Workshop Wrap-Up Comments by William Heard:

I think it is only fitting to start this wrap-up session by first extending an expression of gratitude and thanks to each of the presenters both oral and poster for the wide range of excellent presentations focused on migrations and survival mechanisms of juvenile salmon and steelhead in ocean ecosystems. It is not an easy and sometimes thankless task required to put in the long hours-days-weeks-months-- even years of research, analysis, and focused effort to make such good presentations.

This is the third NPAFC workshop on juvenile salmon and the first including a focus on steelhead. The first workshop held in Tokyo in 2000 was followed by an in depth review of research on the early marine period of Pacific salmon by Canada, Japan, Russia, and the United States published in 2003 as NPAFC Bulletin 3. The second workshop on juveniles was held in 2006 in Sapporo. And given the amount of research since then the timing of this workshop is very appropriate as evidenced by the breadth of significant new information we have heard over the past two days.

I think it is appropriate to extend our sincere thanks to the Secretariat, especially to Nancy Davis, to Joe Orsi and the Workshop Organizing Committee and to the many others who have worked so long and hard to make the workshop a success. In this regard, to express our thanks, would you please join with me in a hearty round of applause for the Secretariat, for Nancy, Joe and others who have made this Workshop so successful!!

It is impossible for me to cover the full range of new findings presented at this workshop, not to mention new insights into some older concepts. There were 33 oral and 42 poster presentations given at this workshop. I will try to summarize some salient issues covered by keynote presentations from Asia and North America, then touch on a few key ideas covered under the six workshop topics.

Review of Asian Studies

My head is still spinning over the extent of information Vladimir Radchenko presented about new Asian research on juvenile salmon. Among other things he reviewed Russian trawl surveys that described concentrations and migration patterns of juveniles for many stock groups of Asian salmon in the Okhotsk and Bering Seas.

Those surveys were effective especially for Asian pink salmon stocks providing a strong basis for making annual forecast of returns to Kamchatka and Sakhalin rivers. Other Russian surveys in winter and early spring have expanded knowledge on juvenile and immature salmon biology during these periods along with late spring and summer surveys providing data for differentiation of stock groups and updating forecast. Increased abundance of pink salmon from eastern Kamchatka has not changed the role of salmon in the trophic structure of epipelagic nekton communities in the western Bering Sea. Some changes in prey were noted in years of high salmon abundance but this did not influence growth and survival of juveniles. Food supply for juvenile salmon and micronekton in waters of far-eastern seas and northwestern Pacific is much higher than the total food consumed by all epipelagic nekton. Food resources consumed by juvenile salmon represent a minor part (1-2%) of total macro-zooplankton biomass.

I have this sense our Russian colleagues, based on their research in the western Pacific involving extensive year round ocean surveys in documenting high standing crops of macro-zooplankton and other micronekton foods of salmon, pretty much hold in abeyance any current concerns about carrying capacity of salmon in these waters. This doesn't mean, however, it can't change in the future.

Review of North American Studies

Marc Trudel's survey of North American research since the 2006 workshop indicated that Chinook and coho salmon had received the most attention. This also turns out to be true for many North American presentations and posters at this workshop, a reflection of increasing concern over population and stock declines of these species over broad geographic regions including Alaska. Marc also reported progress in understanding stock –specific migration behavior of juveniles showing how DNA analyses, tags, and biophysical attributes provide tools for studying ocean distribution and behavior. In British Columbia the role of sea lice parasites transferred from salmon farms have received much attention as potential mortality agents on juvenile salmon. Unlike western Pacific, however, few studies have been conducted in eastern Pacific during winter periods leaving a huge gap in our understanding of North American salmon ecology during this critical life history period.

Topic 1 on Seasonal distribution and migration route/timing had 6 oral and 9 poster presentations.

An important and continuing theme under this topic was applications of multiple technologies identifying stock-specific migratory behavior patterns in juvenile salmon.

Two Japanese papers using otolith marks and single nucleotide polymorphism (SNP) markers documented dispersal and migrating patterns of specific stocks of chum salmon on the Pacific coast of Hokkaido.

