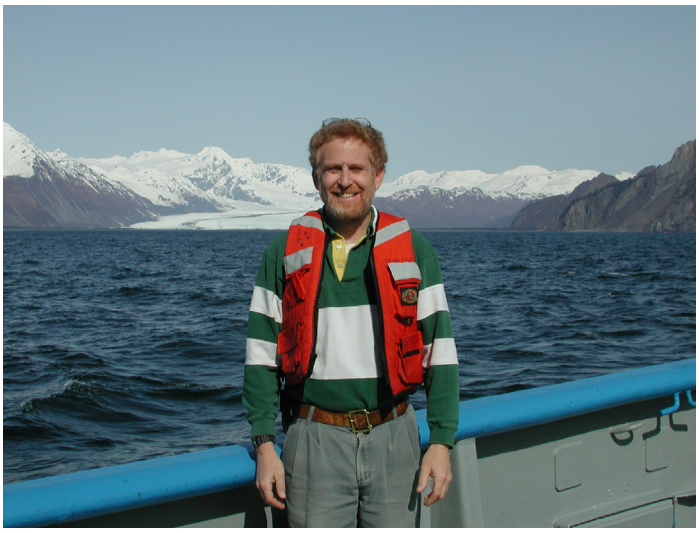
The Bering Sea: Current status and recent events

Jeffrey M. Napp
NOAA – Fisheries/Alaska Fisheries Science Center
7600 Sand Point Way NE,
Seattle, WA 98115-0070, U.S.A.
E-mail: Jeff.Napp@noaa.gov



Dr. Jeffrey (Jeff) Napp is a Biological/Fisheries Oceanographer at the Alaska Fisheries Science Center of NOAA-Fisheries. He is Head of the Recruitment Processes Program at the Center and co-leader (with Dr. Phyllis Stabeno) of NOAA's Fisheries Oceanography Coordinated Investigations (FOCI). His own research is focused on physical and biological processes at lower trophic levels that affect recruitment variability in fish populations. He is active as Principal Investigator in both Bering Sea (NOAA's Bering Sea FOCI, Southeast Bering Sea Carrying Capacity) and Gulf of Alaska (FOCI, GLOBEC) Programs, and currently serves on a steering committee to organize a U.S. science initiative for the Bering Sea (BEST: Bering Sea Ecosystem STudy). Jeff participates in several PICES Working Groups and Technical Advisory Panels.

Pacific Decadal Oscillation index

Previous work (*e.g.*, Mantua *et al*. 1997) has shown that much of the climate variability of the North Pacific can be represented by the Pacific Decadal Oscillation Index (PDO) which is the first mode of the sea surface temperature anomalies in the North Pacific. The recent change in phase of the PDO from negative to positive (Fig. 1) has stimulated predictions of change in the Bering Sea ecosystem. A recent study (Bond *et al*., *GRL*, in press), however, shows that a climate perspective limited to the PDO is incomplete. In particular, the second leading mode of sea surface temperature anomalies accounts for more of the North Pacific climate variability since 1998, and hence should be recognized for its influence on the state of atmospheric forcing (and ecosystem productivity). In other words**,** atmospheric forcing for the Bering Sea/Gulf of Alaska and the southeastern North Pacific (California Current System) appear to have diverged. A north/south dipole in the sea level pressure anomaly (SLPA) has the Bering Sea and Gulf of Alaska experiencing atmospheric forcing characteristic to that after the regime shift of 1976/1977, while the atmospheric forcing for the southeastern North Pacific resembles that before 1976/1977.

Mooring 2 - southeastern Bering Sea shelf

Biophysical mooring data were successfully collected for the ninth consecutive year at Site 2 (56.88°N, 164.03°W) on the southeastern Bering Sea shelf. For the third year in a row, sea ice was not advected over the mooring site during winter (Fig. 2). This is in sharp contrast to the previous six years when ice was present at the site (ice was over the site in February 1996, even though no mooring was present). The lack of sea ice resulted in the water column remaining relatively warm (>3°C) into March. In February and early March of 2003 the water column was stratified, rather than well mixed as expected. While the water column during summer is characteristically two-layered, during winter the strong winds and tidal mixing usually result in the shelf being well mixed to >70 m. The last three years have been significantly warmer than the first six years of observations at this site. Were these observations (no ice and winter stratification) caused by the strong year-to-year variability that dominates the Bering Sea and North Pacific weather patterns, or is it an indication of decadal or longer changes in climate?

