NPAFC

Doc. #435

Rev.

COMPARISON OF THE DIETS OF OCEAN AGE 0 HATCHERY AND WILD CHINOOK SALMON.

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submitted to the

North Pacific Anadromous Fish Commission

by

CANADA

September 1999

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Neville, C. M. and R. J. Beamish. 1999. Comparison of the diets of ocean age 0 hatchery and wild chinook salmon. (NPAFC Doc. 435). Dept. of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C. Canada. V9R 5K6.

COMPARISON OF THE DIETS OF OCEAN AGE 0 HATCHERY AND WILD CHINOOK SALMON.

ABSTRACT

Diets of hatchery and wild ocean age 0 chinook salmon from the Strait of Georgia were studied from 1996 to 1998. Hatchery and wild chinook were identified using otolith microstructure. Diet items were summarized into 9 major categories. Diet was summarized as percent volume and frequency of occurrence represented by each prey category. Diet overlap was determined using modified Morisita Index. There was significant overlap in diets of hatchery and wild ocean age 0 chinook and the overlap persisted even though size differences between the rearing types occurred. The dominant diet items of both rearing types were amphipods, euphausiids, decapods and teleosts.

INTRODUCTION

Chinook salmon (*Oncorhynchus tshawytscha*) have been a key species in the fisheries and culture of the residents living around the Strait of Georgia. In the mid-1900s a prosperous sports fishery developed, but by the mid-1980s it was apparent that both catches and abundances were declining (Beamish et al. 1995). Management responses to the decline in abundance focused on catch reductions, protection of freshwater spawning areas and artificial rearing of juveniles in hatcheries to increase the numbers of chinook that entered the ocean each year. It is now recognised that the declines in abundance resulted from fishing impacts as well as from natural changes in the ocean (Beamish et al. 1995). Despite large additions of hatchery reared juveniles and severe fishing restrictions the former abundances have not been restored (Beamish et al.

1997). There has been, however, a gradual increase in the percentage of hatchery fish in the juvenile rearing areas. In 1996 and 1997 Zhang and Beamish (1998) reported that hatchery percentages could range from 38.6 to 80.8% during the year, with percentages as high as 80.8% in the late fall. In this study, we compare the diets of hatchery and wild, ocean age 0 chinook.

METHODS

Ocean age 0 chinook salmon were sampled though-out the years 1996, 1997 and 1998 using a large rope trawl (Beamish and Folkes 1998). Sampling was conducted throughout the Strait of Georgia and associated waters following a series of transects and with fishing occurring at several depths (Beamish et al 1999). Juvenile chinook were counted and measured for fork length. Otoliths were collected from all chinook that were examined for stomach contents. However, not all of these otoliths were examined for otolith microstructure. Here we analyse only the diet composition of the fish that were identified as hatchery or wild. Otoliths were removed and stored dry. A random sample of these otoliths was classified as hatchery or wild chinook salmon based on differences in the otolith microstructure resulting from rearing conditions in fresh water (Zhang et al. 1995).

Stomachs were opened and examined immediately. When catches were large, a random sample of 20 stomachs was examined. All stomach content data used in this analysis was examined by one individual experienced in identifying plankton and stomach contents of salmon. The volume of the stomach contents was estimated and the percent of total volume of each prey type was recorded. Prey items were identified to order and sub-order when possible. If necessary, 10x magnification was used to look at smaller prey items. When identification was uncertain, samples were saved and examined using a dissecting microscope in the laboratory.

For this study, identifiable stomach contents have been summarised into 9 general categories; amphipods, euphausiids, decapods, calanoids, cephaplapods, teleosts, gastropods, insects and other. Diet items less than 5% of the volume were placed in the "Other Category". Stomachs that contained less than 0.1cc were considered to be empty.

The stomach contents were summarized as total percent volume for each prey category. In addition, the frequency of occurrence or the number of fish the prey category was observed in, was calculated. Material in diet that was too digested to identify was reported, but not used in calculations.

Overlap in diets of hatchery and wild chinook was calculated using a Modified Morista Index (Krebs 1989).

$$C_H = \frac{2\Sigma(p_{ij}p_{ik})}{\Sigma p^2_{ij} + \Sigma p^2_{ik}}$$

We used a cut-off of 0.60 to identify significant overlap in diet items between samples (Zaret and Rand 1971). Average length of the hatchery and wild chinook was tested for significant difference using z-Test.

RESULTS AND DISCUSSION

A total of 8535 ocean age 0 chinook were collected in the 6 cruises in September and November 1996 to 1998 (Table 1). Stomach contents were identified in 2343 individuals and 1129 of these fish were classified as hatchery or wild using otolith microstructure (Table 1). The wild fish were slightly more abundant (54%) than hatchery chinook (46%) in the sample used to compare stomach contents. The wild fish also had a lower percentage of empty stomachs (43%) than hatchery coho (57%).

