

Workshop Review

In 2000 the North Pacific Anadromous Fish Commission (NPAFC) adopted a five-year (2001-2005) science plan that focused cooperative research efforts on major gaps in our understanding of the marine life history of salmon with respect to marine ecosystem processes that affect the abundance and biomass of anadromous stocks. The science plan emphasized in three areas: 1) Bering Sea salmon research, 2) juvenile salmon research in eastern and western North Pacific waters, and 3) winter salmon research. In order to increase our understanding of determination of population sizes and our ability to forecast stock sizes, the science plan addressed juvenile salmon research on seasonal distribution and migration, population size and survival estimates, trophic linkages and growth changes, and primary production and salmon food resources. A purpose of the present workshop was to review juvenile salmon research during 2001-2005 for developing new research strategies.

At the Session 1, “National Overviews” were presented by representative scientists. In Canada, juvenile salmon studies are focused in the Strait of Georgia and off the west coast to examine the relationship between climate and marine survival trends, bioenergetics, coastal migration, and food web dynamics. Korean study has focused on early growth and mortality of juvenile chum salmon in rivers. Russia has a long-term monitoring program by trawl surveys in the Okhotsk Sea, northwestern Japan Sea and western Bering Sea to examine the distribution, abundance and feeding habit of juvenile salmon, quantitative abundance of prey organisms, and ocean carrying capacity. Juvenile salmon research in the United States occurs in the wide coastal areas of Alaska, Washington, Oregon, and California to understand how the marine environment influences the migration, distribution, growth and survival of juvenile salmon during their early marine experience. Japanese marine research for juvenile salmon has been conducted in the coastal waters and the Okhotsk Sea to examine their distribution and survival using otolith and genetic marks.

At the Session 2, “Seasonal Distribution and Migration of Juvenile Salmon” was highlighted. In the west coast of North America, a permanent continental-scale tracking array has been developed for acoustically tagged juvenile salmon. This new system demonstrated striking differences in marine migration pathways and survival even between different populations of species, as well as between species. Juvenile salmon research along the eastern Bering Sea shelf also showed that the distribution of juvenile salmon varied among species. Juvenile coho, chinook and chum salmon were distributed near shore in significantly less saline water than the surrounding habitat. Juvenile pink salmon were distributed offshore during even years, but they inhabited also near shore during odd years maybe because of dominance of the even year adult pink salmon returning to western Alaska. Several papers have emphasized that the Okhotsk Sea and western Bering Sea are major habitat for Asian juvenile salmon during summer and fall. In the Aniva Bay of southern Sakhalin, juvenile pink salmon dwelled in coastal zone for 0.8-2.5 months, and their off-shore migration occurred simultaneously, possibly related with sea surface temperature (SST) increase. Japanese surveys in the coastal water of the Okhotsk Sea also indicated that the distribution of juvenile chum salmon was affected by SST. In the Okhotsk Sea and western Bering Sea, the distribution and migration of juvenile chum salmon were influenced by the abundance of large zooplankton, which were the major component of their diet. When water temperature decreased in late fall, Asian juvenile chum salmon left their foraging habitats for the western North Pacific. In winter they were distributed in a narrow range of lower temperature: the estimated temperature at the center of salmon distribution was 4.7°C in the western North Pacific, and 6.1°C in the eastern North Pacific. Chum salmon inhabited cooler waters, maybe because the abundance of prey zooplankton increased with decreasing water temperature in the western North Pacific.

The topic of Session 3 was “Trophic Linkages, Feeding and Growth of Juvenile Salmon”. Juvenile pollock, sand lance, and capelin were dominant in the diets of juvenile salmon in the eastern Bering Sea shelf and northern Okhotsk Sea. Consumption demand on prey resources by juvenile pink salmon in the coastal Gulf of Alaska varied spatially across oceanic habitats, and the growth potential metric holds promise in its ability to explain variability in the marine survival of pink salmon. In the Okhotsk Sea coast of Hokkaido, cool ocean conditions might affect the growth and survival of juvenile chum salmon. Russian scientists assessed seasonal amounts of food consumed by juvenile salmon in the western Bering Sea during the fall. Juvenile salmon utilized 112-154 thousand tons of different zooplankton and nektons, while other major fish species have consumed 6.4-8.9 million tons of food animals.

The Session 4 dealt with “Climate Changes and Ocean Ecosystem”. Climate variability, fishing, carrying capacity, and nutrients are important forces driving the growth and survival during the early life stages of salmon

in the ocean. The stable isotope analysis indicated significant inter-annual variability in diet overlaps and trophic interactions among salmon species, and trophic shifts within each of the species as a function of body size. It would be fundamentally important to develop comparative food web modeling of salmon in Eastern versus Western Bering Sea, because there are major diet differences. In the Okhotsk Sea, the growth of juvenile chum salmon increased in the 1990s, in association with increase in the SST during summer and fall, and decrease in the sea ice concentration. Thus their survival and growth in the Okhotsk Sea may be affected by climate changes such as the global warming.

“Population Size and Survival Estimates of Juvenile Salmon” was adopted at the Session 5. Marine survival of salmon is related to size and growth rate during juvenile and subsequent life stages. Juvenile pink salmon in Prince William Sound and the coastal Gulf of Alaska exhibited a 3-fold difference in marine survival during 2001–2004. High survival was associated with broader spatial distribution, greater feeding rates, faster growth and larger size during the first summer of ocean feeding. Significant size selective mortality occurred after the summer growing season. An opposite phenomenon was observed by Japanese scientists. In the coast of Nemuro Strait, eastern Hokkaido, 2000 brood year chum salmon juveniles had much higher growth rates than other brood years due to high prey production, but their adult return was the least abundant. Winter is generally considered to be a critical period in the early life of salmon. Size-selective mortality was apparent for juvenile chinook salmon in southeast Alaska. Size-selective mortality may regulate the dynamics of salmon at northern latitudes, but not at southern latitudes. Larger salmon utilized a larger fraction of their energy reserves over winter than smaller salmon.

At the final panel session, four questions were raised: 1) Why juvenile salmon inhabit in the continental shelf of the Bering Sea and Gulf of Alaska or the open water of the Okhotsk Sea during summer/fall? 2) Where, When, and How does mortality occur on juvenile salmon in the oceans? 3) What causes the fluctuations in marine survivals of juvenile salmon? 4) Future juvenile salmon research? In at least some species of anadromous stocks (e.g. pink and chum salmon), variation in adult returns may depend more on marine survival than on reproductive efficiency during the freshwater period. A common hypothesis is that the initial period of after migration to sea is the most critical phase with respect to ocean survival of anadromous stocks. Many papers have suggested considerable interannual variation in abundance, growth, and survival rates of juvenile salmon in the ocean. These variations may be related to climate-induced changes in habitat environments that operate at regional and local scales. To a greater or lesser extent, these processes are monitored annually in marine survey areas along the coasts of Asia and North America. A better understanding of these processes is needed for conservation and management of anadromous stocks. Future cooperative research may focus on 1) seasonal distribution and migration route/timing of juvenile salmon; 2) hydrological characteristics, primary production, and prey resources in the habitats; 3) trophic linkages, growth rates and predation rates of juvenile salmon; and 4) population size, survival rate and survival mechanism of juvenile salmon.

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