The Bering Sea: Current Status and Recent Trends

by Lisa Eisner

Climate and oceanography

The eastern Bering Sea shelf experienced relatively cold weather from October 2012 through March 2013. This period included an anomalously weak Aleutian Low, as indicated in the sea level pressure (SLP) anomaly pattern (Fig. 1). A weak Aleutian Low generally means suppressed storminess which, in turn, implies a lower than normal incidence of relatively warm air masses of maritime origin *versus* colder air of Arctic or continental origin. This was indeed the case in the present example, during which air temperatures were about 2°C colder than normal on the eastern Bering Sea shelf (not shown). The SLP anomalies also were associated with wind anomalies of 1–2 m/s from the north over the southeastern portion of the shelf.

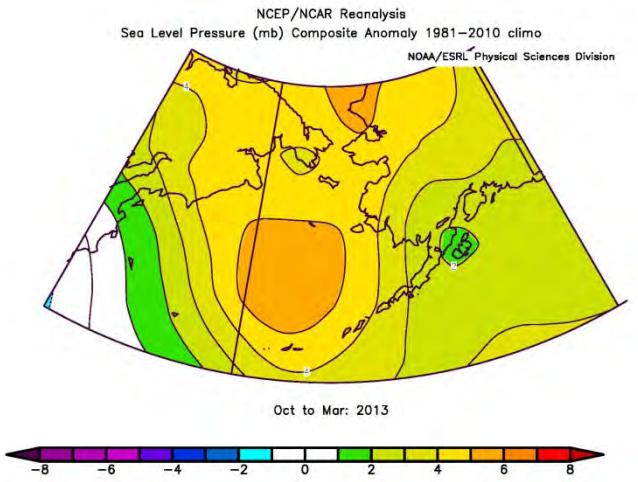

Fig. 1 NOAA sea level pressure (mb) composite anomaly (deviations from 1981–2010 climatology) for October 2012–March 2013. Figure courtesy of N. Bond.

The winter and early spring of 2013 featured more sea ice than usual. It also appears to have included substantial temporal variability in sea ice extent, *i.e.*, a series of marked advances and retreats over the course of winter. This variability is reproduced in the daily air temperatures at St. Paul Island, which show the particularly cold weather that occurred in the early and middle of December 2012, and in the middle and latter periods of February 2013 (Fig. 2). Considering the coverage of sea ice since the first of the year, it can be anticipated that the Bering Sea cold pool during summer 2013 will be larger than normal, but probably not quite as extensive as during some of the extremely cold years in the recent past such as 2010.

Sea surface temperature (SST) variations for the entire Bering Sea were evaluated using Empirical Orthogonal

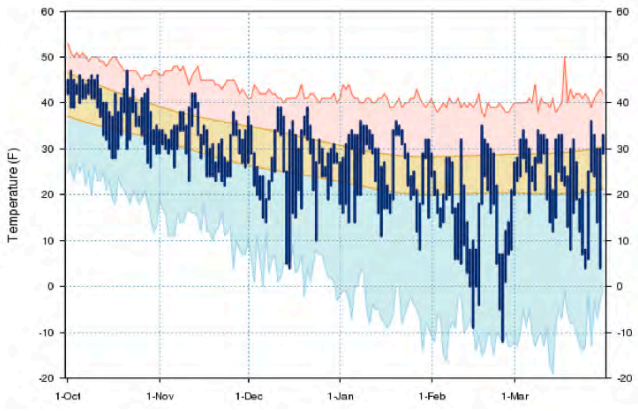

Fig. 2 Daily air temperature (°F) at St. Paul Island for October 2012–March 2013. The reddish and aqua lines at the top and bottom, respectively, refer to the all time high and low temperatures for each date; the tan lines in the center refer to the average daily high and low temperatures for each date. The period of record is 1949 to present. Figure courtesy of N. Bond.

Function (EOF) analysis of satellite data for 1982–2013 (Fig. 3). The significant cold that began in November 2011 persisted through January 2013, as shown by negative EOF 1 values (Fig. 3, top left). The loadings for the Bering Sea on EOF 1 are all positive (*i.e.*, the whole sea co-varied positively with this EOF, but to different degrees depending on location, Fig. 3 top right). EOF 1 is correlated with the Pacific Decadal Oscillation (PDO) in winter (r = 0.68 in January). The subdominant mode (EOF 2) shows an east–west see-saw pattern (Fig. 3, bottom right). Positive EOF 2 values (Fig. 3, bottom left) are associated with cold surface temperatures on the Alaskan side and the reverse on the Russian side of the Bering Sea. Positive SLP anomalies (as shown in Figure 1) and north winds over the eastern Bering Sea coincide with a positive sense to EOF 2 for the Bering Sea. So, the combination of negative EOF 1 and positive EOF 2 are associated with a cold eastern Bering Sea during recent years.

