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Feeding of Pacific Salmon in the Eastern Bering Sea in 2005

by

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The research of feeding pacific salmons were conducted in the eastern Bering Sea in August-October 2005 under umbrella BASIS program onboard R/V Sea Storm (USA).

Materials on fish feeding were taken from trawl yield. A sample usually included 10 or any other available number of stomachs for each size group of the same fish species. The stomachs were processed without preliminary fixation according to Guidance … (1974) and Fish Feeding Research Guide (1986). Stomach contents were weighed, mass of each food component determined, digestibility classified on 5-level scale, and value of the components estimated (% of food weight), Feeding Index - as ratio of food mass to of fish mass multiplied by 10000). The volume of the materials collected and processed is given in Table 1.

Table 1. Number of samples and processed stomachs of salmon juveniles in August-October 2005, N stomachs/ N samples

Species	Bristol Bay (Leg 1-2)	Nunivak area (Leg 3)
Pink	303 / 53	134 / 35
Chum	416 / 108	165 / 49
Sockeye	591 / 97	9 / 6
Coho	94 / 31	4 / 3
Chinook	174 / 41	98 / 43

Pink salmon *(Oncorhynchus gorbusha)*. The pink salmons in 2005 was made basically of fishes, mostly juvenile pollock, capelin and other fishes from 55 up to 80 % of food weight, and with increase in the sizes its value fishes grew in a diet. In Bristol Bay the share of *Limacina helicina* was high (20 %) in a diet of juvenile pink salmon. The share *Megalopa crabs* and *Euphausiacea* was essential in a diet of larger juvenile pink salmon (20-30 cm). In the Nunivak area *Euphausiacea* played an appreciable role in a diet juvenile pink salmon (20-40 % of food weight). The juvenile pollock made more than 90 % of diet of large pink salmons. Intensity of a feeding juvenile pink salmon was high, and in the Nunivak area Feeding Index was higher, than in the Bristol Bay (Table 2).

Chum salmon *(Oncorhynchus keta)*. Fishes and *Coelenterata* made the basic diet of chum salmon. Fishes, basically juvenile pollack, dominated in a diet chum salmon in the Bristol Bay (70-93 %). In area Nunivak the share of fishes made 32-44 % of a diet, almost as well as *Euphausiacea* (32-27 %). *Megalopa crabs, Limacina helicina* and *Oikopeura sp*. was appreciable in this area. Fishes and *Coelenterata* had also the basic components of a diet of the large chum salmon. Fishes prevailed in a diet of the large chum salmon in the Bristol Bay, *Coelenterata* - in the Nunivak area (Table 3 and 4). Intensity of a feeding of juvenile chum salmon was high, Feeding Index made 135-164 ‰ in the Bristol Bay and 183-208 ‰ - in the Nunivak area. Intensity of a feeding of a large chum salmon was appreciablly lower in the Nunivak area.

Sockeye salmon *(Oncorhynchus nerka)*. In The Bristol Bay juvenile sockeye salmon (up to 10 sm) fed mainly *Copepoda* (97 %). Fishes, mainly juvenile pollock (79-81 % of food weight) prevailed in a diet juvenile sockeye (10-20 and 20-30 sm). *Pteropoda, Copepoda, Hyperiidea, Eupausiacea* and *Megalopa crabs* occurred as well in a diet of sockeye salmon. The share *Limacina helicina and Megalopa crabs* was more significant in a diet of larger

sockeye salmons, and *Euphausiacea* (67 %) dominated in a diet of fishes of 50-60 sm. In the Nunivak area a diet was composed *Megalopa crabs, Limacina helicina, Oikopeura sp., Chaetognatha* and *Coelenterata* (Table 5 and 6).

Juvenile sockeye fed most actively in the Bristol Bay. Feeding Index were low from 0 up to 80 ‰ in the morning at 7-8 o'clock., the greatest number of fishes with empty stomaches was fixed in this period. The "fresh" food was observed constantly during day-time. Feeding Index of juvenile sockeye salmon changed considerably, and the highest values (400-799 ‰) were observed from 19 till 23 o'clock. At large sockeye salmon intensity of a feeding was low during this period.

The diet **coho salmon (Oncorhynchus kisutch**) has consisted mainly from fishes, *Megalopa crabs* and *Gammaridea* met in insignificant number. In Bristol Bay juvenile pollock and sandlance prevailed among fishes, in the Nunivak area - a herring and capelin. Squids made 70 % of food weight at coho salmon 30-40 cm. Coho salmon fed rather intensively in Bristol Bay, Feeding Index was 184-270 ‰ (Table 7).

