Early Marine Residence of Juvenile Pink and Chum Salmon in the Northern California Current: Life at the Southern End of the Range

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Juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon have been regularly captured in the northern California Current (NCC) off of Washington and Oregon in ecological studies focused on the dominant salmon species in the region, juvenile Chinook (*O. tshawytscha*) and coho (*O. kisutch*) salmon. The NCC area represents the southern end of the species range for pink and chum salmon in North America, which occurs on the central Oregon Coast (45°N) for chum salmon (Salo 1991; ODFW 2005), and in Puget Sound (47°N) for pink salmon (Heard 1991). Here, we provide an overview of the marine ecology of juvenile pink and chum salmon in the NCC: their seasonal, interannual, and latitudinal distributions and abundances, and their seasonal size and growth. Our results come from two studies spanning three decades (1981-2011), a period characterized by variable ocean productivity.

The first study was conducted by Oregon State University (OSU) during 1981-1985 (hereafter referred to as the "1980s"; see Pearcy and Fisher 1990, Pearcy 1992), and the second was initiated by NOAA Fisheries and OSU in 1998 and continues to the present (referred to as the "2000s"; see Fisher et al. 2007). Both studies sampled common east-west transects from Cape Flattery, Washington (48°N), to Newport, Oregon (45°N; Fig. 1), during three months (May, June, September) following a similar methodology. However, the studies used fundamentally different types of nets (purse seine vs. rope trawl) to collect juvenile salmon. Because these nets undoubtedly had different (but unknown) efficiencies for catching juvenile salmon, we compared patterns of abundance rather than actual abundances. To explore latitudinal variation in distributions, we also used additional sampling south to Cape Blanco, Oregon (43°N), in the 1980s (Pearcy and Fisher 1990) and to the Oregon/California border (42°N) during two years in the 2000s (Pool et al. 2011).

Juvenile pink and chum salmon were minor members of the juvenile salmon communities during both time periods, contributing an average relative abundance of 4% and 8%, respectively (Table 1). Although there was considerable variation in this community between the two periods (more coho salmon in the 1980s and more Chinook salmon in the 2000s), neither pink nor chum salmon ever became as abundant as the two dominant species.

Perhaps the most striking difference between pink and chum salmon in the NCC was their spatial and temporal distributions, which were generally consistent between the two time periods. On a seasonal basis, very few pink salmon were caught in

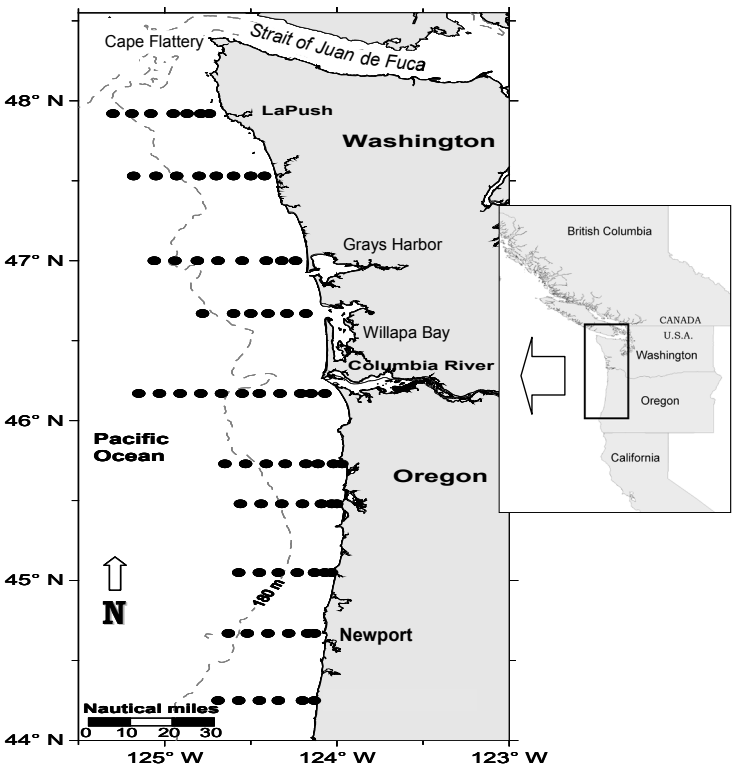

Fig. 1. Location of sampling transects and stations used in the 2000s by the Columbia River Plume Study. Most transects were also used during the 1980s by the Oregon State University Study.