Amphipods, euphausids, teleosts, and decapods were the dominant food items, representing at least 85% of the volume of identifiable contents in all surveys (Table 2). In particular, gammarid and hyperid amphipods were a major diet item in all samples. In 1996 and 1998, euphausids were the second most important food item by volume, while in 1997 teleosts were the second most important item. The teleosts could not all be identified, but of those that were, Pacific herring (*Clupea pallasi*) was the most common by volume.

When the frequency of occurrence was compared, amphipods were the most frequently consumed item in all surveys, occurring in 78.4% of all samples combined (Table 2). Copepods were found in 19.4% of all samples, indicating that they were moderately common despite their small size and resulting low percent volume. Terrestrial insects were not common diet items and were only moderately abundant in the September 1996 sample. Diet overlap was significant in all samples (exceeding 0.6 in the Morista index). In all but two surveys the Morista index equalled or exceeded 0.8 (Table

2). Hatchery fish had a greater percentage of volume of teleosts and a lower percentage of volume of decapods than wild chinook, but the volume of teleosts relative to other items was too small to influence the degree of diet overlap.

There was a significant difference in the lengths of hatchery and wild chinook in 4 of the 6 surveys (Z-test, $p < 0.001$). Hatchery fish were larger in the November 1996, September 1997, November 1997 and September 1998 samples. Despite the size differences, the prey items remained the same.

References

Beamish, R.J., B.E. Riddell, C.M Neville, B.L. Thomson and, Z. Zhang. 1995. Declines in chinook salmon catches in the Strait of Georgia in relation to shifts in the marine environment. Fish. Oceanogr 4(3) 243-256.

Beamish, R.J., C. Mahnken, and C. M. Neville . 1997. Hatchery and wild production of Pacific salmon in relation to large scale, natural shifts in the productivity of the marine environment. ICES Journal of Marine Science 54: 1200 - 1215.

Beamish, R. J. and M. Folkes. 1998. Recent changes in the marine distribution of juvenile chum salmon off Canada. NPAFC Bull No. 1

Beamish, R. J., D. McCaughran, J. R. King, R. M. Sweeting and G. A. McFarlane. 1999. Estimating the abundance of juvenile coho salmon in the Strait of Georgia using surface trawls. N. Amer. J. Fish. Mngt. (submitted).

Krebs, C.J. 1989. Ecological Methodology. HaperCollins. New York. 645pp.

Zaret, T. M. and A. S. Rand. 1971. Competition in tropical stream fishes: support for the competitive exclusion principle. Ecology, Vol. 52. No. 2.

Zhang, Z., R.J. Beamish, and B.E. Riddell. 1995. Differences in otolith microstructure between hatchery-reared and wild chinook salmon (*Oncorhynchus tshawytscha*). Can. J. Fish. Aquat. Sci. 52:344-352

Zhang, Z., and R.J. Beamish, 1998. Use of Otolith Microstructure to Study Life History of Juvenile Chinook Salmon in the Strait of Georgia in 1995 and 1996. accepted, 2nd International Symposium on Fish Otolith Research and Application.

Table 1: Total catch and total number of stomachs sampled for ocean age 0 chinook salmon collected in September and November 1996-1998. The number of hatchery and wild chinook used in the diet comparison is provided.

CRUISE	NO. OF SETS	TOTAL CATCH	NUMBER OF STOMACHS		HATCHERY AND WILD COMPARISON			
			TOTAL NO.	NO. OTOLITHS IDENTIFIED	HATCHERY		WILD	
					NO.	EMPTY	NO.	EMPTY
September 1996	62	1890	305	175	91	42	84	44
November 1996	55	320	124	93	79	37	14	2
September 1997	122	3689	492	182	45	16	137	23
November 1997	58	445	349	274	109	35	165	36
September 1998	95	1777	683	212	77	20	135	12
November 1998	95	414	390	193	117	27	76	17

Table 2. Diet categories summarized as percent volume and Frequency of Occurrence for the total sample and the hatchery and wild ocean age 0 chinook. Data is summarized by survey (a) September 1996, (b) November 1996, (c) September 1997, (d) November 1997, (e) September 1998, (f) November 1998.

