North Pacific Anadromous Fish Commission
Technical Report No. 9: 136-138, 2013

# Density-Dependent Trophic Interactions Between Juvenile Pink *(Oncorhynchus gorbuscha)* and Chum Salmon *(O. keta)* in Coastal Marine Ecosystems of British Columbia and Southeast Alaska

**Erica S. Jenkins**[1,3], **Marc Trudel**[1,2], **John F. Dower**[1], **Rana W. El-Sabaawi**[1], and **Asit Mazumder**[1]

[1]*Department of Biology, University of Victoria, P.O. Box 1700, STN CSC, Victoria, BC V8W 2Y2, Canada*
[2]*Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, BC V9T 6N7, Canada*
[3]*Present address: Pacific Salmon Commission, 600 - 1155 Robson Street, Vancouver, BC V6E 1B5, Canada*

**Keywords:** juvenile pink salmon, juvenile chum salmon, stable isotope analysis, density, dietary niche, trophic position

Pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) are the two most abundant salmon species in the North Pacific. After emerging from the freshwater environment, juvenile pink and chum salmon enter the coastal marine environment of the North Pacific Ocean, where their numbers are further augmented by the release of billions of fry from hatcheries (Ruggerone et al. 2010). It is unclear the degree to which the trophic niches of these two species overlap during their early marine life, and how trophic interactions might change according to conditions in the coastal marine environment, such as temperature, density of juvenile salmon, and prey abundance.

Stable isotope analysis is an excellent tool for studying the feeding ecology of a population because isotopes offer a robust approximation of niche characteristics, such as food source and trophic level (Peterson and Fry 1987). Stable isotopes of carbon ($\delta^{13}C$) reflect the source of production (Post 2002), while the trophic position of a consumer can be inferred from stable isotopes of nitrogen ($\delta^{15}N$; Peterson and Fry 1987).

The purpose of this study was to determine the degree to which the dietary niches of juvenile pink and chum salmon overlap, and how this is affected by temperature, juvenile salmon abundance, and the availability of prey resources. Because increased competition would result in fewer prey choices for juvenile salmon, we expected that the trophic niche (based on $\delta^{15}N$ and $\delta^{13}C$) of juvenile pink and chum would overlap more when the abundance of juvenile salmon is high and the abundance of zooplankton is low.

**Table 1.** Mean trophic position (based on $\delta^{15}N$) , $\delta^{13}C$ (lipid and trophic corrected), and length (mm) of juvenile pink salmon and chum salmon in the Alaska Coastal Current (ACC/northern region) and the Transition Domain (TD/southern region) in 2000/2001 (cooler years) and 2004/2005 (warmer years).

| Year | Region | Species | $\delta^{13}C$ | SD | Trophic Position | SD | Length (mm) | SD |
|---|---|---|---|---|---|---|---|---|
| 2000 | ACC | chum | -19.57 | 0.58 | 2.62 | 0.15 | 217.0 | 18.0 |
| | | pink | -19.41 | 0.27 | 2.47 | 0.10 | 238.3 | 23.2 |
| | TD | chum | -19.09 | 0.58 | 2.93 | 0.14 | 221.0 | 16.3 |
| | | pink | -19.43 | 0.56 | 2.83 | 0.13 | 210.7 | 15.8 |
| 2001 | ACC | chum | -18.77 | 0.41 | 2.48 | 0.16 | 217.6 | 19.5 |
| | | pink | -18.62 | 0.39 | 2.39 | 0.13 | 218.0 | 26.7 |
| | TD | chum | -18.89 | 0.59 | 2.73 | 0.16 | 211.6 | 20.1 |
| | | pink | -19.09 | 0.63 | 2.60 | 0.22 | 198.3 | 16.9 |
| 2004 | ACC | chum | -19.89 | 0.49 | 2.59 | 0.20 | 227.8 | 8.1 |
| | | pink | -18.80 | 0.51 | 2.57 | 0.13 | 242.1 | 19.6 |
| | TD | chum | -19.03 | 0.55 | 2.98 | 0.09 | 218.6 | 16.4 |
| | | pink | -18.88 | 0.36 | 2.89 | 0.06 | 215.3 | 11.3 |
| 2005 | ACC | chum | -18.68 | 0.51 | 2.55 | 0.10 | 222.8 | 12.8 |
| | | pink | -19.12 | 0.36 | 2.59 | 0.10 | 233.9 | 25.7 |
| | TD | chum | -19.09 | 0.57 | 2.80 | 0.17 | 236.9 | 14.8 |
| | | pink | -18.51 | 0.43 | 2.60 | 0.14 | 218.2 | 32.0 |

All correspondence should be addressed to E. Jenkins.
e-mail: ericasjenkins@gmail.com

The study area for this research extended northward from the northern tip of Vancouver Island to the southern end of Southeast Alaska. This area represents the southern portion of the downwelling domain of the Alaska Coastal Current (ACC) and also the transitional domain (TD) between the ACC and the upwelling domain of the California Current system (Ware and McFarlane 1989). Juvenile salmon were collected in the fall of 2000, 2001, 2004, and 2005. The average sea surface temperatures in the study area in the months leading up to the sampling time were relatively cool in 2000 and 2001 and relatively warm in 2004 and 2005. Due to the dominance of odd-year spawners in the Fraser River, we expected that a greater abundance of juvenile pink salmon would be entering the Strait of Georgia and migrating northward (and into the study area) in 2000 and 2004. By selecting warmer and cooler years we intended to cover a range of feeding conditions, and by selecting odd- and even-numbered years we hoped to observe a range of salmon densities.