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Table 1. Relative abundance (%) of juvenile salmon species caught in the northern California Current (NCC) by month and study period. The 1980s refer to the study by Oregon State University conducted during 1981-1985 and the 2000s refer to the Columbia River Plume Study conducted during 1998-2011.

	1980s			2000s		
Species	May	June	September	May	June	September
Chum	4.6	3.8	9.9	9.3	18.6	2.8
Pink	<0.1	<0.1	10.5	<0.1	<0.1	12.4
Chinook	27.2	19.3	22.7	35.4	35.7	74.3
Coho	62.4	74.0	56.8	43.6	42.2	10.5
Sockeye	3.3	0.9	0.1	4.1	2.8	<0.1
Steelhead	2.5	2.0	0	7.4	0.2	<0.1

either May or June, and abundances were high in September (Fig. 2). By contrast, chum had relatively high abundances in May and June, which either remained high in September (1980s) or decreased to low levels (2000s). Latitudinal variation in catches was equally distinct (Fig. 2): in May and June chum salmon were distributed across four degrees of latitude (44-48°N), with higher abundances north of the Columbia River (46°N) at a time when pink salmon were largely absent. By September, however, both pink and chum salmon were restricted to the northern portion of the study area (47-48°N; Fig. 2). Taken together, these patterns likely reflect geographic differences in source populations and migratory behavior. Chum salmon populations exist in most river basins along the Washington and northern Oregon coasts (Phinney and Bucknell 1975, ODWF 2005), and juveniles appear to occupy coastal marine habitats early in the summer, but have largely dispersed or moved northwards by late summer. By contrast, there are no known pink salmon populations on the Washington and Oregon coasts, although large populations (millions of spawners) exist in Puget Sound and the Strait of Georgia, including the Fraser River (PFMC 2011, PSC 2011). Juvenile pink salmon in our study likely originated from these large populations and were caught as they exited the Strait of Juan de Fuca.

There was also large interannual variation in the abundances of both pink and chum salmon, with annual monthly abundances varying by an order of magnitude among years (Fig. 3). In the 2000s chum salmon catches in May and June were particularly high (> 3 fish/km^2) in 2001, 2003 and 2006-2009, and were unusually high in September 2006. There were large peaks in the abundance of pink salmon in 2006 and 2008. However, these abundance peaks had little correspondence with adult abundances in likely source populations (i.e., Willapa Bay and Grays Harbor for chum salmon [PSC 2011, WDFW 2011], Fraser River for pink salmon [PFMC 2011]) in either the previous year (the parent generation) or 1 year (pink) or 2-4 years (chum) later when juveniles would return as adults. Lack of correspondence in pink salmon abundance is likely due to essentially random movement of fish into the study area from the Strait of Juan de Fuca. Lack of consistency between chum salmon juvenile and adult abundances is less clear; better information on actual source populations, eggs to smolt survival rates, and adult age structure would help resolve this issue.

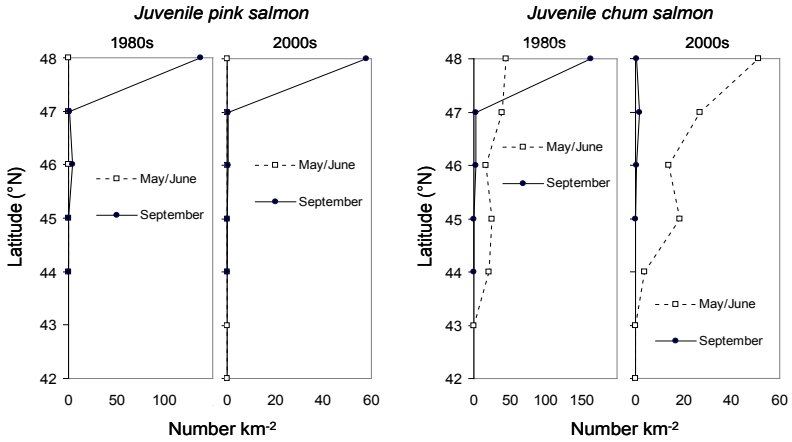

Fig. 2. Juvenile salmon densities by latitude for pink salmon (left) and chum salmon (right) in the 1980s and 2000s by month (May/June, September).