Chinook salmon *(Oncorhynchus tschawytscha).* Fishes and squids made the basis of food of chinook salmon. The squids dominated in a diet at large chinook salmon (50-70 sm) in Bristol Bay. Juvenile pollock and sandlance prevailed in the food from fishes in the Bristol Bay, capelin and herring - in Nunivak area, juvenile other fishes was identified too (Table 8 and 9). The share *Gammaridea, Megalopa crabs, Mysidacea* and *Eupausiacea* was appreciable. Iuvenile chinook salmon fed most actively, Feeding Index made 134-182 ‰ (Table 8 and 9).

Prevalence of fish food in a diet of juvenile pink, chum and sockeye salmon in coastal areas of Alaska is connected with high concentration of juvenile fishes, especially juvenile pollock. Small and average fractions prevailed in zooplankton. The large fraction of zooplankton made no more than 8,6 % in the shallow waters and 33 % on the shelf (Volkov et. al., 2004, 2005). Juvenile plankton as the food replaces a zooplankton large fraction (*Euphausiacea, large Copepoda* and *Hyperiidea)*, therefore can always provide juvenile salmons with necessary number of food during recession of stocks zooplankton parts of their forage reserve.

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Table 2. Food composition of pink salmons in the eastern Bering Sea in 2005, (% of food weight)

	Bristol Bay			Nunivak area	
	10-20 cm	20-30 cm	50-60 cm	10-20 cm	20-30 cm
Thysanoessa raschii	1.3	6.3	3.0	22.7	6.1
Th. inermis	1.1	1.4	-	0.1	1.7
Th. sp.	0.1	-	-	-	-
Mysidacea	0.04	-	-	-	-
Themisto pacifica	6.2	-	-	4.7	3.8
T. libellula	-	-	-	0.7	0.7
Hyperia sp.	0.4	1.6	-	0.7	0.4
Gammaridea	0.3	0.2	-	0.1	-
Epilabidocera amphitrites	4.0	-	-	-	-
Centropages abdominalis	1.4	-	-	-	-
Eurytemora herdmani	0.4	-	-	-	-
Calanus glacialis	0.1	-	-	0.4	0.5
Tortanus discaudatus	0.1	-	-	-	-
Evadne nordmanni	0.01	-	-	-	-
Eucalanus bungii	0.3	-	-	-	-
Megalopa Brachyura	0.7	8.6	-	18.0	15.6
Zoea Brachyura	2.9	-	1.1	0.04	-
Caridea juv	2.3	-	-	-	0.03
Cumacea	-	-	-	0.1	0.1
Clione limacina	0.4	0.6	-	0.4	0.8
Limacina helicina	19.6	0.6	1.9	0.02	0.03
Oikopleura sp.	1.3	-	-	0.1	-
Chaetognatha	0.1	-	-	0.3	0.1
Coelenterata	0.0	-	-	0.5	1.6
Cephalopoda	1.4	-	-	-	2.4
Theragra chalcogramma	29.5	65.5	92.0	22.0	33.8
Ammodytes hexapterus	12.5	-	-	-	-
Mallotus villosus	-	-	-	15.2	24.4
Sebastes sp.	3.0	14.7	-	8.2	1.6
Gadus macrocephalus	0.2	-	-	-	-
Pisces larvae	7.5	0.2	2.0	3.2	0.8
Pisces other	2.2	0.3	-	2.1	5.5
Insecta	0.6	-	-	0.4	-
Feeding Index, o/ooo	179.1	128.2	99.1	197.0	211.6

Table 3. Food composition of chum salmons in the Bristol Bay of the Bering Sea in 2005, (% of food weight)

	10-20 cm	20-30cm	30-40 cm	40-50 cm	50-60 cm	60-70 cm	70-80 cm
Thysanoessa raschii	1.1	13.2	-	-	-	-	-
Th. inermis	-	-	0.4	-	0.03	-	-
Th. spinifera	-	-	-	0.5	0.1	-	-
Mysidacea	0.1	-	-	-	-	-	-
Themisto pacifica	0.1	-	0.02	0.3	0.02	-	-
Hyperia sp.	0.9	-	0.1	-	-	-	0.1
Gammaridea	0.7	-	-	-	-	-	-
Epilabidocera amphitrites	0.5	-	-	-	-	0.4	-
Pseudocalanus newmani	0.01	-	-	-	-	-	-
Centropages abdominalis	0.2	-	0.1	-	-	-	-
Eurytemora herdmani	0.04	-	-	-	-	-	-
Tortanus discaudatus	0.005	-	-	-	-	-	-
Pareuchaeta japonica	-	-	-	-	0.01	-	-
Megalopa Brachyura	0.02	-	0.4	0.01	0.1	-	-
Zoea Brachyura	0.4	-	0.02	0.05	-	-	-
Caridea juv	0.3	-	-	0.3	-	-	-
Clione limacina	0.2	-	4.1	4.5	2.4	-	-
Limacina helicina	5.9	-	4.8	1.2	0.4	-	-
Oikopleura sp.	4.9	-	-	-	-	-	-
Coelenterata	12.2	6.8	8.7	1.0	0.9	9.2	6.1
Beroe sp.	1.0	-	-	-	-	1.2	1.1
Salpae	-	-	-	-	0.1	-	-
Cephalopoda	-	-	1.7	0.9	-	-	-
Theragra chalcogramma	58.1	75.2	78.5	90.7	95.8	83.7	92.5
Ammodytes hexapterus	6.0	-	-	-	-	-	0.2
Mallotus villosus	-	-	-	-	-	0.4	-
Gadus macrocephalus	-	-	-	-	-	3.0	-
Pisces larvae	4.3	-	-	0.5	0.1	-	-
Pisces spp.	3.0	4.8	1.2	-	-	2.1	-
Feeding Index, o/ooo	164.2	135.2	115.2	85.9	97.3	75.0	116.0