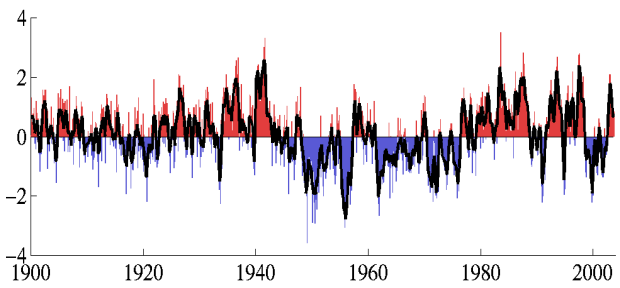


Fig. 1 Pacific Decadal Oscillation Index, 1900 - 2003. Source: http://tao.atmos.washington.edu/pdo/

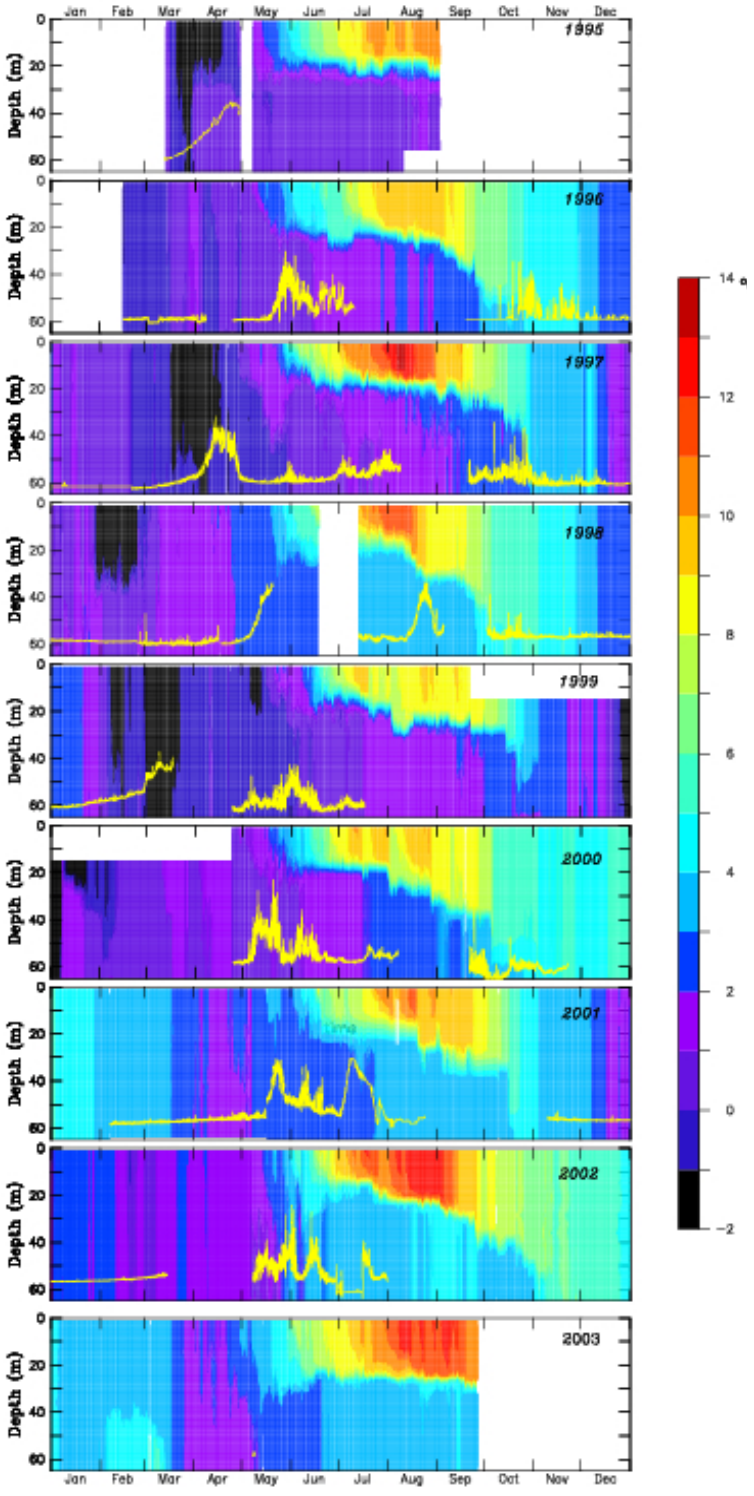


Fig. 2 Time series of biophysical properties measured at Site 2 by NOAA. Color contours show the vertical distribution of temperature (and mixed layer depth). The coldest temperatures (black) occurred when ice was over the mooring. The yellow line is the time series of chlorophyll fluorescence measured at ~11 m. Figure provided by Dr. P. Stabeno.

