The complexity of juvenile Chinook salmon

Ruston Sweeting, C. Neville and R. Beamish

Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC

Ruston.Sweeting@dfo-mpo.gc.ca

Fisheries and Oceans Canada | Pêches et Océans Canada

Background

Juvenile Chinook salmon (Oncorhynchus tshawytscha) rear in freshwater for weeks to months before migrating downstream to the marine environment. In southern British Columbia, most rear in the Strait of Georgia, a semi-enclosed inland sea, for several months before migrating to the open ocean. This early period is thought to be the major determinant of total marine survival, with upwards of 60% mortality occurring in these first few weeks in salt water. Midwater trawl surveys conducted in July, 1998-2011, (Figure 1) fished at 15m strata throughout the water column, both to determine habitat usage by juvenile salmon and to observe the complexity of the whole ecosystem. Data has shown that juvenile Chinook salmon occupy a far greater depth of the water column than do other juvenile salmonids, which tend to stay in the upper 15 meters. Furthermore, average size and diet both shift with increasing depth. The objective of this paper is to determine the importance of these changes with depth to the ecology of chinook salmon in this early marine period.

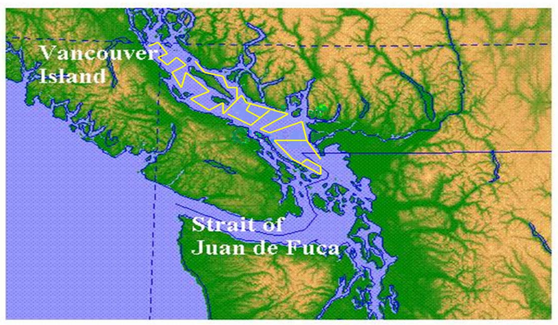

Figure 1. Southern British Columbia, showing the Strait of Georgia and the survey tracklines.

<u>A. Catch per Unit Effort (CPUE)</u>

Surface tows (0-15m) dominated the CPUE (Figure 2a), averaging 78.1 (± 11.03) over the extended time period (Figure 2b, Table 1), or about 54% of the total CPUE. The average CPUE for each 15 m strata declined about 50%, but still provide sufficient catch data (Table 1). While some general trends were consistent between strata, the overall correlations are fairly weak (Table 2). No survey was conducted in 2003. Total catch = 7287 Chinook.

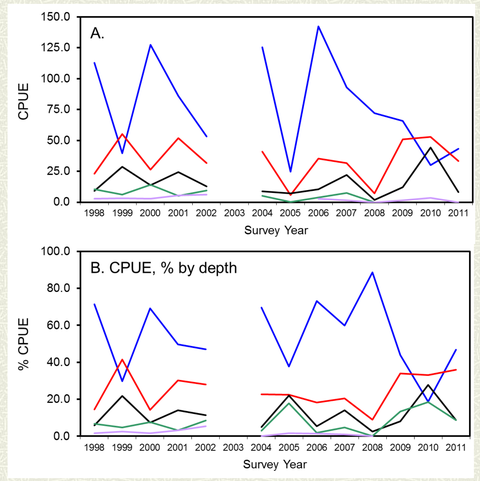

Figure 2. Catch of juvenile Chinook salmon as A. CPUE and B. % total CPUE for each 15m strata: 0-15m: blue lines, 15-30m: red lines, 30-45m: black lines, 45-60m: green lines; 60+:purple ,

	# Sets	CPUE (se)	% CPUE (se)
0-15 meters	550	78.1 (11.03)	54.2 (5.49)
15-30 meters	253	34.3 (4.50)	24.9 (2.70)
30-45 meters	166	15.6 (3.18)	11.8 (2.15)
45-60 meters	93	9.2 (2.27)	7.6 (5.82)
60+ meters	64	2.5 (0.52)	1.6 (0.40)

Table 1. Number of sets, average CPUE (se) and % CPUE, by strata over the 1998-2011 period.

	Year	0-15m	15-30m	30-45m	45-601m	60+ m
0-15m	-0.15					
15-30m	0.15	**-0.85**				
30-45m	0.05	**-0.88**	**0.57**			
45-601m	0.31	**-0.73**	0.37	**0.65**		
60+ m	**-0.48**	**-0.41**	0.27	0.38	0.17	

Table. 2. Correlation matrix of CPUE by depth 1998-2011. There were no significant correlations between CPUE and year. The CPUE for 0-15m strata was negatively correlated with deeper strata, but correlations between other strata were positive.

<u>B. Average fork length, by strata</u>

Most years demonstrated a clear increase in average size of Chinook with increasing depth (increasing blue color), with the exception of the 60+ meter strata (Figure 3. This pattern of increasing size with depth was not observed for other juvenile Pacific salmon. Histograms showed that this observed increase in average fish size with increasing depth was primarily driven by a decreasing contribution of lower mode of size range.