Using variations of 14 DNA microsatellites North American scientists followed individual Fraser River and central B.C. sockeye stocks migrating out of British Columbia and tracked them northwestward throughout much of Gulf of Alaska (GOA).

Russian scientists identified mixed-stock aggregations of 24 Okhotsk Sea even-year pink salmon stocks using mtDNA restriction fragment length polymorphism analysis and found by September most juveniles originating from the southern part of the basin had migrated into northern Okhotsk Sea.

Otolith microstructure was used in another Russian study to identify mixed stock groups of Okhotsk Sea pink and chum salmon.

Migration behavior was another important theme in Topic 1. In Northern Bering Sea juvenile Chinook from western Alaska rivers migrated in opposite directions along the coast during a series of warm and cold years that affected survival.

Late migration timing and ocean entry was shown to have significant beneficial effects on populations of Fraser River Chinook and sockeye.

And a study on persistent age-specific homing and return timing of Columbia River Chinook provided a basis for inferring different ocean distribution patterns for different age groups of these fish.

Also related to homing behavior was the first empirical evidence of geomagnetic imprinting in any animal determined from analyzing divergences in geomagnetic field drift at mouth of Fraser River that could account for the two different entry routes of returning sockeye migrating around Vancouver Island.

Topic 2 on Hydrological characteristics, primary production, and prey resources had 4 oral and 4 poster presentations.

In the Strait of Georgia survival of hatchery coho dropped from 8-10% to 1% over a 30 year period leading to new research focused on staggered smolt release dates along with plankton monitoring to assess food quality and availability. The study also has a fish health component to test if a marine bacterium is affecting survival.

In the Northern California Current a study on spatial associations from shipboard acoustic surveys of distribution and abundance of krill, satellite derived indexes of Chlorophyll-a and occurrences of juvenile Chinook showed persistent high krill and salmon abundance associated with Chlorophyll-a hot spots

Along coastal GOA juvenile salmon migrating though the perimeter of the Sitka Eddy were shown to have increased foraging opportunities and elevated growth rates that could mitigate increased competition in years with high salmon abundance.

Topic 3 on Trophic linkages, growth rates, and predation rates had 5 oral and 7 poster presentations.

Another California Current study demonstrated a strong positive relationship between growth and survival in coho during the first summer with little mortality occurring during the following winter period.

A coastal British Columbia study found stock- specific predation on juvenile salmon by rhinoceros auklets at different nesting colonies indicating important spatial-temporal salmon migration patterns. Concurrent coast wide trawl surveys for juvenile salmon also demonstrated evidence for size-selective predation where salmon at each auklet colony were smaller relative to salmon caught in trawl surveys.

To better understand coast wide declines in Chinook salmon a continental-scale analyses of juvenile feeding ecology from northern California to eastern Bering Sea and Chukchi sea found large gradients in δC-13 isotopes corresponding to regional variations in zooplankton and forage fish in diets, especially in smaller Chinook up to 200mm in length.

Another trophic study utilized a food supply index to examine relationships between biomass of all nekton species, zooplankton, and juvenile salmon in western Bering

and Okhotsk Seas found that while diets changed somewhat during years of high abundance there were no strong negative consequences for juvenile salmon.

Topic 4 on Ecological interactions among species and populations had 2 oral and 4 poster presentations.

A study in Southeast Alaska examined interactions between pink and chum salmon suggested high broodline returns of adult pink salmon influenced feeding and growth of juvenile chum salmon.

A Southeast and Prince William Sound Alaska study over 16 years examined adult pink salmon predation on juvenile salmon and herring. This relates to the hypothesis that cannibalism by returning adults contributes to brood line oscillations in pink salmon. Results indicated cannibalism was rare occurring in >1.1% of over 2000 adult pink salmon stomachs analyzed. I note, however, that Vladimir Radchenko showed an interesting photo of an adult pink with a large number of juvenile pinks in the stomach.

In Puget Sound a study found likely competition between juvenile salmon and Pacific herring due to some similarities and diets and to greater population biomass of herring.

Topic 5 on Survival rate and survival mechanisms had 13 oral and 13 poster presentations.

