National Overview of BASIS Research for the United States

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Small-scale studies on early marine life history of juvenile sockeye salmon (*Oncorhynchus nerka*) in Bristol Bay in the southeastern Bering Sea were done during 1966–1972 (Straty 1974; Straty and Jaenicke 1980). Current salmon research by the Unites States in the Bering Sea began in 1999 with emphasis on monitoring the effects of ocean conditions on growth, migration, and distribution of juvenile sockeye salmon in Bristol Bay (Farley et al. 1999). Since then, the U.S. program has expanded to include most of the continental shelf in the eastern Bering Sea and includes comprehensive ecosystem information on other species of salmon, forage fish, other nekton, plankton, and oceanographic conditions. Research on immature and adult salmon in the Bering Sea has been accomplished largely through retrospective studies and cooperative high seas research programs with other North Pacific Anadromous Fish Commission (NPAFC) parties.

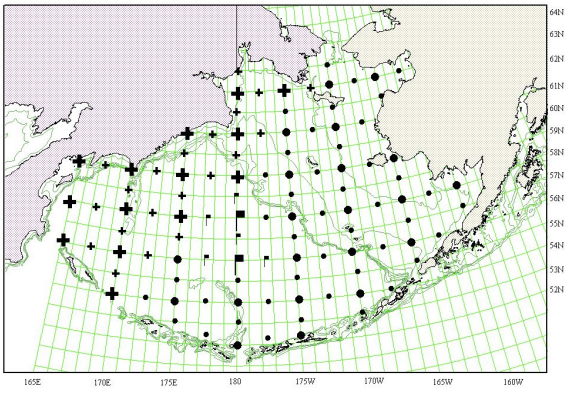
Concerns about declines in salmon abundance on both the Asian and North American sides of the Bering Sea resulted in the NPAFC developing a BASIS research plan in 2001. This plan called for seasonal synoptic surveys of salmon abundance and distribution throughout the Bering Sea (Fig. 1). Russian scientists would survey the western Bering Sea, Japanese scientists would survey the central Bering Sea, and U.S. scientists would survey the eastern portion. In addition to salmon surveys, observations would be made on forage fish, plankton, and oceanographic conditions. Synoptic surveys began in 2002 and continued in 2003 and 2004.

Large trawls towed at the surface were used to capture salmon and associated marine species. Each country had developed trawls to fish from their own vessels in previous marine salmon research. In 2002, the Russian vessel RV *TINRO*, the Japanese vessel RV *Kaiyo maru*, and the U.S. vessel FV *Northwest Explorer* rendezvoused near Attu Island in the western Aleutian Islands and the three vessels made side-by-side tows to compare the catches by the three different vessels and trawls. In addition to the FV *Northwest Explorer*, the United States also used the FV *Sea Storm* for surveys in the eastern Bering Sea in 2002. Due to budget cuts, the United States used only the FV *Sea Storm* for surveys in 2003 and 2004.

One U.S. scientist participated in cruises on the *TINRO* in 2002 and one U.S. scientist was on the *Kaiyo maru* in 2002. Three U.S. scientists participated on the *Kaiyo maru* cruise in 2003 and one U.S. scientist was aboard the *Kaiyo maru* in 2004. One Russian scientist participated in the *Northwest Explorer* cruise in 2002. Two Russian scientists participated in cruises of the *Sea Storm* in 2003 and in 2004. A Canadian scientist was aboard the *Sea Storm* in 2002 and 2003.

United States research activities in the BASIS plan were designed to address four major issues or questions: 1) what are the seasonal stock-specific migration patterns of salmon inhabiting the Bering Sea, particularly those stocks exhibiting recent declines in production, and what is their relation in the Bering Sea ecosystem, 2) what are the key biological, climatic, and oceanographic factors affecting long-term changes in Bering Sea food production and salmon growth rates, 3) what are the similarities (or dissimilarities) in production or survival trends among salmon populations originating in rivers around the Bering Sea Rim, and 4) is there a limit (carrying capacity) to the amount of salmon that can be produced in the Bering Sea, and what is the effect of hatchery salmon on Bering Sea food supplies?

Fig. 1. Sampling locations for BASIS. Symbols indicate stations in Russian (plus sign), international (flag), and U.S. (closed circle) waters.



