

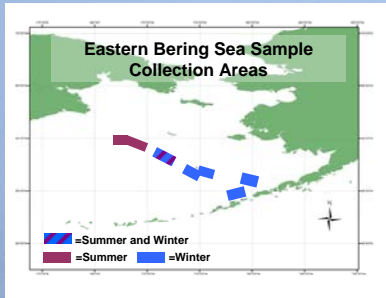
Winter Food Habits of Chinook Salmon in the Eastern Bering Sea

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Introduction

Declining returns of Chinook salmon to western Alaska have resulted in management restrictions on commercial and subsistence fishing. Information is needed to understand effects of fishing and ocean conditions on growth, maturation, and survival of Arctic-Yukon-Kuskowim (AYK) Chinook salmon. There is currently no winter information on the diets of Chinook salmon in the eastern Bering Sea. The objective of this study was to obtain and analyze winter food habits data during this critical period of their life history.



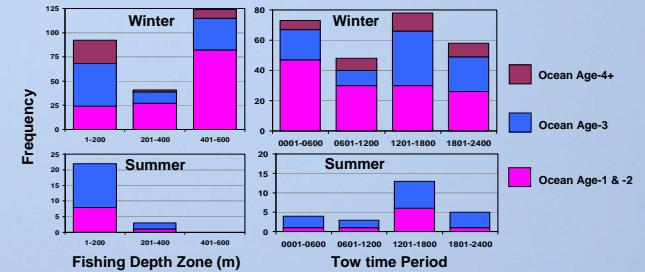
Results

Chinook Salmon Stomach Samples Description

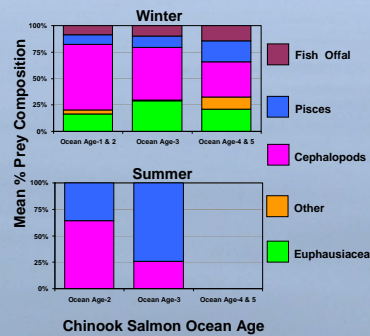
Description	Winter 2007	Summer 2007
No. of Chinook samples	257	25
Mean fishing depth m (sd)	308 (176)	138 (56)
Tow Time Period		
0001 to 0600 hours	28%	16%
0601 to 1200 hours	19%	12%
1201 to 1800 hours	39%	52%
1801 to hours 2400	23%	20%
Ocean age-1		
number (%)	5 (2%)	0
mean FL cm (sd)	28 (4.5)	
mean BW kg (sd)	0.25 (0.11)	
proportion empty stomachs (for age group)	0.20	
Ocean age-2		
number (%)	128 (50%)	9 (36%)
mean FL cm (sd)	52 (5.0)	64 (6.8)
mean BW kg (sd)	1.71 (0.61)	3.63 (1.08)
proportion empty stomachs (for age group)	0.52	0.00
Ocean age-3		
number (%)	89 (35%)	16 (64%)
mean FL cm (sd)	66 (5.1)	73 (5.9)
mean BW kg (sd)	3.58 (1.14)	5.27 (1.30)
proportion empty stomachs (for age group)	0.54	0.19
Ocean age-4 or more		
number (%)	35 (14%)	0
mean FL cm (sd)	76 (6.5)	
mean BW kg (sd)	5.68 (1.90)	
proportion empty stomachs (for age group)	0.40	

A total of 282 Chinook salmon stomach samples was collected in winter (91%) and summer (9%), 2007. Half of the Chinook salmon collected in winter (50%) were ocean age-2 and most of the summer samples (64%) were ocean age-3 fish. Winter samples were collected from significantly (t-test, one tail, $p < 0.001$) deeper depths (mean 308 m) than summer samples (mean 138 m). Plots showed that age composition varied across fishing depth zone and tow time period. For winter samples, chi-square goodness of fit tests showed the frequency of ages in samples from each habitat were not equal (both χ^2 , $df=2$ $p < 0.001$).

