of its food can fundamentally change depending on biological structure of epipelagial, therefore in different seasons and years, different groups and species of animals (fishes, squids and zooplankton) can predominate in food.

The juvenile of coho during the summer - autumn period feeds fairly intensively; fullness of stomachs in this period is high - 90-300 $^{o}/_{ooo}$ (Table 2). With the exception of cases which will be further discussed, the fry, larvae and immature fishes and squids were of fundamental importance in feeding of coho while a share of zooplankton was less.

In the area near western Kamchatka and TINRO depression, in 1994, in food of coho juvenile, the fishes have also predominated (See Table 2) and, among them, the fingerlings of pollack and squid attained up to 20%. Zooplankton constituted only 22-25%, and, in this case, the megalopes of king crab, hyperiids and pte- ropods have predominated. It should be noted that large share of larvae of king crab in food of fry has been earlier observed: in 1985, it has attained 18% at fullness of stomachs of 144 $^{o}/_{ooo}$.

In the Central Hollow in the Sea of Okhotsk, fishes and squids were absent in food of fry in October - November and its base was large zooplankton: in 1991, hyperiids, appendicularian and euphausiids predominated while, in 1994, hyperiids, small coelenterates and copepods. The fullness of stomach was quite high but it was evidently lower than in two previous areas.

As the sizes of coho increase, a role of nekton in food inc- reases while a share and qualitative diversity of zooplankton species decrease: copepods nearly disappear - even the largest ones (Calanus criststus) are found in the food composition occasi- onally and in a small number.

As to feeding of coho during the oceanic period of life, there are only materials obtained in April - May 1985 (Tutubalin, Chuchukalo, 1992): in the Pacific Ocean (40-46 N, 172 E - 170 W), in the catches,

fishes of 40-50 cm length (194) predominated and number of fishes with a length of 50-60 cm was only 34. Nekton (fishes and squids) formed there the basis of feeding of coho, as to zooplankton, nearly exceptionally euphausiids have been con- sumed in a small number. Feeding took place in the light time, and two peaks were noted in fullness of stomachs: greater - in the morning and lesser - in the twilight. A quantity of daily ration was 4-5% of body mass.

At the summer period (June - August) in the course of anadromous migrations, the fishes and squids also predominated in food of large coho (50-70 cm), but a share of zooplankton was signifi- cant was exemplified by Table 3 in which data of coho feeding are combined for large areas with the indication of year carrying out works.

Coho feeds quite intensively, empty stomachs are usually observed in the hours before drawn; the fullness in generally fairly high - average indices fullness (IF) in 1991-1992 in the Sea of Okhotsk and Pacific waters near the Kuril Islands were 86-96 $^{o}/_{ooo}$ while in 1993 they, in some place, proved to be higher - 146 - 181 $^{o}/_{ooo}$ (See Table 3) and in the Pacific waters near eastern Kamchatka slightly lower - 114 $^{o}/_{ooo}$.

In the individual catches and for some individuals, the fullness of coho stomach is higher - up to 200-300 $^{o}/_{ooo}$ - and, some- times, exclusively high but one should take account of the fact of the stress overeating. When, in the trawl, a great quantity of small fishes (anchovy, immature greenlings etc.), coho begin to snatch them so actively that not only stomach but also digestive tract prove to be crowded with victims. Such newly-swallowed food is easily detectable and it should be excluded from the stomach contents.

A list of species of zooplankton regularly being found in food of mature coho is shortest and fits in the ten.

Among the plankton food of mature coho, the hyperiids (Parathemisto japonica and P. pacifica) and euphausiids (Th. longipes and Th. raschii) predominate in all of areas. The large specimens of Th. longipes which rises to the upper horizons usually by night may, in summer and by day, leave there in sufficient quantity, probably, for spawning. Particularly, this has been manifested in 1993 a great quantity of euphausiids has been found in trawls.

Sufficiently frequently but in small quantity, the magalopes of crabs, prawns and the greatest individuals of pteropods, mainly Clione limacina, are revealed in food of coho.

A list of fishes is much larger but it is possible to determine far from all of ones discovered in food due to their diges- tion but those which constitute a basis of food are presented in Tables 3.

The greatest share in food of coho in the Sea of Okhotsk including waters near western Kamchatka has been constituted by fishes (63-90%) while in the Pacific waters near Kuril Islands and eastern Kamchatka - by small squids (42-58%).