Table 4. Food composition of chum salmons in the Nunivak area of the Bering Sea in 2005, (% of food weight)

	10-20 cm	20-30 cm	50-60 cm	60-70 cm	70-80 cm
Thysanoessa raschii	31.8	25.6	1.3	0.6	-
Th. sp.	-	0.3	-	-	-
Themisto pacifica	0.4	0.7	-	0.5	-
Hyperia sp.	1.3	0.7	0.5	0.2	-
Gammaridea	0.3	-	-	-	-
Epilabidocera amphitrites	0.03	-	-	-	-
Centropages abdominalis	0.02	-	-	-	-
Tortanus discaudatus	0.01	-	-	-	-
Megalopa Brachyura	2.6	2.2	1.6	4.7	-
Zoea Brachyura	-	0.9	-	-	-
Caridea juv	-	0.05	-	0.04	-
Clione limacina	2.2	1.1	-	1.0	-
Oikopleura sp.	2.3	0.2	-	-	-
Chaetognatha	0.4	-	-	-	-
Coelenterata	18.8	20.2	11.4	43.4	100
Beroe sp.	4.9	3.8	0.4	0.4	-
Salpae	3.3	-	-	-	-
Theragra chalcogramma	19.0	23.2	82.2	6.8	-
Mallotus villosus	6.8	17.9	-	-	-
Pleuronectidae larvae	-	-	1.4	4.8	-
Pisces larvae	4.8	2.1	0.5	9.6	-
Pisces spp.	1.0	1.0	0.7	28.0	-
Feeding Index, o/ooo	182.8	207.6	36.9	30.9	3.8

Table 5. Food composition of sockeye salmons in the Bristol Bay of the Bering Sea in 2005, (% of food weight)

	5-10 cm	10-20 cm	20-30 cm	30-40 cm	40-50 cm	50-60 cm	60-70 cm
Thysanoessa raschii	-	-	1.1	5.9	-	66.5	-
Th. inermis	-	0.2	-	0.3	-	-	-
Th.spinifera	-	0.6	-	0.5	-	-	-
Th. sp.	-	-	0.01	-	-	-	-
Mysidacea	-	0.4	-	-	-	-	-
Themisto pacifica	-	0.4	1.8	10.5	-	1.7	-
Hyperia sp.	-	0.1	0.03	0.5	-	-	-
Cyphocaris sp.	-	-	-	0.2	-	-	-
Gammaridea	-	1.3	-	-	-	-	-
Epilabidocera amphitrites	87.7	1.6	-	-	-	-	-
Centropages abdominalis	-	0.4	0.02	-	-	-	-
Eurytemora herdmani	9.7	0.2	-	-	-	-	-
Calanus glacialis	-	0.01	0.1	-	-	-	-
Tortanus discaudatus	-	0.1	-	-	-	-	-
Podon sp.	-	0.01	-	-	-	-	-
Eucalanus bungii	-	-	0.8	-	-	-	-
Megalopa Brachyura	-	0.5	3.8	18.2	-	10.1	-
Zoea Brachyura	-	2.1	-	0.5	-	-	-
Caridea juv	-	2.2	0.4	-	-	-	-
Clione limacina	-	-	0.02	-	-	-	-
Limacina helicina	-	5.8	8.0	2.0	-	21.7	-
Oikopleura sp.	-	0.3	-	-	-	-	-
Chaetognatha	-	0.2	-	-	-	-	-
Coelenterata	-	-	0.5	-	-	-	-
Nauplii Cirripedia	-	0.01	-	-	-	-	-
Beroe sp.	-	-	0.1	-	-	-	-
Cephalopoda	-	-	1.3	6.8	-	-	-
Theragra chalcogramma	-	78.5	81.0	52.4	-	-	100
Ammodytes hexapterus	-	1.6	-	-	-	-	-
Hexagrammos stelleri	1.8	-	-	-	-	-	-
Pisces larvae	-	1.6	0.2	-	-	-	-
Pisces spp.	-	1.3	0.8	2.2	-	-	-
Insecta	0.8	0.6	-	-	-	-	-
Feeding Index, o/ooo	219.8	194.2	156.7	13.1	0.0	29.8	111.9

