A Synthesis of Research on Early Marine Ecology of Juvenile Pacific Salmon in Southeast Alaska

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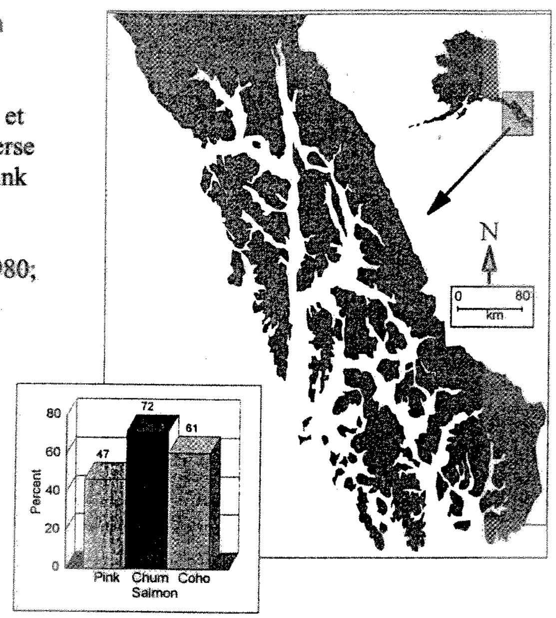
Southeast Alaska, with over 2000 productive salmon rivers, is one of the State's most productive areas for Pacific salmon, accounting for 47%, 61%, and 72% respectively of Alaska's pink, coho, and chum salmon catch (Fig. 1) along with significant numbers of sockeye and chinook salmon in recent years. This productivity is due, in part, to pristine habitats, favorable environments, abundant foods during early sea life, and good management. Significant research has focused on early marine ecology of salmon to better understand behavior, survival, and carrying capacity of this region.

Fig.1. Percentage of statewide commercial harvest of pink, chum, and coho salmon caught in southeast Alaska, 1995–1999.



Most juvenile salmon originate from inner islands and mainland streams and migrate through complex, interconnecting waterways and diverse marine habitats to reach the Gulf of Alaska (GOA). Upon marine entry (March to early June) pink and chum salmon occupy nearshore, littoral habitats, and were captured using dip nets, beach seines, and small traps (Bailey et al. 1975; Orsi and Landingham 1985; Mortensen and Wertheimer 1988; Celewycz et al. 1994; Mortensen et al. 2000). Complex shorelines offer diverse littoral habitats that are utilized differently by young salmon. Pink and chum salmon juveniles actively migrate along long straight, smooth, "transition" beaches whereas they mill about and feed along more protected "nursery" beaches (Bailey and Mattson 1980; Jaenicke et al. 1985), while larger smolt species (sockeye, coho, and chinook salmon) move more readily from littoral areas into open water.

From late May to July juveniles move away from nearshore areas, and all five species occupy open-water habitats sympatrically where they were captured with round haul seines (Martin 1964), two-boat trawls (Mortensen et al. 2000), table and drum purse seines (Jaenicke and Celewycz 1994), small hooks and lures (Orsi 1987; Orsi et al. 1987), and epi-pelagic Nordic trawls that are now used in the Southeast Alaska Coastal Monitoring (SECM) Study (Orsi et al. 1997; Murphy et al. 1999).

Occurrence and distribution studies of age-.0 juveniles from regional stocks generally find pink, chum, sockeye, and coho salmon spending an average of 3–4 mo in Southeast Alaska waters before reaching GOA, although some stay as long as 6 mo. Along the outer coast juveniles from southeast intermingle with more southerly stocks migrating northward, generally following the continental shelf. Juvenile chinook salmon from Southeast Alaska and to some extent more southerly stocks are present for 8 mo (June–December) as age-.0 fish in inside and outside waters. Some reside year round as prerecruits (age-.1 and -.2 fish), exhibiting seasonal size and depth preference patterns (Fig. 2) before reaching legal size in regional fisheries (Orsi and Jaenicke 1996).

Trophic relationships among juvenile salmon vary among species, other cohorts, and life history stages. Pink and chum salmon in littoral areas feed mostly on planktonic zooplankton and epibenthic harpacticoids depending on seasonal timing and habitats (Bailey et al. 1975; Celewycz and Cordell 1988; Landingham and Mothershead 1988). In open waters, along with sockeye salmon they feed on a larger variety of prey including many neustonic and planktonic taxa (Landingham et al.1998). Juvenile coho and chinook salmon eat some invertebrate prey but feed mostly on fishes. As visual predators with highly plastic diets juveniles eat a limited subset of prey based on size and visibility and not necessarily on local abundance (Landingham et al. 1998). Therefore, quantifying and understanding intra- or inter-specific interactions for food or space between juvenile salmon or sympatric cohorts is

