NPAFC International Symposium on Bering-Aleutian Salmon International Survey (BASIS):

Climate Change, Production Trends and Carrying Capacity of Pacific Salmon in the Bering Sea and Adjacent Waters

November 23-25, 2008
Sheraton Seattle Hotel, Seattle, WA, U.S.A.

Dramatic fluctuations in the ocean growth and survival of many Asian and North American salmon populations over the past decade have been attributed to changes in the Bering Sea and other marine ecosystems. The absence of scientific observations for salmon, ecologically related species, and environmental conditions in the North Pacific Ocean has limited our understanding of these changes and how they affect salmon populations and economies around the Pacific Rim. International research efforts to address these issues were developed by the NPAFC, as part of its Science Plan. The research plan called BASIS (the Bering-Aleutian Salmon International Survey), began in 2002 as a coordinated program of cooperative research on Pacific salmon in the Bering Sea. The goal of BASIS research was to clarify the mechanisms of biological response by salmon to the conditions caused by climate change in the Bering Sea.

The symposium was held November 23 – 25, 2008, in the Sheraton Hotel in downtown Seattle, Washington. E. Farley chaired a steering committee consisting of: T. Azumaya, R. Beamish, K.B. Seong, V. Sviridov, and S. Urawa. During the symposium, NPAFC commemorated the efforts from research and contract vessels: *Kaiyo maru* and *Wakatake maru* (Japan), *TINRO* (Russia), and *Sea Storm* and *Northwest Explorer* (USA) for their expertise and support in conducting BASIS research surveys.

There were three main topics: 1) Overviews of climate change, Bering Sea ecosystems, and salmon production; 2) biological responses by salmon to climate and ecosystem dynamics; and 3) discussion and summary on BASIS 2002 – 2006: where do we go from here? There were 42 oral and 30 poster presentations. All presentations were in English. It was evident that the Arctic is warming and that sea ice extent is declining (Fig. 1).

N. Bond showed that climate warming will increase water column stability on the eastern Bering Sea shelf, limiting the flux of nutrients into the photic zone and perhaps negatively impacting primary and secondary productivity. O. Temnykh suggested that climate warming will not impact carrying capacity for salmon in the western Bering Sea and that current models indicate that the carrying capacity for salmon in the Bering Sea is much higher than present abundance levels. G. Ruggerone presented a different view on carrying capacity, suggesting that the large increase in the abundance of hatchery salmon impacted wild salmon stocks by limiting growth via density-dependent processes in the ocean, increasing their mortality rates. K. Myers reviewed BASIS data and revealed new migrations models for salmon, some which indicate varying migration pathways depending on whether sea surface temperatures are warm or cold.

M. Kaeriyama showed prediction models for the impact of global warming on the ecosystems of the North Pacific Ocean and concluded that: 1) global warming will decrease salmon carrying capacity by reducing their preferred ocean habitat; 2) increase density-dependent effects on growth of salmon thus potentially reducing their marine survival; and 3) Hokkaido chum salmon will no longer migrate to the Sea of Okhotsk, an important rearing region for

Dr. J. Helle, the former BASIS Working Group Chairperson, introduced the BASIS program.

Mr. J. Downing (right), the owner of F/V *Northwest Explorer*, got a commemorative plaque from the NPAFC Exective Director V. Fedorenko. Five research vessels were commended for their expertise and support in conducting BASIS researches.

Approximately 130 people attended the 3-day symposium at the Sheraton Seattle Hotel.

In addition to 42 oral presentations, 30 significant posters were presented during the symposium.