BEST-BSIERP Bering Sea Project summary

The collaborative "Bering Sea Project" integrates two research programs, the National Science Foundation (NSF) Bering Ecosystem Study (BEST) and the North Pacific Research Board (NPRB) Bering Sea Integrated Ecosystem Research Program (BSIERP), together with substantial in-kind contributions from the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service. As reported in previous issues of PICES Press, the Bering Sea Project concluded an ambitious series of field seasons in the autumn of 2010. Since then, over 100 peer-reviewed publications have emerged from

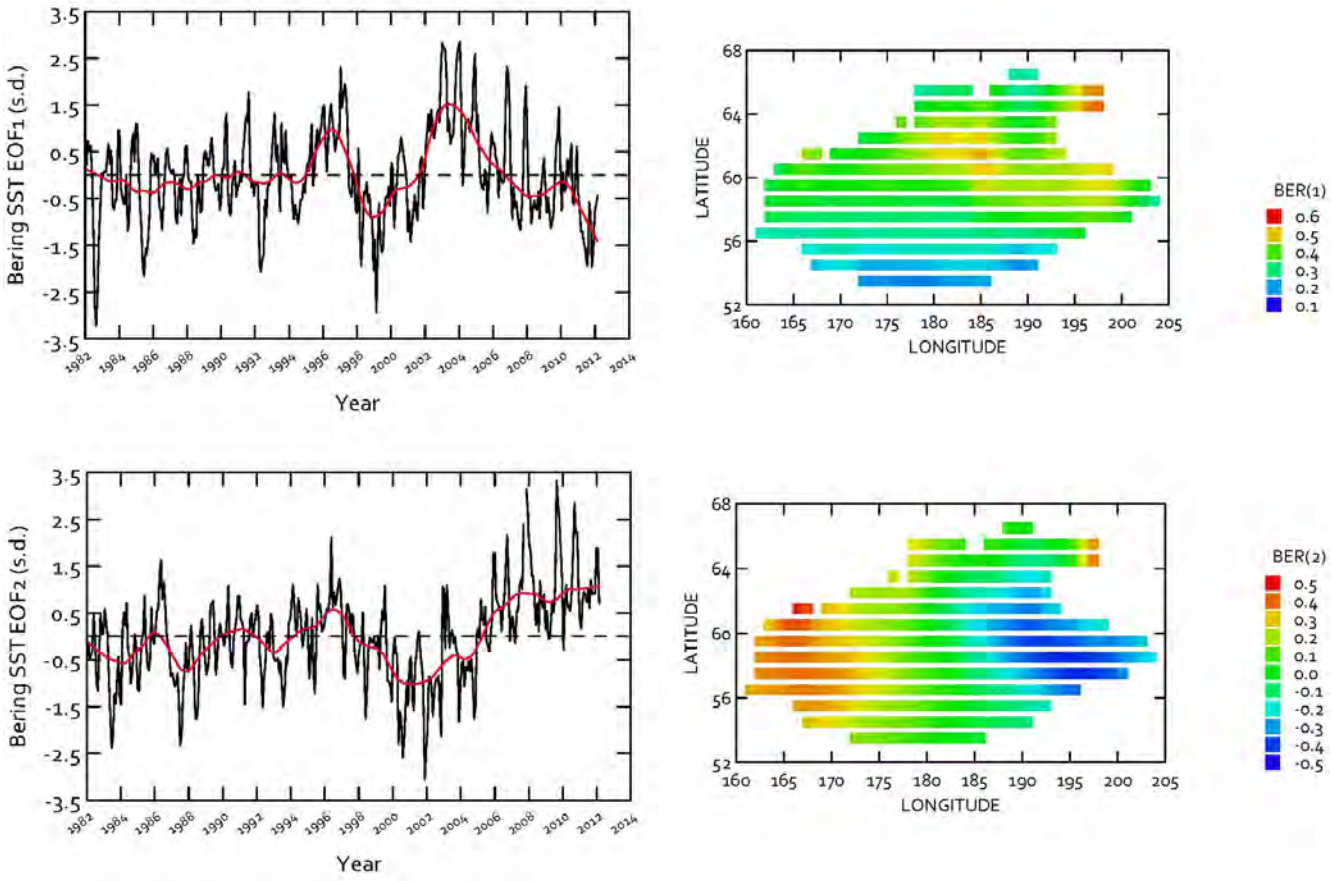

Fig. 3 EOF analysis for the Bering Sea SST for 1982–2013. The upper row is EOF 1 (45%) and the bottom row is EOF 2 (20%). Left and right panels show temporal and spatial variations, respectively. In left-side plots, smoothed data are shown with red trend lines. In right-side plots, the minimum loadings are set to blue and the maximum to red. Data courtesy of S. McKinnell.

the project (http://bsierp.nprb.org/results/publications.html). Around half of those publications are in the first and second Bering Sea Project special issues of *Deep-Sea Research II*; another two dozen manuscripts are currently under review for a third special issue, and a fourth special issue is anticipated with a submission deadline in December 2013.

