Ecological Processes Influencing Mortality of Juvenile Pink Salmon (*Oncorhynchus gorbuscha*) in Prince William Sound, Alaska

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This component of the Sound Ecosystem Assessment (SEA) program focused on improving our understanding of the mechanisms regulating survival of juvenile pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound (PWS), Alaska. Our approach involved field studies and development of a mechanistic numerical foraging-physiology model of the predator-prey interactions regulating juvenile salmon mortality. The model was used as a tool to integrate our knowledge of system function and examine processes that could not be directly observed. Field studies were directed at (1) identifying the predator taxonomic groups that accounted for the greatest predation losses of salmon, (2) validating our foraging-physiology model, and (3) testing our hypotheses related to mortality processes. Field sampling was conducted from May through June at 16–25 sites each year, 1994–1997. The following parameters were estimated at each site: (1) juvenile salmon relative abundance, (2) juvenile salmon diet composition, (3) juvenile salmon growth rate, (4) predator relative abundance, (5) predator species and size composition, (6) predator diet composition, (7) surface-layer macrozooplankton density and composition, (8) surface-layer ocean temperature, and (9) ambient light intensity. Multiple coded-wire tagged (CWT) groups of juvenile salmon released from four hatcheries bordering PWS proved to be an invaluable tool for examining mortality processes both in the field and through numerical modelling.

Approximately 726 million juvenile pink salmon entered PWS from bordering streams and hatcheries each year. Predation during the spring plankton bloom accounted for the mortality of approximately 413 million juveniles (57%) and therefore appeared to be the primary mechanism causing mortality during this life stage. Two facultative planktivores, herring (*Clupea pallasi*) and walleye pollock (*Theragra chalcogramma*) consumed the greatest numbers of juvenile salmon. Several piscivorous fish (*Gadus macrocephalus, Microgadus proximus*, and *Salvelinus malma*) consumed the second greatest numbers and an assemblage of nearshore demersal fishes (Cottidae, Hexagrammidae, and *Sebastes spp.),* and seabirds (*Rissa tridactyla, Larus spp.*) consumed the smallest numbers of salmon. Numerical modelling demonstrated that a relatively small subset of trophic elements of the system were needed to predict patterns of survival of CWT groups by release date. In our study, these elements were the densities and sizes of juvenile salmon and their predators, and six key zooplankton taxonomic groups. The predictive capability of the model was dependent on model time scales on the order of one day, tracking growth and mortality of multiple CWT groups, and modelling the dispersion and spatial overlap of multiple CWT groups. Interactions within the simulated predator and prey complex determined predation losses of salmon and no single variable could consistently predict survival. Our field results indicated that the copepod *Neocalanus* played a unique role in modifying predation losses of juvenile pink salmon in PWS. Reduced large copepod densities caused (1) reduced growth when juvenile salmon densities were high, (2) greater predation losses to facultative planktivorous fish as these predators switched to alternative prey including salmon, and (3) dispersion of foraging juvenile salmon offshore where they suffered greater predation losses to piscivorous and demersal fishes. Thus, bottom-up processes affecting the spring *Neocalanus* bloom influenced juvenile salmon growth rates and foraging behavior, but also modified top-down processes through size-selective predation on juvenile salmon and by altering the timing of a shift from planktivory toward piscivory among major predators on juvenile salmon.

Future research in this area should focus on further developing and validating numerical models of predator-prey interactions. Field sampling programs should measure parameters needed as model inputs and for model validation. Tagging of multiple groups of salmon entering the system at various times during the spring bloom will be an essential tool needed to understand system function.