Conclusions

1. Basic food objects for chinook are euphausiids, squids and fishes. Among the latters, in the Bering Sea, waters of the eastern and western Kamchatka, the herring predominates while in the southern Sea of Okhotsk and waters of Kuril Islands Japanese anchovy prevails.

2. Juvenile of chinook consumes at the autumn-winter period, mainly, euphausiids, small and immature squids and walleyed pollack fingerlings. Daily ration of chinook juvenile is at the au- tumn winter period 3.8-3.9% of body mass.

3. Nekton (fishes and squid in equal parts) prevailed every where in food of coho salmon (50-70 cm). Chinook (50-70 cm) in the Bering Sea, waters of the eastern Kamchatka and Pacific waters near the Kuril Islands fed also on nekton (fishes mainly) and euphausiids in the Sea of Okhotsk.

4. Daily rations of coho in all of areas were much larger than those of chinook (Table 4).

Literature

Andrievskaya L.D. 1957. Summer migrations of the Pacific - salmons and their feeding at the sea period of life. - Izv. TINRO, vol 44., p. 75-96.

Gorbatenko K.M., Chuchukalo V.I. 1989. Feeding and daily rations of the Pacific salmons of Oncorhynchus genus in the Sea of Okhotsk at the summer-autumn period. - Vopr. ikht. vol. 29, No 3, p. 456-464.

Healey M.C. 1991. Life history of chinook salmon (Oncorhynchus tschawytscha) - Pacific Salmon Life Histories. UBC Press. Vancower. p. 313-393.

Karpenko V.I. 1979. On feeding of juvenile of the Pacific salmons in the coastal waters of Kamchatka. - Biologiya morya. No 5, p. 30-38.

Manual on examination of fish feeding under natural conditions. 1961. Moscow. Izd. AN SSSR. 262 p.

Manual on examination of fish feeding. 1986. (Compilers: V.I. Chuchukalo and A.F. Volkov). - Vladivostok. TINRO. 32 p.

Methodical manual on the fish feeding examination and food relations between fishes under natural conditions. 1974. - Moscow. Nauka. 254 p.

Pearcy W.G., Brodeur R.D., Shenker J.M., Smoker W.W., Endo Y. 1988. Food habits of Pacific salmon and steelhead trout, midwater trawl catches and oceanographic conditions in the Gulf of Alaska, 1980-1985. - Bull. Ocean. Res. Inst. 26 (11) p. 29-78.

Reid G. 1961. Stomach content analysis of troll caught king and coho salmon, southeastern Alaska, 1957-1958. - U.S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish. No. 379, 8 pp.

Synkova A.I. 1951. On feeding of the Pacific salmon in the Kamchatka waters. - Izv. TINRO, vol. 34, p. 105-121.

Tutubalin B.G., Chuchucalo V.I. 1992. Estimation of daily ration of chum, pink and coho salmon in the northern Pacific Ocean. - Biological resources of the Pacific Ocean. Moscow, VNIRO, p. 350-360.

Yurovitsky Yu.G. 1962. On feeding of zope (Abramus balberus (L.)) in Rybinsky reservoir. - Vopr. ikhtiol., vol. 2, No 2, p. 350-360.

Address: 690600 Vladivostok. Shevchenko Alley,4, TINRO.
Volkov Anatoly Fedorovich
Chuchukalo Valery Ivanovich
Efimkin Alexander Yakovlevich

Table 1

Foods composition of chinook (55-105 cm) of northern-western Pacific at summer (%)

Composition of Food	Kuril Isl. (Pacific)		Bering and E.Kamchat.		Center of Okhotsk		West. Kam.
	1991	1993	1991	1993	1991	1993	1992
Calanus cristatus	+	-	+	-	+	-	+
Eucalanus bungii	+	-	+	-			
Parathemisto sp.	+	-	+	+	0.5	+	1.0
Thysanoessa longipes	16.8	20.3	0.9	27.5	0.5	90.3	+
Th. raschii	1.1	1.1	-	5.2	+	+	+
Euphausia pacifica	19.2	5.0	-	-			
Clione limacina	-	-	13.0	+	2.0		+
Berryteuthis magister	33.2	10.0	20.1	1.5	2.8	3.0	18.1
Gonatus kamtchaticus	2.5	1.7	-	-			
Gonatopsis borealis	15.0	11.0	16.0	1.0	12.4	3.5	40.3
Theragra chalcogramma	-	-	10.8	0.5			6.2
Hemilepidotus sp.	1.9	30.7	35.1	6.9	1.0	0.8	
Leuroglossus schmidti	-	-	2.1	-	2.7		3.2
Engraulus japonicus	2.5	12.0	-	-	30.9	2.0	
Sardinops sagax mel.	7.1	-	-	-	44.8		
Clupea pallasi	-	-	+	34.2	+	-	20.5
Ammodytes hexapterus	+	-	1.5	15.8	1.1	+	4.6
Mallotus villosus	-	-	+	4.1	+	+	1.8
Other fishes	0.7	5.2	0.5	3.3	1.3	0.4	2.0
Average IF (o/ooo)	30	39	19	36	48	64	35
Number of stomachs	26	23	24	19	26	19	22