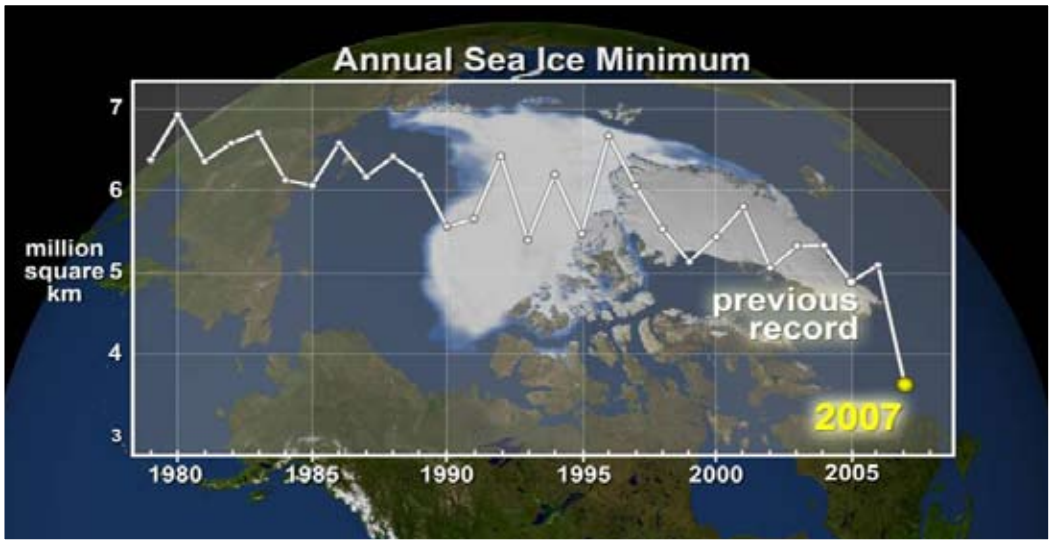

Fig. 1. Annual September sea ice extent in the Arctic. Courtesy of NASA http://www.nasa.gov/vision/earth/environment/arctic_minimum.html.

juvenile chum salmon. H. Seo revealed that climate change would likely impact survival of Asian chum salmon during their first year at sea.

Well-researched papers on the migration and distribution of Pacific salmon were presented by A. Bugaev, T. Nagasawa, J. Seeb, J. Murphy, C. Habicht, S. Urawa, T. Beacham, M.H. Kang, R. Walker, and J. Irvine. Most of these presenters provided stock-specific information on salmon distribution using genetic stock identification techniques. T. Nagasawa (for T. Azumaya) presented a fish bioenergetic model that suggested carrying capacity for salmon distributed in the Bering Sea is not limited during summer, but is limited for salmon distributed in the North Pacific Ocean during winter and spring.

Climate cycles are embedded in the climate trends. For instance, our Russian colleagues have shown that shifts in the position the Far Eastern Low and Aleutian Low pressure systems determine whether or not the Bering Sea experiences warming or cooling and also affect velocity of ocean currents. The position of these atmospheric low pressure systems (NE and W respectively) during 2002 to 2005 brought warmer air to the Bering Sea during winter and was related to decreased storm activity during summer. The position of these low pressure systems shifted again (SW and E respectively) during 2006; as a result, colder arctic air covered much of the Bering Sea during winter and summer storm activity increased.

The impacts of these climate cycles (cool versus warm) on physical and biological parameters in the eastern Bering Sea were presented S. Danielson, L. Eisner, A. Andrews, J. Murphy, K. Coyle, K. Cieciel, and E. Farley. These papers suggested pelagic productivity was highest during years with warm SSTs, as abundance levels of juvenile salmon and age 0 pollock are much higher than during years with cool SSTs. However, the zooplankton community shifted from large to small taxa during warm SSTs years, altering energy transfer to pelagic fish and negatively impacting fish energy density prior to winter. This finding may explain why recruitment of commercial fish species in the eastern Bering Sea was low during warm SST years, as fish with low energy reserves prior to winter would be expected to have higher mortality during winter.

Within the western Bering Sea, climate cycles of warm and cool also resulted in shifting food webs and abundance of pelagic consumers. S. Naydenko showed that juvenile walleye pollock consumed a large portion of the forage resource during 2002 and 2003 and Pacific salmon, squids, Atka mackerel, herring, and capelin were the dominate consumers of the available forage during 2004 to 2006. S. Naydenko (for A. Volkov) noted that copepods dominated the zooplankton biomass in the western Bering Sea during 2006, whereas euphausiids and hyperiids dominated the zooplankton biomass during 2003 and 2005. M. Koval connected 11 year cyclic solar activity to shifts in biomass of dominant pelagic fish species in the western Bering Sea (between salmon and Atka mackerel to walleye Pollock).

E. Martinson, J. Helle, and G. Ruggerone showed how salmon scale pattern analyses, where long time series of scale collections are available for salmon populations, can be used to reveal possible impacts of climate change to salmon marine growth. B. Beckman and T. Kaga described methods to measure salmon fitness in connection with recruitment success and monitoring the impact of climate variation on salmon health.

There was a lively discussion at the end of the meeting regarding future research for BASIS and a resounding commitment to continue this vital research by Parties within NPAFC. C. Pautzke, the Executive Director of the North Pacific Research Board (NPRB), suggested NPAFC researches keep NPRB in mind for funding research during the 2nd phase of the "Bering Sea Integrated Ecosystem Research Program" that would likely occur several years from now. There was a general sense of satisfaction knowing that BASIS research captured the response of the Bering Sea pelagic ecosystem to cyclic patterns in climate. There was no question that the North Pacific Anadromous Fish Commission, BASIS research strengthened our knowledge of the effects of climate variation on pelagic ecosystems of the Bering Sea. This research also fostered unprecedented cooperation among NPAFC Parties and is a model for future collaborative research efforts in the North Pacific Ocean.

Ed Farley
BASIS Symposium
Steering Committee Chairperson