Shifts in regional climate patterns could have profound impacts on the southeastern Bering Sea ecosystem. The timing of the spring bloom is closely tied to the presence of sea ice. If ice is present after mid-March, there is an ice-associated bloom (Fig. 2). If sea ice is absent, then a bloom occurs in May or June with the stratification of the water column. From 2000-2002, and presumably in 2003, the spring bloom occurred in May or later. It has been hypothesized that blooms after April are utilized within the water column (by zooplankton), while production from blooms in March or April sinks to the bottom and feeds the benthic food web. Therefore, decadal shifts, which determine the prevalent spring bloom pattern, are important determinates of the productivity of the benthic and pelagic food webs of the southeastern Bering Sea shelf ecosystem.

Bering-Aleutian Salmon International Survey

A multi-year, international field research program, Bering-Aleutian Salmon International Survey (BASIS) began sampling in the summer of 2002. This research program includes synoptic surveys of salmon and other marine fish species throughout the Bering Sea with vessels from U.S.A., Japan and Russia (Fig. 3). Research objectives include: (i) understanding stock-specific migration, distribution, and abundance of salmon throughout the Bering Sea, and (ii) identification of linkages between oceanographic conditions, prey abundance and salmon growth and energetics.

NOAA's Ocean Carrying Capacity (OCC) program at the Alaska Fisheries Science Center's Auke Bay Laboratory (Juneau) is a member of BASIS, and sampled the southeastern shelf this past September (Fig. 3). Preliminary results indicate that species-specific distribution patterns exist for juvenile salmon along the eastern Bering Sea shelf. Juvenile sockeye salmon were mainly distributed throughout the Middle Shelf Domain. Juvenile chum and pink salmon were distributed along coastal waters north of 57°N, while juvenile chinook and coho salmon were distributed within near-shore locations. Juvenile salmon diet appeared to be related to their distribution (*i.e.* age - 0 pollock for juvenile chum and sockeye salmon; larval and juvenile sandlance for juvenile chinook and coho). Relative abundances of juvenile salmon during 2003 were similar to those observed in 2002; both years had higher relative abundances than those estimated during 2000 and 2001.

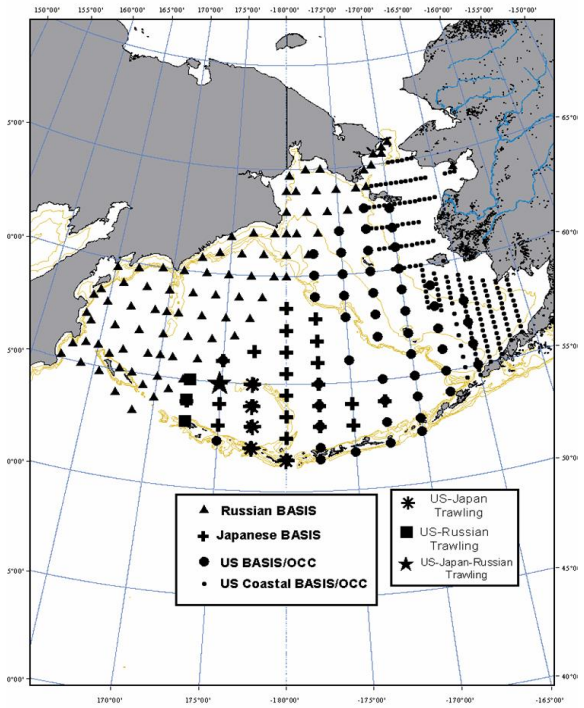


Fig. 3 Station locations for the Bering-Aleutian Salmon International Survey (BASIS) in 2002. Station locations for the 2003 field work were almost identical to that in 2002.

Scientists also collected oceanographic and plankton data at 150 stations during the survey. Fall phytoplankton (likely diatom) blooms were observed at many stations in Bristol Bay. Future analyses will focus on interactions of physical and biological oceanographic variables with the fall juvenile salmon abundances.