Age Composition by Fishing Depth and Tow Time Period



Prey Composition by Chinook Ocean Age



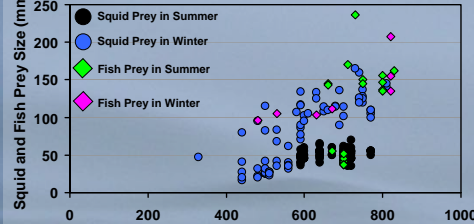
Winter Diets: Chinook salmon had a high percentage of empty stomachs (20-54%). Prey composition indicated decreasing proportion of squid (62.5% to 33.3%) and increasing proportion of fish (8.8% to 19.8%) with increasing ocean age. The squid species identified from stomach contents included *Berryteuthis magister*, *Gonatopsis borealis*, and a mixture of other *Gonatus* species. Fish offal was present in the diets of all age groups, ranging from 8.7% in ocean age-1 and -2 fish to 14.3% in ocean age-4 and older fish. Fish offal was defined as distinct, isolated body parts not typical of a fish consumed whole, such as wads of skin and individual fins. ANOVA tests comparing prey proportions to age group indicated significant differences in the proportion of squid between the youngest and the oldest age category ($df=1,84$ $F=6.148$, $p=0.015$) and the proportion of "Other" prey between the youngest age and oldest age category ($df=1,84$ $F=4.144$ $p=0.045$) and between age-3 and older fish ($df=1,60$ $F=4.421$, $p=0.040$). The "Other" category included shrimp, other unidentified crustaceans, and in the case of two stomach samples, plastic debris (plastic rope and monofilament). The "Other" prey category is a minor constituent of the diet and differences among age groups are likely not biologically significant.

Summer Diets: Chinook salmon had a low percentage of empty stomachs (0%-19%). Prey composition indicated increasing proportion of fish prey (26% to 74%) and decreasing proportion of squid (64.3% to 35.7%) with increasing ocean age. Fish prey identified from stomach contents included *Theragra chalcogramma* (walleye pollock) and *Blepsias bilobus* (crested sculpin), and squid were predominately *Gonatus kamschaticus* and *B. magister*. In summer, euphausiids, fish offal, and plastic debris were not found in stomach samples.

Methods

BASIS (Bering-Aleutian Salmon International Survey) research was not conducted in winter. Sampling by the U.S. North Pacific Groundfish Observer Program (NOAA Fisheries) provided an opportunity to sample Chinook salmon in winter in the eastern Bering Sea. Frozen Chinook salmon stomach samples, scales, and biological data were collected by observers from the commercial trawl fishery in winter (January to March) and summer (July to August), 2007. Data were grouped by ocean age based on scale age determination. The trawl tow time period was the 6-hour time period when at least 50% of the tow was conducted. Chinook salmon stomach contents were counted, weighed, and identified to the lowest possible taxonomic group. When possible, the body size of squid (ML=mantle length) and fish (SL=standard length) were measured. Winter diet samples were analyzed using ANOVA. For each stomach containing prey, the proportion of weight in each prey category was transformed (arcsine squareroot) and grouped by ocean age.

Comparison of Squid (ML) and Fish Prey (SL) Size to Chinook Body Size (FL)



Comparison of Chinook salmon fork length to fish and squid prey size shows in winter there is a positive relation between predator size and maximum size of squid and fish consumed. In summer, there is no relation between Chinook salmon size and either squid and fish prey size. In summer Chinook salmon might consume fish and squid that are smaller, or younger, than those encountered in winter. However, sample sizes were small and might not be representative of summer diets.

Conclusions

This was the first study of winter diets of Chinook salmon in the eastern Bering Sea. Chinook salmon diets varied by season, ocean age, and size group. In winter, significant differences were observed in the proportion of squid prey in the stomach contents of younger (ocean age-1 & -2) and older (ocean age-4 & -5) Chinook salmon. The high frequency of empty stomachs for all age groups suggests winter is characterized by low prey consumption and long periods between meals. Changes in prey availability between seasonal capture depths and the tow time period could contribute to observed differences in diets. All Chinook salmon age groups consumed fish offal generated by human fishing activities, which might supplement salmon diets, but could also have deleterious effects. Future studies will include examination of Chinook stomach contents collected by observers in 2008, which will allow for a more detailed examination of differences in Chinook salmon food habits with respect to body size and season.