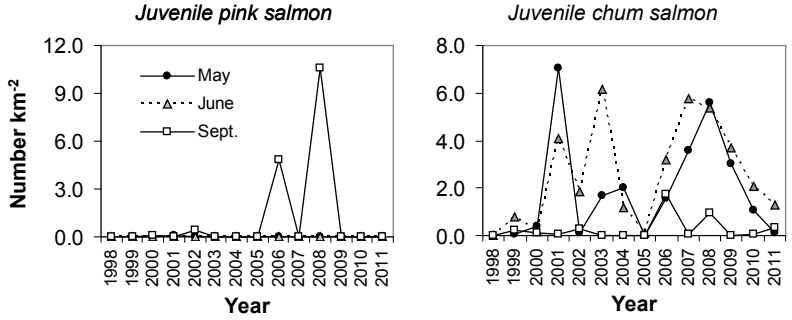

Fig. 3. Mean density of juvenile pink (left) and chum (right) salmon by month and year during the 2000s.

While seasonal and latitudinal abundance patterns were consistent over the three-decade time span, the size of fish was not. Chum salmon in both time periods rapidly increased in size over the summer, however, in the 1980s juvenile pink and chum salmon were 14-19% longer than fish caught in the 2000s (Fig. 4). These differences were statistically significant ($p < 0.05$), except for chum salmon caught in September. Furthermore, visual (but not statistical) comparisons of the size of juvenile pink and chum salmon caught in regions where they are abundant, such as Southeast Alaska and Strait of Georgia, suggest that NCC pink salmon caught in September in the 2000s were somewhat smaller than in these other regions, and NCC chum salmon caught in the 1980s appear to be larger than in these other regions (Fig. 4). The reason(s) for these size differences, if they truly exist, is presently unknown.

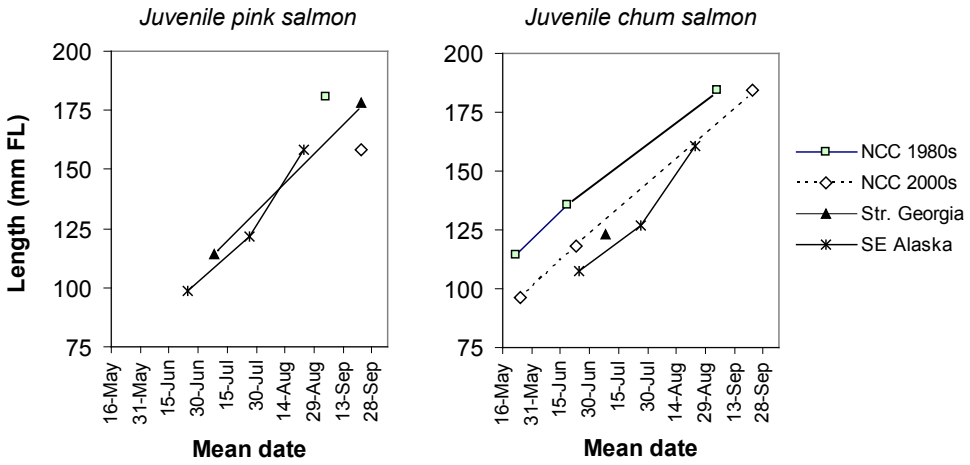

Fig. 4. Mean length (mm FL) of juvenile pink (left) and chum salmon (right) by mean date of capture in the northern California Current (NCC) during 1980s and 2000s compared to the mean size of juvenile pink and chum salmon reported from the Strait of Georgia and Southeast Alaska. (Strait of Georgia data source: Sweeting et al. 2004, Beamish et al. 2010; Southeast Alaska data source: Orsi et al. 2005, 2006, 2007a, 2008, 2009, 2010.)

Juvenile pink and chum salmon at the southern end of the species range in North America experience marine conditions that are quite different from those experienced by fish in northern British Columbia or Alaska. Compared to these regions, pink and chum salmon in the NCC experience warmer and more saline waters, and they are a minor—rather than major—component of the epipelagic fish community (Fisher et al. 2007, Orsi et al. 2007b). Given recent concerns about the competitive interactions between juvenile pink salmon and other salmon species (Ruggerone and Nielsen 2004, Beamish et al. 2010), the NCC provides a unique opportunity to study chum salmon for much of the summer in the absence of pink salmon. Further understanding of the ocean ecology of juvenile pink and chum salmon in the NCC and comparisons to the same species in northern regions should yield valuable information about the ability of these species to adapt to diverse environments; how these environments, in turn, influence survival; and the factors that limit their southern distribution.

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