A study in Strait of Georgia suggested during years of poor ocean productivity biological stressors such as harmful algal blooms and pathogens may weaken immune systems of juvenile salmon and are associated with higher levels of mortality.

An analysis of high-seas food habitats revealed salmon and steelhead consume a variety of types and forms of plastic debris. The study explored potential mechanisms of marine mortality due to ingestion of plastic debris and emphasized a need to for field and laboratory process studies on this issue.

Two separate modeling studies considered the influence of large-scale climatic patterns such as the PDO and North Pacific Gyre Oscillation on survival of Pacific northwest coho salmon. Both found large-scale events have strong influence on physical and biological components of ecosystems but effects are more uncertain at

local and regional levels. For example, in one case spatial comparisons of large scale events and ocean SST were better predictors for survival of coastal populations than those interior in Puget Sound.

Within Southeast Alaska researchers found that marine rearing pre-smolt coho nomads provide substantial life history diversification for efficient use of discontinuous freshwater habitats along with providing a population buffer against survival shocks.

Another study examining critical periods in marine life history of Pacific salmon argued, on need to consider all phases of life history rather than focusing on the assumption that one "critical" period is of overriding importance.

A study on mortality of Bristol Bay sockeye, based on scales of out migrant smolts and returning adults found size-selected mortality was dependent on ocean conditions and biological characteristics of smolts. The study suggested productivity of Bristol Bay stocks was largely dependent on the degree of size-selective ocean mortality.

Mesoscale eddies in GOA were shown to be drivers of sable carbon isotopes in oceanic copepods and how these eddies can account for some of the interannual variability of Prince William Sound pink salmon survivals.

Another study on British Columbia sockeye looked at long term trends and breaks in survival patterns and increased competition at sea, in part related to continued releases of large numbers of hatchery salmon (here read pink and chum) may have played a significant role in reduced sockeye survival since 1991.

Theme 6 on Survival and salmonid ecology during the first winter at sea had 1 oral and 4 poster presentation.

Russian studies on the food supply of pink salmon salmon during winter and spring of 2009-2011 in the upper epipelagic layer of the western Subarctic frontal zone estimated the total biomass of nekton along with the consumption of various zooplankton groups by pink salmon and other organisms. Estimates showed that consumption of zooplankton by pink salmon and all nekton was a minor fraction of the available food in the upper epipelagic zone. Feeding by pink salmon during this period was not low as evidenced by indices of stomach fullness.

In summary here are a few key take home points for me from this workshop.

1. ● Major new continuing improvements in discerning stock- specific migration routes of juvenile salmon based on genetic stock identification techniques, otolith microstructure, otolith marking, and other stock identification technologies.

2. ● The growing body of evidence regarding the importance of early marine growth in juvenile salmon and the significance of size- selective mortality in marine life stages as a key determinate of overall survival and a cornerstone of the critical size hypothesis. We even learned that rhinoceros auklets can be added to the list of other predators demonstrating effects of size-selective mortality. Looking at this from the salmon's point of view, I guess we might summarize this whole concept as: "getting bigger quicker is better".

3. ● Possible phenological mismatches in migration timing and suitable marine prey resources of juvenile salmon from changes in freshwater and marine environments due to global warming and differential climatic affects in these waters.

4. ● New insights into homing migratory behavior based empirical evidence of geomagnetic imprinting. There was another original abstract on homing that didn't make the final cut I would liked to have heard based on persistence of free amino acids in natal stream soils

5. ● Potential deleterious impacts of marine debris on salmon ecology and survival.

In closing I would like to add a comment regarding future research direction involving Pacific salmon. Because we definitely are in a period of fairly rapid climatic changes it is important for us to collectively do whatever and however we can to maintain those important long term data sets, those marine surveys, and long standing observations that give us critical tools to help us better understand what is going on. I know this is tough in times of budget shortfalls and sequesters but we must persevere and strive to keep the need for these valuable long-term data sets front and center in the minds of administrators and others.

I thank you for your attention and apologize for the many subjects and issues from both oral and poster presentations I was unable to touch on during this wrap up.