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**Feeding and Daily Rations of Sockeye Salmon
(*Oncorhynchus nerka*) During the Summer Period**

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FEEDING AND DAILY RATIONS OF SOCKEYE SALMON (ONCORHYNCHUS NERKA) DURING THE SUMMER PERIOD

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Complex works of TINRO on accounting of salmon during anadromous migrations in 1991-1993 allowed to obtain, in addition to other information, new materials on the qualitative and quantitative characteristics of feeding for different salmon species, in particular, sockeye salmon.

Most literature information of the salmon feeding concerns largely the feeding spectra and identification within them of primary and secondary objects (Synkova, 1951; Andrievskaya, 1966; Foerster, 1968; Favorite, 1970; French et al., 1976), feeding characteristics of yearlings and fishes aged 2 years in the coastal area (Karpenko, 1979; Karpenko, Piskunova, 1984) and general data about feeding sockeye juvenile in the open waters (Gorbatenko, Chuchukalo, 1989). E.M. Krokhin (1957) determined the daily ration and annual food consumption in the Dalnee lake. The quantitative estimates of the sockeye feeding during sea period were not available up to the present. This paper carries out an analysis of materials concerning the feeding of sockeye obtained in the three expeditions of TINRO in 1991, 1992 and 1993.

Accounting works in respect to the Pacific salmon have been carried out in June-August 1991, on the RS "Professor Levanidov" and RS "Professor Kaganovsky", RS "TINRO" and RS "Novouljanovsk" and in June-July 1993 on the RS "Professor Kizevetter", RS "TINRO" and RS "Professor Soldatov". The scheme of trawling in these expeditions was nearly the same. The studies have covered the extensive territory situated between 47N and 48N and including the Western Bering Sea, Eastern Sea of Okhotsk, waters near the eastern Kamchatka and northern Kuril Islands within the band of 300 miles. The trawling have been made using floating trawls 108/528 with speed of 4.5-5.0 knots at upper 50-m layer. In all, more than 1480 stomachs of sockeye were collected and processed. A volume of data obtained allowed to identify the following length size classes 50-60cm, 40-50cm, 30-40cm and 20-30cm. Because it is practically impossible to do stationary daily stations on feeding for such mobile objects as salmon we combined materials of daily feeding dynamics for great areas of water (Western Bering Sea, eastern Kamchatka and northern Kuril Islands) dividing preliminarily all of materials into 4-hour periods.

Calculation of rations has been carried out using methodologies of Yu. G. Yurovitsky (1962) and A. V. Kogan (1963) based on computing an average value of food consumption between two and more maximums of stomach fullness with, at least, one interruption in feeding during a day. These methodologies applied in TINRO have demonstrated a quite well conformity with calculation of rations from balance equality of Vinberg (Gorbatenko, Chuchukalo, 1989).

Bering Sea

Despite a considerable number of trawling, the sockeye in 1991 has not too well been caught, therefore, feeding of 10 fishes with length size of 30-40cm and 5 larger fishes of 40-60cm in length was surveyed. The indices of fullness of stomachs first size group varied from 0 in the morning hours 75 at midday while for second group they were within the limits of 25-35. In both cases, among the food objects, hyperiids, large copepods and pteropods predominated by mass as, on the whole, corresponds to earlier published results (Karpenko, 1979; Karpenko, Piskunova, 1984; Foerster, 1968; French et al., 1979).

More representative materials were obtained during next two years. Data of Table 1 show that importance of each of major food objects can essentially vary in different years even among groups of fishes of the same length size but the most importance in the sockeye feeding play the following objects: *Parathemisto pacifica*, *Thysanoessa longipes*, *Limacina helicina*, *Calanus cristatus* and immature squids represented by two species, - northern - *Gonatus borealis* - and Komandorian - *Berryteuthis magister*.

In 1992, the larvae of crabs (mainly, king crab) at stage of megalopes formed a quite considerable rations part of sockeye of 50-60 and 30-40cm in length while in 1993, the pteropods *L. helicina* played an important role in feeding of sockeye of all length size groups. Such variations in the food composition were apparently caused by higher development of one or other of forms in plankton. Very great variations in the sockeye ration have been observed for sagitts and fishes. The latter for all length size, groups were mainly presented by juvenile of Irish lords (*Hemilepidotus* sp.) and Atka makerels (*Pleurogrammus monopterygius*) as well as lanternfishes (*Lampanictus* sp.) and capelins (*Mallotus villosus*).