Table 6. Food composition of sockeye salmons in the Nunivak area of the Bering Sea in 2005, (% of food weight)

	20-30 cm	30-40 cm
Thysanoessa raschii	-	4.5
Themisto pacifica	1.0	-
Megalopa Brachyura	-	53.3
Zoea Brachyura	-	1.5
Oikopleura sp.	15.0	-
Chaetognatha	5.1	-
Coelenterata	9.9	1.5
Theragra chalcogramma	-	36.9
Pisces larvae	-	1.8
Pisces spp.	69.0	0.5
Feeding Index, o/ooo	31.3	38.7

Table 7. Food composition of coho salmons in the eastern Bering Sea in 2005, (% of food weight)

	Bristol Bay					Nunivak area		
	20-30 cm	30-40 cm	50-60 cm	60-70 cm	70-80 cm	20-30 cm	30-40 cm	50-60 cm
Gammaridea	0.8	-	-	-	-	-	-	-
Megalopa Brachyura	-	-	-	-	-	-	4.9	-
Zoea Brachyura	0.9	-	-	-	-	-	-	-
Cephalopoda	-	-	-	-	-	-	70.1	-
Theragra chalcogramma	70.8	81.8	100	76.0	100	-	-	-
Ammodytes hexapterus	25.2	18.2	-	24.0	-	-	-	-
Mallotus villosus	-	-	-	-	-	-	-	82.0
Clupea pallasii	-	-	-	-	-	100	-	-
Pisces larvae	2.3	-	-	-	-	-	-	-
Pisces spp.	-	-	-	-	-	-	25.0	18.0
Feeding Index, o/ooo	137.3	210.7	270.4	184.0	228.3	534.1	26.8	60.4

Table 8. Food composition of chinook salmons in the Bristol Bay of the Bering Sea in 2005, (% of food weight)

	10-20 cm	20-30 cm	30-40 cm	40-50 cm	50-60 cm	60-70 cm	70-80 cm	80-90 cm
Thysanoessa raschii	-	2.6	-	-	-	-	-	-
Mysidacea	3.6	-	-	-	-	-	-	-
Gammaridea	-	0.3	19.9	-	-	-	-	-
Cephalopoda	-	-	-	42.6	74.0	82.7	-	-
Theragra chalcogramma	33.9	30.5	23.7	51.8	-	-	-	21.6
Ammodytes hexapterus	49.7	65.2	42.1	-	-	-	-	-
Sebastes sp.	-	0.6	-	-	-	-	-	-
Clupea pallasii	7.9	-	-	-	-	-	-	-
Pleuronectidae larvae	0.5	0.6	-	-	-	-	-	-
Hexagrammos stelleri	-	-	14.3	-	-	-	-	-
Zaprora silenus	-	-	-	-	-	14.6	-	-
Anoplopoma fimbria	-	-	-	-	-	-	-	78.4
Pisces larvae	-	-	-	5.6	-	-	-	-
Pisces spp.	4.1	0.2	-	-	26.0	2.7	100	-
Insecta	0.3	-	-	-	-	-	-	-
Feeding Index, o/ooo	181.6	133.8	49.5	30.0	9.6	126.0	0.8	31.9

Table 9. Food composition of chinook salmons in the Nunivak area of the Bering Sea in 2005, (% of food weight)

	10-20 cm	20-30 cm	30-40 cm	40-50 cm	50-60 cm	60-70 cm	70-80 cm
Thysanoessa raschii	-	1.8	0.5	-	-	-	-
Th. sp.	-	-	0.5	-	-	-	-
Hyperia sp.	-	0.8	-	-	-	4.2	0.2
Megalopa Brachyura	13.6	13.3	-	2.1	-	-	0.3
Cephalopoda	10.9	9.2	18.2	1.9	-	-	0.2
Theragra chalcogramma	-	26.0	10.3	-	3.9	-	2.2
Ammodytes hexapterus	12.3	0.8	-	-	-	-	-
Mallotus villosus	31.9	30.3	51.9	94.4	73.9	86.4	-
Clupea pallasii	-	2.0	-	-	-	-	97.1
Pleuronectidae larvae	15.0	0.9	0.8	-	-	-	-
Hexagrammos stelleri	-	3.2	-	-	-	-	-
Anoplopoma fimbria	-	-	-	-	21.4	-	-
Pisces larvae	-	6.4	-	-	-	-	-
Pisces spp.	16.3	5.2	17.8	1.6	0.8	9.4	-
Insecta	-	0.1	-	-	-	-	-
Feeding Index, o/ooo	153.7	148.8	72.0	74.3	213	13.3	104.9