Table 2(a). C_H=0.936

	TOTAL		HATCHERY		WILD	
	% volume	Freq. of occurrence	% volume	Freq. of occurrence	% volume	Freq. of occurrence
Amphipods	42.4	64.8	33.8	59.6	57.2	68.4
Euphausiids	10.0	37.4	10.1	34.6	12.0	40
Teleosts	16.2	12.1	22.3	15.4	4.5	7.9
Decapods	16.6	39.6	20.9	36.5	8.3	42.1
Cephalopod	3.6	3.3	1.0	1.9	9.5	5.3
Copepods	3.1	15.4	2.8	23.10	3.9	5.3
Gastropods	2.0	5.5	2.1	5.80	1.1	5.3
Insects	6.0	11.0	6.9	13.50	3.5	7.9
Other	0.1	1.1	0.1	1.9	0	0
Unidentified	26.3	89.0	24.6	80.8	30.0	97.4

Table 2(b) C_H=0.810

	TOTAL		HATCHERY		WILD	
	% volume	Freq. of occurrence	% volume	Freq. of occurrence	% volume	Freq. of occurrence
Amphipods	47.99	85.50	49.28	81.00	45.50	100.0
Euphausiids	31.64	54.50	30.55	54.80	34.04	58.3
Teleosts	6.16	5.50	9.55	7.10	0	0
Decapods	0	0	0	0	0	0
Cephalopod	8.88	16.40	2.74	11.90	20.46	33.3
Calanoids	2.73	21.80	3.82	26.20	0	0
Gastropods	2.60	5.50	4.06	7.10	0	0
Insects	0	0	0	0	0	0
Other	0	0	0	0	0	0
Unidentified	15.6	94.6	16.2	95.2	14.5	91.7

Table 2(c). C_H=0.643

	TOTAL		HATCHERY		WILD	
	% volume	Freq. of occurrence	% volume	Freq. of occurrence	% volume	Freq. of occurrence
Amphipods	33.7	88.8	23.0	82.2	41.3	90.4
Euphausiids	7.3	34.3	0.2	10.3	12.3	40.4
Teleosts	39.1	16.1	65.7	34.5	20.3	8.8
Decapods	11.1	50.3	5.2	24.1	15.3	57.0
Cephalopod	0.2	1.4	0	0	0.4	1.8
Calanoids	2.5	24.5	0.5	10.3	3.9	28.1
Gastropods	0.1	1.4	0	0	0.1	1.8
Insects	0	0	0	0	0	0
Other	6.0	21.0	5.4	17.2	6.4	21.9
Unidentified	0.4	7.7	0.1	3.4	0.5	8.8

Table 2(d). C_H=0.795

	TOTAL		HATCHERY		WILD	
	% volume	Freq. of occurrence	% volume	Freq. of occurrence	% volume	Freq. of occurrence
Amphipods	15.5	69.5	3.7	44.6	31.9	83.7
Euphausiids	10.7	40.0	10.8	36.5	10.5	35.7
Teleosts	69.2	24.6	84.7	32.4	47.6	15.5
Decapods	0.4	11.8	0.1	2.7	0.8	17.1
Cephalopod	1.0	8.4	0.1	5.4	2.2	10.1
Calanoids	2.8	31.5	0.4	10.8	6.1	43.4
Gastropods	0	0	0	0	0	0
Insects	0.2	7.4	0.1	2.7	0.5	10.1
Other	0.2	5.4	0.1	2.7	0.4	7.0
Unidentified	.6	5.9	.4	6.8	.1	5.4

Table 2(e). C_H=0.702

	TOTAL		HATCHERY		WILD	
	% volume	Freq. of occurrence	% volume	Freq. of occurrence	% volume	Freq. of occurrence
Amphipods	27.7	74.2	18.4	94.5	33.8	71.9
Euphausiids	39.0	44.8	54.7	31.0	30.9	41.5
Teleosts	21.8	16.6	8.2	32.3	27.4	11.9
Decapods	7.8	43.6	11.3	15.5	6.3	40.7
Cephalopod	1.0	1.7	1.8	2.8	0.6	0.7
Calanoids	0.6	13.3	0.5	11.3	0.7	11.9
Gastropods	0.1	0.6	0.2	1.4	0	0
Insects	0.3	1.7	0	0	0.3	2.2
Other	1.7	2.8	4.9	4.2	0.0	1.5
Unidentified	0.4	3.3	0.3	1.4	0.5	3.7

Table 2(f). C_H=0.983

	TOTAL		HATCHERY		WILD	
	% volume	Freq. Of occurrence	% volume	Freq. of occurrence	% volume	Freq. of occurrence
Amphipods	48.9	89.3	50.2	90.0	45.0	86.4
Euphausiids	30.3	46.3	29.0	44.4	33.8	49.2
Teleosts	9.4	10.7	10.8	10.0	7.4	11.9
Decapods	0.8	4.0	0.3	4.4	1.6	3.4
Cephalopod	6.3	17.4	3.9	14.4	10.4	20.3
Calanoids	1.8	10.1	2.2	13.3	1.2	5.1
Gastropods	2.1	4.0	3.1	4.4	0.5	3.4
Insects	0	0	0	0	0	0
Other	0.4	2.0	0.5	2.2	0.1	1.7
Unidentified	0.1	0.1	0	0	0.2	1.7