Pacific waters near Kamchatka

The spectrum of feeding and major food objects of sockeye in the Pacific waters of Kamchatka are not much different from those in the Bering Sea (Tables 1 and 2). In 1992, as in the previous case, a robe of crab larvae was considerable in the sockeye ration, however, an increase

of a part of pteropods was not observed in the next year although they occupied also one of leading places in ration. Euphausiids in the sockeye ration were presented by several species in the Eastern Kamchatka region and pronounced predominance of *Th. longipes* was not here observed. So, in 1992, *Thysanoessa raschii* was more important while, in 1993, a high percentage of *Euphausia pacifica* was noted.

The amount of daily rations for the same-length size groups of sockeye in two areas proved to be quite close. Reduction of rations for large sockeye in 1993 was caused by the fact that the ripeness degree of reproductive products during period under consideration was much higher than in 1992 and feeding intensity of Salmons as known comes down as fish migrates to the mouths of spawning rivers.

The Sea of Okhotsk waters near Kamchatka

The most considerable volume of data concerning the sockeye feeding in the waters of the western Kamchatka coast was, obtained in 1991 (Table 3). In the sockeye feeding, in this area as compared with previous ones, some differences caused by peculiarities of food base were observed. So, copepods were presented in ration by not only *Calanus cristatus* but also, to considerable extent, by *Eucalanus bungii* as well as *C. plumchrus* and *C. glacialis*.

Euphausiids were here of lesser importance in ration than near the eastern Kamchatka coast and a share of hyperiids was, on the contrary, greater (See Tables 2 and 3). The squids were revealed in large quantities only for large fishes whose size exceeded 50cm. On the whole, a volume of ration of nubilous fishes was not high that implied a near approach of sockeye the spawning rivers.

Northern Kuril region

The limited material collected near the Pacific coast of the northern Kuril Islands in 1991 (13 stomachs of fishes of 42-62cm in length) shows that sockeye in this region fed mainly on hyperiids and pteropods. Copepods, oikopleuras, chaetognaths and euphausiids had a secondary role. The indices of stomach filling were quite high (50-180 ‰).

As to feeding of sockeye caught in the Kuril region in 1993 diet of large fishes was high (Table 4). A ripeness of reproductive products of the majority of individuals was yet at the stage 3-4, the before, sockeye fed quite intensively. Euphausiids in diet had the fundamental importance, even somewhat greater, than hyperiids as well as squids and pteropods. A fairly substantial role was played by fishes which were presented by night by smooth-tongue and myctophidae. On the

whole, our data for this region are somewhat different from materials of A. I. Synkova (1952) who argues that, in summer, the sockeye near the northern Kuril Islands consumes largely hyperiids as well as larvae of crabs and prawns.

In all of regions, two peaks - at 12-14 and 18-20 o'clock are, as a rule, traced during a day. By morning, the stomachs of sockeyes are found to be empty, i. e. the sockeye does not feed after midnight and begins to feed approximately at 6-7 o'clock.

Conclusions

A volume of daily rations of sockeye varies from 2.1% to 5.4% of body mass, and decreased during migration. In addition it is apparently reduced even more within zones adjoining the river mouths.

E. M. Krokhin (1957) has pointed to considerable variations of the sockeye ration volume at freshwater period. According to his data, diet of fingerlings varied from 1.5% of body mass in winter to 11.3% in summer while thought a year it, on the whole, was about 3% of body mass.

According to our data, during summer months, the changes of the ration volume are also significant and can be in different parts of area 2.5-4.1% for small individuals (20-30cm in length), 2.9-3.2 and 2.9-5.4% of body mass for sockeyes of 30-40cm and 40-50cm in length respectively. The sockeye feeding intensity at the moment is apparently determined by its physiological demands rather than volume of food base because a wide spectrum of feeding allows for fishes to change from one object to the other. At the same time, the favorite feeding objects of sockeye are in the first place hyperiids (*P. pacifica*), euphausiids (*T. longipes*) and pteropods (*C. limacina*) (plankton) and immature squids (*Gonatus borealis* and *Berryteuthis magister*) (nekton).

By night (before midnight), euphausiids and squids predominate in the sockeye ration while by day a share of copepods, hyperiids and pteropods increases.