Coccolithophore bloom reappears

The eastern Bering Sea coccolithophore bloom, which failed to appear in the summers of 2001 and 2002, re-appeared this past summer. Dr. L. Eisner of NOAA's Auke Bay Laboratory spotted the aquamarine-colored water in September during this summer's BASIS cruise (Fig. 4, top panel). The observation occurred somewhat later than other years; it was not seen during the annual Hokkaido University T/S *Oshoro Maru* cruise (late July). BASIS shipboard observations found it along 166°W from 57.4°N to 57.9°N (~60 km north to south) and along 165°W at 57.3°N. The offshore limit of the bloom could not be determined from shipboard observations. Satellite observations however, show that the bloom covered parts of the Middle and Outer Shelf Domains from the southeast to St. Lawrence Island (Fig. 4, bottom panel).

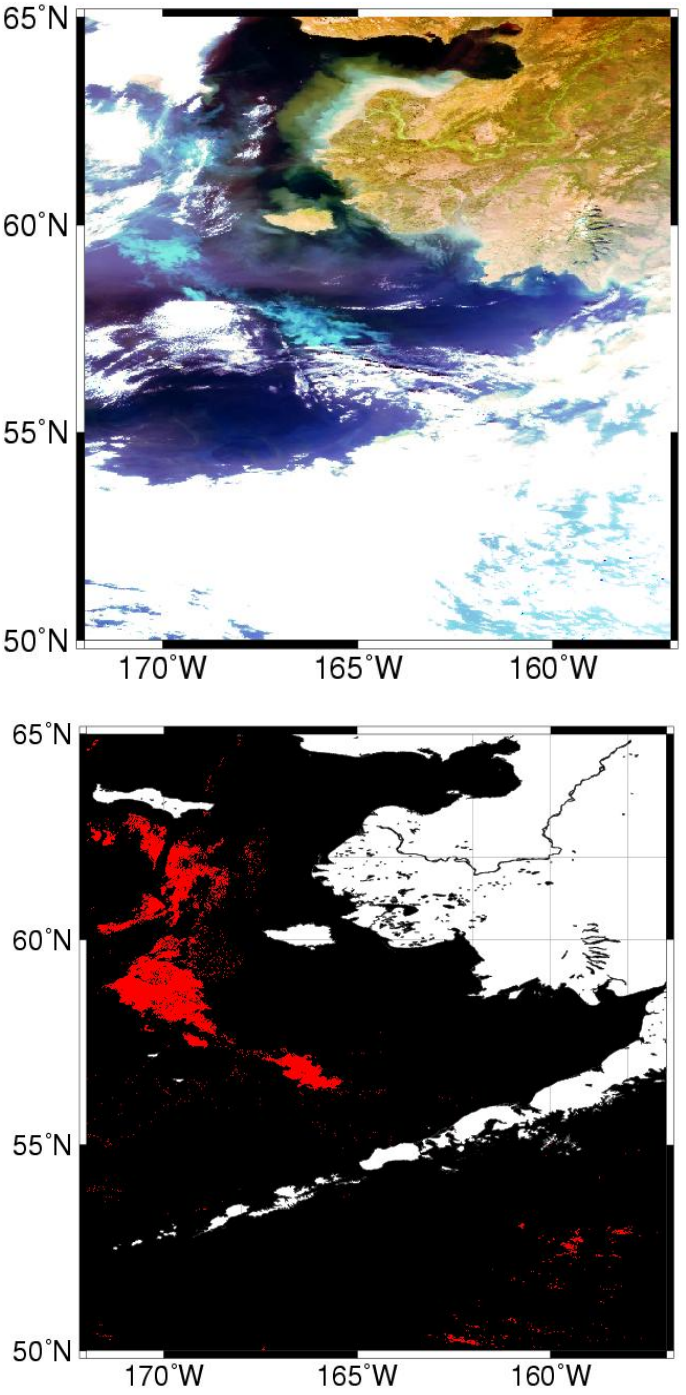


Fig. 4 Top panel: True color SeaWiFS image of the southeastern Being Sea, September 18, 2003. Bottom panel: Same image processed using a special algorithm (coccolithophore mask; Iida et al., 2002) to show extent of waters with reflectance characteristic of coccolithophore blooms. Images generously provided by Dr. S. Saitoh and Mr. T. Iida, Hokkaido University.

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