Juvenile salmon and zooplankton were collected in October and November; zooplankton density was used to indicate prey availability and as an isotopic baseline signature to estimate the trophic position of juvenile salmon (Post 2002). The CPUE for both species combined was used as an indicator of the overall juvenile salmon density. Similarities between the isotopic compositions (i.e. dietary niches) of juvenile pink and chum salmon were calculated using Euclidean distance. Regression analyses were performed to explore the relationships between the Euclidian distance and CPUE, zooplankton density, SST, and differences in species' mean lengths.

**Table 2.** Similarity of isotopic composition of juvenile pink and chum salmon as measured by Euclidean distance (‰) and calculated using the baseline corrected $\delta^{15}N$ and trophic corrected $\delta^{13}C$. Smaller distance indicates greater niche overlap. Difference in the mean lengths between species of juvenile salmon, catch per unit effort (for both species combined), and the mean density of zooplankton (g*1000 $m^{-3}$ dry weight) provide information on habitat conditions. ACC: Alaska Coastal Current; TD: transition domain.

| Year | Region | Euclidean distance (‰) | Difference in mean length between species (mm) | CPUE (both species combined) | Zooplankton density (g*1000 $m^{-3}$) |
|---|---|---|---|---|---|
| 2000 | ACC | 0.53 | 21.3 | 13.9 | 1.6 |
| | TD | 0.46 | 10.3 | 53.2 | 1.5 |
| 2001 | ACC | 0.33 | 0.4 | 15.5 | 2.1 |
| | TD | 0.48 | 13.2 | 10.7 | 1.4 |
| 2004 | ACC | 1.09 | 14.3 | 1.1 | 2.4 |
| | TD | 0.36 | 3.3 | 25.3 | 0.7 |
| 2005 | ACC | 0.47 | 11.1 | 10.8 | 1.3 |
| | TD | 0.89 | 18.7 | 5.9 | 2.1 |

The combined trophic position and $\delta^{13}C$ of salmon showed that the trophic niches of juvenile pink and chum tend to overlap, though the degree of overlap varied significantly (Table 1). We expected that the niches of juvenile pink and chum would overlap more when salmon abundance was high and prey availability was low (Table 2). This hypothesis was supported by our results as the distance between their niches decreased with increasing $\log_e$ CPUE ($R^2 = 0.73$, $p = 0.007$) and was positively correlated with zooplankton density ($R^2 = 0.51$, $p = 0.05$). The isotopic niche difference did not appear to be simply the result of a size difference between the two species as this was not significantly correlated with the degree of niche overlap ($R^2 = 0.34$, $p = 0.13$). Nor was there a significant relationship between mean Euclidean distance and mean sea surface temperature ($R^2 = 0.25$, $p = 0.21$). It appeared that when competition was greater for fewer prey items, both species became less selective and incorporated a wider range of prey items into their diets; thus creating more dietary overlap between them.

Although trophic interactions between juvenile pink and chum varied among years, their niches seemed to remain similar to each other, and they most likely competed for the same resources and were affected similarly by changing ocean conditions. In conclusion, the dynamic niche shifts for the two species suggest that they are capable of modifying their diet to compete within and among salmon species for available resources, and that the greater numbers of juvenile pink and chum salmon in the coastal marine environment due to hatchery stocking may thus increase competition for prey resources.

## REFERENCES

Peterson, B.J., and B. Fry. 1987. Stable isotopes in ecosystem studies. Annu. Rev. Ecol. Syst. 18: 293–320.
Post, D.M. 2002. Using stable isotopes to estimate trophic position: models, methods, and assumptions. Ecology 83: 703-718.
Ruggerone, G.T., R.M. Peterman, B. Dorner, and K.W. Myers. 2010. Magnitude and trends in abundance of hatchery and wild pink salmon, chum salmon, and sockeye salmon in the North Pacific Ocean. Mar. Coast. Fish. 2: 306-328.
Ware, D.M., and G.A. McFarlane. 1989. Fisheries production domains in the Northeast Pacific Ocean. *In* Effects of ocean variability on recruitment and an evaluation of parameters used in stock assessment models. *Edited by* R. J. Beamish and G.A. McFarlane. Can. Sp. Pub. Fish. Aquat. Sci. No. 108: 359-379.