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Table 1

Foods composition of sockeye of Bering Sea
in June-July 1992 and 1993., %

Composition of Food	Length size classes of fish, cm							
	20-30		30-40		40-50		50-60	
	1992	1993	1992	1993	1992	1993	1992	1993
Calanus cristatus	12.6	3.7	11.1	2.4	5.4	9.9	8.5	2.9
Parathemisto pacifica	63.4	22.9	34.6	24.2	45.9	18.2	42.8	21.0
Thysanoessa longipes	8.7	1.3	13.2	11.8	37.7	36.1	1.9	40.0
Crab (megalopa)	+	0.1	12.3	+	1.2	+	11.1	+
Pandalus goniurus lar.	+	0.5	2.3	1.0	0.1	+	16.8	+
Limacina helicina	0.6	42.2	1.2	8.4	0.4	5.8	0.1	14.9
Clione limacina	+	+	+	2.5	+	1.2	+	+
Cephalopoda larvae	0.1	6.0	2.2	31.2	1.6	12.6	16.6	10.9
Parasagitta elegans	8.4	0.7	11.6	0.2	+	0.1	+	3.7
Fishes	1.9	20.1	8.3	10.9	0.9	8.3	0.1	2.6
Other	4.3	2.5	3.2	7.4	6.8	7.8	2.1	4.0
Number of stomachs	86	80	112	155	77	105	60	66
Daily ration, %	4.1	2.5	3.2	2.9	5.4	3.1	4.0	2.1

Table 2

Foods composition of sockeye of Pacific waters near
the Kamchatka in June-August 1991 - 1993., %

Composition of Food	Length size classes of fish, cm							
	<30	30-40	40-50	50-60				
	1993	1991	1993	1992	1993	1991	1992	1993
Calanus cristatus	17.2	41.9	18.6	6.0	2.1	1.7	0.6	1.8
Parathemisto pacifica	47.7	0.8	18.7	29.6	29.2	18.2	22.6	11.2
Thysanoessa longipes	+	0.2	1.0	+	5.8	49.8	+	26.8
Th. raschii	+	+	+	12.0	+	0.2	20.4	+
Th. inspinata	-	+	-	-	-	0.8	-	-
Euphausia pacifica	1.2	+	0.5	3.0	7.5	+	2.5	12.5
Crab (megalopa)	+	+	+	18.0	+	+	9.3	+
Limacina helicina	10.0	21.6	30.0	10.3	21.1	17.4	16.1	3.3
Clione limacina	5.8	1.3	14.3	8.5	0.2	9.3	7.5	0.7
Cephalopoda larvae	13.8	20.1	10.9	8.0	26.0	0.8	15.0	24.4
Aglanta digitale	+	-	+	1.0	+	+	0.5	0.1
Beroe cucumis	+	7.2	+	-	-	0.5	+	-
Fishes	+	+	+	2.6	2.5	+	4.5	11.2
Other	4.3	6.9	6.0	1.0	5.6	1.3	1.0	8.0
Number of stomachs	25	104	40	12	100	56	15	54
Daily ration, %	-	2.2	2.4	-	3.1	4.2	-	2.2

Table 3

Foods composition of sockeye of Okhotsk waters near
the Kamchatka in June-August 1993., %

Composition of Food	Length of fish, cm		
	30-40 cm	40-50 cm	50-60 cm
<i>Calanus cristatus</i>	30.7	13.8	5.8
<i>C. plumchrus</i>	3.5	4.1	2.4
<i>C. glacialis</i>	1.8	0.2	+
<i>Eucalanus bungii</i>	7.8	5.3	4.6
<i>Parathemisto japonica</i>	50.4	68.0	38.3
<i>Thysanoessa longipes</i>	+	1.0	6.0
<i>Th. raschii</i>	-	+	+
<i>Th. inermis</i>	+	1.3	0.6
<i>Limacina helicina</i>	3.9	4.6	17.2
<i>Clione limacina</i>	+	+	0.3
Cephalopoda larvae	+	+	19.0
<i>Beroe cucumis</i>	-	-	0.7
Fishes	1.8	1.2	2.1
Other	0.1	+	3.0
Number of stomachs	86	98	61
Daily ration, %	3.8	2.9	2.2

Table 4

Foods composition of sockeye of waters near northern
Kuril Island in June-July 1993., %

Composition of Food	Length of fish	
	40-50	50-60
<i>Calanus cristatus</i>	2.0	3.3
<i>Parathemisto pacifica</i>	21.9	12.2
<i>Hyperia galba</i>	0.1	0.3
<i>Primno macropa</i>	0.3	0.1
<i>Thysanoessa longipes</i>	21.4	28.4
<i>Th. inspinata</i>	0.5	1.2
<i>Euphausia pacifica</i>	4.3	5.6
Crab (megalopa)	1.9	0.7
<i>Limacina helicina</i>	16.0	14.6
<i>Clione limacina</i>	0.6	+
Cephalopoda larvae	21.7	19.1
<i>Beroe cucumis</i>	1.0	3.0
<i>Aglantha digitale</i>	+	+
Fishes	6.2	9.6
Other	2.1	1.9
Number of stomachs	25	56
Daily ration, %	-	4.5