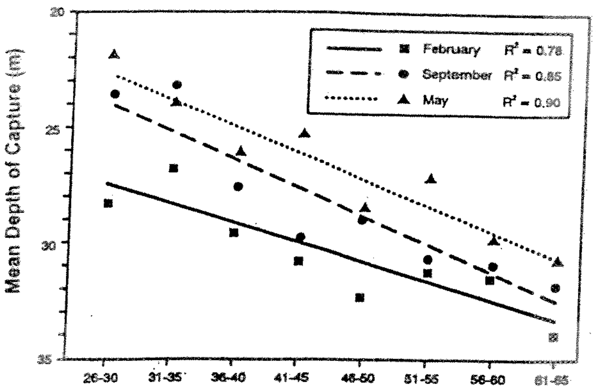


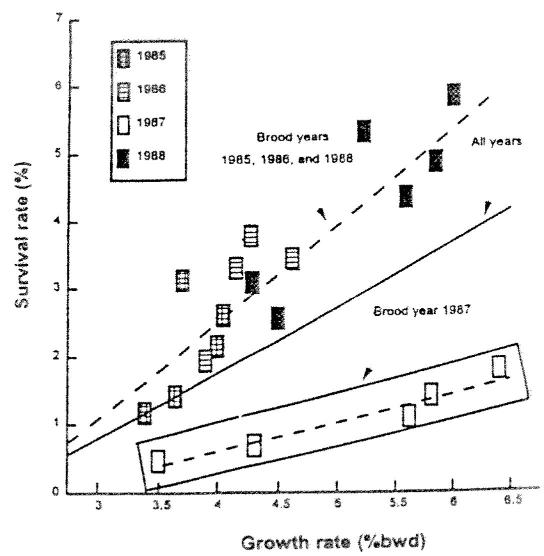
Fig.2. Seasonal depth occurrence and size related behavior patterns in juvenile chinook salmon in southeast Alaska (from Orsi and Wertheimer 1995).

a difficult task. However, with concerns over hatchery-wild stock interactions (Heard 1998), carrying capacity, and perturbations in marine environments, fishery science has no choice but to carefully examine these complex issues.

Predation on juveniles during early sea life may cause significant mortality and influence year class survival. Predators in inshore waters of southeast Alaska can include Dolly Varden (*Salvelinus malma*), flatfishes, sculpins, herring, smelts, greenlings, and other salmon (Celewycz et al.1994; Mortensen et al. 2000). One study of 188 Dolly Varden stomachs from an estuary near a salmon stream found juvenile salmon remains in only four stomachs (Lagler and Wright 1962). SECM examined 661 stomachs from 19 potential predator species and found juvenile salmon in only four species; age 1+ sablefish (*Anoplopoma fimbria*), adult coho salmon, adult Pacific sandfish (*Trichodon trichodon*), and adult spiny dogfish (*Squalus acanthias*). Although walleye pollock (*Theragra chalcogrammus*) are also considered potential predators, SECM examined 138 pollock over three years and found no salmon in their stomachs (Orsi et al. 2000).

Rapid growth of juvenile salmon is important in reducing size-selective mortality from predators. Growth, in turn, depends on timing of juveniles leaving streams, temperatures, seasonal plankton blooms, and presence or absence of sympatric cohorts. Survival can vary in juveniles from early and late spawners in the same stream (Taylor 1980). Mortensen et al. (2000) studied timing of pink fry leaving a stream, early marine growth in the estuary, and survival to adults with four broods differentially tagged at weekly intervals. Significant correlations between early growth and survival, in all years, showed higher growth resulted in higher survival (Fig. 3). This study demonstrated that high initial growth reduces mortality from predation although intensity of predation varies across years. While annual survival may often be similar for regional groups of stocks, it can also vary significantly between stocks in close geographic proximity (Heard 1979; Sturdevant and Landingham 1993).

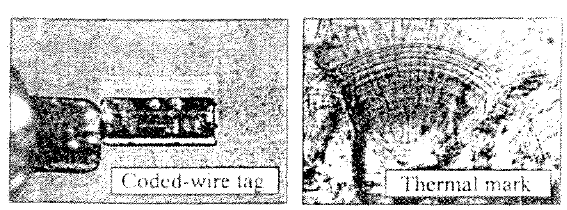
Fig.3. Interannual survival to mature adult life stage in four broods of Auke Creek pink salmon fry marked differentially at weekly intervals plotted against instantaneous growth rates as juveniles (from Mortensen et al. 2000).



Through the use of code-wire tags and thermally-induced otolith marks (Fig. 4), researchers are beginning to understand some of the seaward migration patterns and other stock-specific life history characteristics of juvenile salmon (Orsi and Jaenicke 1996; Murphy et al.1999; Courtney et al. 2000; Orsi et al. 2000). Why does a certain stock have a particular migration and timing pattern to reach the open sea? Is the chosen route related to available foods, to temperature, to salinity patterns, or predation pressures? Is the migration route genetically controlled? Do the same stocks always use the same migration pathway, and do adults retrace in reverse order the route they took as juveniles? Do adjacent hatchery and wild stocks co-occur, interact, and migrate together?

These and similar complex issues can only be answered through long-term research commitments. Since the 1960s studies in this region have produced over 60 reports on the early sea-life ecology of salmon. While many specific details have been learned, some research has been sporadic and not comprehensive due to funding limitations. A comprehensive focus on early marine-life behavior, survival and variability in year-class strength, carrying capacity, and some understanding of hatchery-wild stock interactions at sea will require a committed deployment of long-term programs to study fish populations, food resources, environmental, and oceanographic parameters.

Fig.4. Recaptures of marked juvenile salmon provide critical information for determining stock-specific migration and behavior patterns.



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