Table 2

Foods composition (%) of coho juvenile (20-30 cm) in Sea of Okhotsk (W.K. - Western Kamchatka, Leb. - Mountain of Lebed, C.H. - Central Hollow)

Composition of Food	Sept.- Octob. 1994			Oct. 1991	Aug. 1991
	W.K.	Leb.	C.H.	C.H.	W.K.
Zooplankton	24.9	24.0	100	100	26.0
Calanus plumchrus		0.7	10.0		2.0
C.cristatus	0.2		10.0		
Parathemisto japonica		6.3	40.0	25.8	22.0
Primno macropa		0.3		17.6	2.0
Hyperia medusarum		0.5			
Euphausia pacifica				8.8	
Thysanoessa raschii	2.3	0.9			
T.longipes		3.2		9.4	
Megalopa Brachyura	11.5	7.4			
Limacina helicina	10.9	4.7			
Coelenterata (Medusae)			40.0		
Sagitta elegans				2.3	
Oikopleura sp.				36.1	
Nekton	75.1	76.0			74.0
Cephalopoda	19.0				
Theragra chalcogramma	43.1	72.6			25.0
Mallotus villosus	13.0				24.0
Engraulus japonicus					25.0
Other fishes		3.4			
Number of catches	7	7	1	3	2

Table 3

Foods composition (%) of coho (50-70 cm) at summer (June-August) (W.K. - Western Kamchatka, E.K. - Eastern Kamchatka, Okh. - Sea of Okhotsk, Kur. - Pacific waters near Kuril Islands)

Composition of Foods	1992	1991	1991	1993		
	W.K.	Okn.	Kur.	E.K.	Okh.	Kur.
Zooplankton	12.8	3.2	25.9	23.0	26.5	15.3
Calanus cristatus		0.8	0.2			
Parathemisto japon.	7.7	0.7	0.3	0.6		2.3
Gammaridea	+			1.2		
Hyperia galba	0.5	0.2	+			
Euphausia pacifica						0.8
Thysanoessa raschii	+	+	+		8.6	
Th.longipes	2.5	1.5	27	18.5	17.9	12.2
Larvae Brachyura	+	+		1.0		+
Clione limacina	1.3	+	+			
Limacina helicina	+	+	0.8	1.7		
Coelenterata (Medusae)	0.8		0.9			
Necton						
Cephalopoda (juv.)	8.4	6.4	56	57.7	10.1	41.7
Pisces	78.8	90.4	18.1	19.3	63.4	43.0
Pleurogrammus monopterigius	12.6			2.5	30.1	2.7
Leuroglossus schmidti	12.8	7	0.1		3.9	2.6
Clupea pallasi	2.8	6.7				
Mallotus villosus	7.5	2				
Ammodytes hexapterus	0.5	0.2				
Theragra chalcogramma	30.3	12	+			
Hemilepidotus sp.		31	11.6	6.7	4.6	17.7
Engraulus japonicus		22.5	+			10.0
Sardinops sagax melanosticta		5				
Cololabis saira					18.6	6.3
Stenobrachius leucopsarus				2.6		1.3
Stychaeidae				0.7		
Other fishes	12.3	4	6.4			
Average IF (o/ooo)	96	88	86	114	146	181
Number of stomaches	98	22	30	21	9	28

Table 4

Daily rations of coho and chinook salmons (summer 1993)
(% - percent of body mass)

Fish	Length	Bering		East.Kam.		Okhotsk		Pacific	
	(cm)	%	g	%	g	%	g	%	g
Coho	50-70	2.1	54.2	2.1	54.2	3.0	106	3.6	107
Chinook	50-70	1.2	43.8	1.2	43.8	1.2	54.0	0.3	11.2