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Genetic stock identification is an integral part of research on all of the issues above. For more than a decade, the United States, Russia, and Japan collaborated to produce a common allozyme data base (Kondzela et al. 2002) that provides substantial insight into the migration of chum salmon in the Bering Sea (Urawa et al. 2004). New DNA techniques are enhancing our ability to identify salmon stocks anywhere in the Bering Sea (Seeb et al. 2005; Habicht et al. 2005; Fig. 2).

When BASIS was being planned in 2001, scientists were primarily concerned about the declining numbers of salmon returning to Russia, Japan, and western Alaska. Similar declines in all three countries suggested the source of the problem was in the marine environment and not in the rivers. Now, because of the very obvious changes in the ocean and atmosphere in the Bering Sea, BASIS is evolving into a major international ecosystem and climate-change research program.

A highly visible change in the eastern Bering Sea has been coccolithophore blooms. These blooms were first noticed in 1997 by ships at sea and were clearly visible from satellite photos. These blooms were present in 1997–2000, mostly absent in 2001–02, and scattered in 2003–04. When possible, juvenile salmon appeared to avoid these blooms.

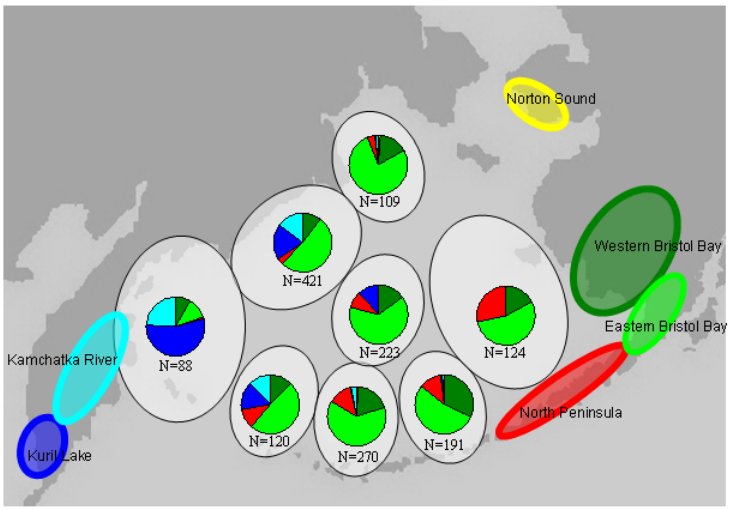
Sea surface temperatures, as reported by Japan, Russia, and the Unites States at this workshop have been warmer during the past several years. Sea temperature data from a NOAA mooring in the southeastern Bering Sea shows temperatures at depth have warmed too. Depth-averaged temperatures were consistently warmer during mid-July through mid-September for 2001–2003 when compared to the same months for 1995–1997 (Overland and Stabeno 2004).

Air temperatures at St. Paul Island in the eastern Bering Sea have been warmer in the past four years; however, the warming pattern actually started in the mid–1970s (Overland and Stabeno 2004). Along with warming sea and air temperatures, sea ice concentration in the eastern Bering Sea has also decreased. Feeding areas of walrus and grey whales have moved northward with the receding sea ice (Kelly 2001; Moore et al. 2003).

The warming trend has also affected the land. In northern Alaska, permafrost has been melting, causing a change in vegetation types (Jorgenson et al. 2001) and subjecting villages in coastal areas to erosion (see Time Magazine, October 4, 2004, pp. 68–70).

Clearly, the Bering Sea ecosystem is in the midst of a major climate change. Whether the changes are part of natural cycles in climate or are "global warming" caused by anthropogenic causes may be arguable. Regardless of the causes, the changes to natural resources in the Bering Sea are already large and the implications for the future are unknown. The research done under the BASIS program has already significantly added to our knowledge of the Bering Sea. Expanding our observations to encompass more data that can be used to evaluate climate change is an obvious goal. The original BASIS plan called for field observation during 2002–2006. The success of BASIS at a time of major ecological change suggests that BASIS should be extended beyond 2006.

Fig. 2. Stock proportions of immature sockeye salmon sampled from throughout the Bering Sea during August of 2002 and 2003 (*N* = sample size). Baseline stocks were pooled into six reporting groups and are symbolized with colored ovals. Pale ovals under the pies represent the general area where stock mixtures were captured and pie colors correspond to reporting group colors.



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