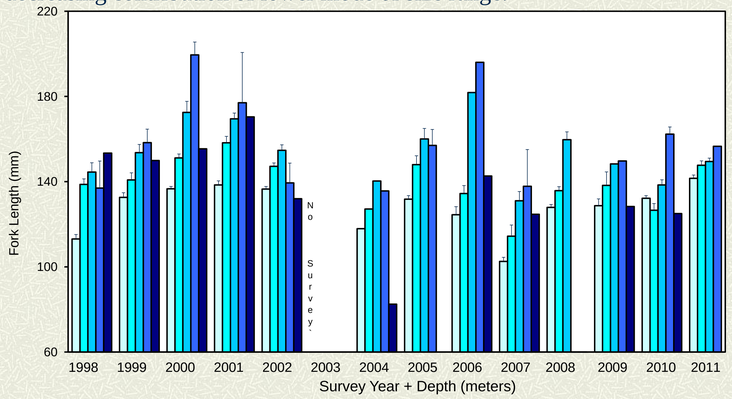

Figure 3. The average fork lengths (mm) (+SE) of juvenile Chinook salmon for each 15m strata for each July survey (1998-2011). Each increase in blue intensity is a 15m increase in depth (0,15,30,45 and 60m). Note that no survey was done in 2003. Total number of Chinook fork lengths was 7287.

<u>C. Diet breakdown, by strata</u>

The contribution of each prey group, by percent volume (Figure 4A) for juvenile Chinook salmon from July midwater trawl surveys (1998-2011) does not show any major differences with strata depth, with the exception of 60+ meters which may be an artifact of low sample size (N=22). The Fish category was primarily composed of juvenile herring (average: 56.4 ± 3.84%) and sandlance (average: 14.2 ± 3.38%). The percent occurrence of fish in Chinook diets (Figure 4B) generally increased with increasing strata depth ($R^2 = 0.96$), while the percent occurrence of decapods decreased ($R^2 = -0.92$) (Figure 4). Other diet categories showed no general trends with strata depth.

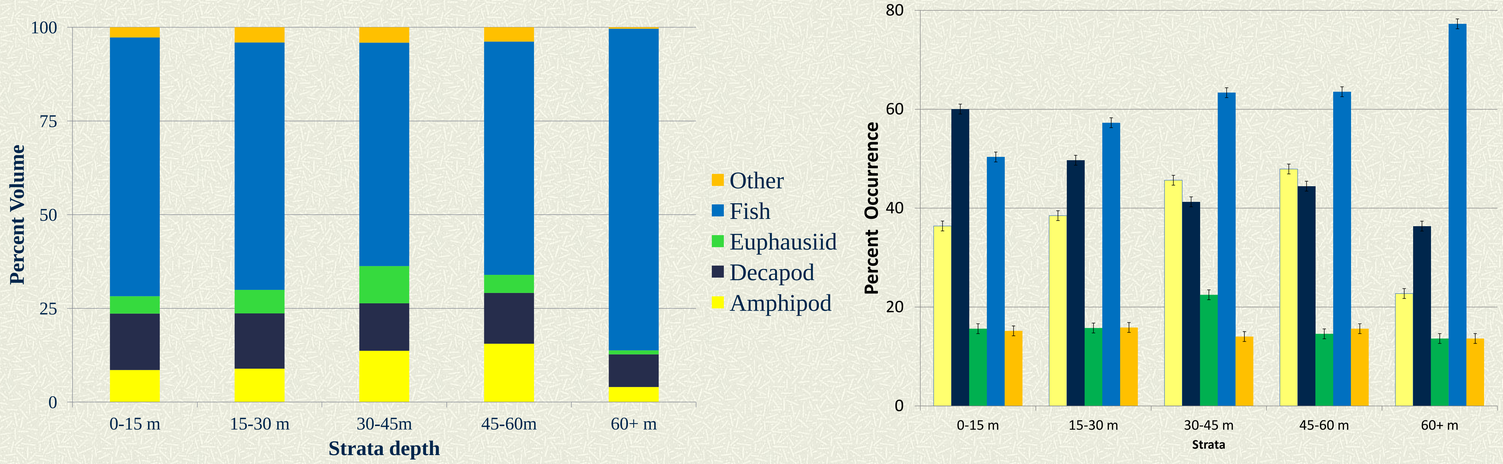

Figure 4. Shifts in juvenile Chinook salmon diet composition A. % Volume and B. % Occurrence, by strata, for July midwater trawl surveys 1998-2011 combined. Totall number of stomachs = 7287.

SUMMARY

- CPUE values consistently declined by about 50% for each step in strata depth, while the average size of the captured juvenile Chinook increased. Catch trends were not correlated between strata.
- Some authors have suggested that the catch of juvenile salmon in deeper tows is an artifact of continued fishing as the net is being retrieved. No such trends were observed with juvenile pink or chum salmon, which were in considerably greater densities than Chinook in the upper strata.
- While not shown here, the increase in average fork length with depth was driven to a great degree by the decreasing presence of the lower size mode. An early hypothesis was that this increase in size reflected an decreasing contribution of small ocean-type (underyearling) Chinook and a consequently increasing contribution of the larger stream-type (yearling) Chinook. DNA analysis, however, did not support this hypothesis.
- Fish in the Chinook diet increased in occurrence with increasing Chinook size and with strata depth. There was no concurrent increase in percent volume of fish in the diet associated with depth.
- Future DNA analysis will examine these differences at stock levels, to determine the importance of these habitat choices to both population and stock marine survival patterns.