Highlights from the second Bering Sea Project special issue (in press) include the role of microzooplankton in the Bering Sea ecosystem—Sherr *et al.* found significant rates of microzooplankton herbivory in spring in both non-bloom and bloom conditions; their experiments together with others led by Stoecker *et al.* show that multiple consumers regulate phytoplankton stocks in the Bering Sea, with microzooplankton playing a more significant role than previously understood.

Bering Sea Project results also provide additional understanding of why a key Oscillating Control Hypothesis prediction—that warm years would lead to higher recruitment rates and increased abundance of piscivorous species—has been shown to be incorrect. Siddon *et al.* devised a conceptual model of energy allocation in walleye pollock from larvae to age-1 and propose that the time after the end of larval development and prior to the onset of winter represents a short, critical period for energy storage in age-0 pollock. This links to results from Heintz *et al.*, who showed that pollock survival to age-1 can be predicted by the condition of age-0 pollock prior to their first winter, and that survival is improved by cold conditions in the eastern Bering Sea.

Another highlight is a series of five papers centered on the human dimension in the eastern Bering Sea. Fienup-Riordan *et al.*, Fall *et al.*, and Huntington *et al.* pursued a diverse range of approaches to show interconnectedness between people, culture, change, and the environment. Case studies included Fienup-Riordan *et al.*'s collaborative perspective on the coastal community of Emmonak, Alaska, placing subsistence harvest survey and interview data into an ethnographic and historical context and arguing that a comprehensive approach, including both local and traditional knowledge and cultural history, is essential in understanding contemporary Bering Sea communities. Another collaborative study brought climate and interdisciplinary scientists, harvest and management specialists, and local hunters together to examine environmental influences on walrus hunting success, showing that factors other than ice and wind conditions (*e.g.*, fog and fuel prices) collectively dominate the variability in harvest levels.

Fig. 4 The participants of the Friday Harbor workshop on "Sea ice and large crustacean zooplankton in the eastern Bering Sea". Photo by T. van Pelt.

Peer-reviewed publications will shape the core accomplishment of the Bering Sea Project, but participants also are communicating their work in a variety of other ways. The 2013 Alaska Marine Science Symposium in Anchorage was again a popular venue for presenting Bering Sea Project results, with a dozen talks and 20 posters. And 30 PIs and collaborators came together for an NSF-sponsored 'synthesis' workshop in late February 2013 at the Friday Harbor Labs on San Juan Island, Washington, focusing on the impact of sea ice on bottom-up and top-down controls of crustacean zooplankton (Fig. 4); for more information see http://www.jisao.washington.edu/data/BEST-BSIERP.

Looking forward, the Project Steering Committee submitted a proposal for a special session at the upcoming AGU/ASLO/TOS Ocean Sciences Meeting to be held in Honolulu, Hawaii, in February 2014. The Science Advisory Board and program managers are also planning a one-day 'Open Science Meeting' in conjunction with the 2014 Ocean Sciences Meeting. This is intended as one of the final activities before 'closing' the Project and also to welcome participation by people in other programs or regions. Program managers are currently soliciting expressions of interest for this meeting to help plan the logistics and scientific program and also to better anticipate participation in these times of strained travel budgets—visit http://bsierp.nprb.org/meetings/index.html for more information and an online survey.

2013 surveys planned

Fisheries oceanography surveys are planned for summer and fall 2013. Hokkaido University's T/S *Oshoro Maru* will conduct a survey in the Bering Sea and Chukchi Sea from June 16–July 31. NOAA's Alaska Fisheries Science Center will conduct a forage fish acoustic, surface and mid-water trawl survey in the northern Bering Sea and eastern Chukchi Sea (Arctic EIS, 2nd year), on the F/V *Bristol Explorer*, from August 1–September 2; an eastern Bering Sea bottom trawl survey on board the F/V *Aldebaran* and F/V *Alaska Knight*, from June 3–August 9, and a Chukchi Sea survey (ArcWEST program), from August 19–September 12. The Russian Pacific Federal Fisheries Research Institute (TINRO) will conduct two complex surveys in the western Bering Sea on the R/V *Professor Kizivetter*, from June 2–July 17 (salmon survey) and R/V *TINRO*, from August 8–October 10 (emphasis on pollock and salmon).

Upcoming science meetings

Meetings in the second half of 2013 and first half of 2014 of interest to scientists working in the Bering Sea include:

- PICES Annual Meeting, October 11–20, 2013, Nanaimo, Canada;
- Alaska Marine Science Symposium, January 21–25, 2014, Anchorage, U.S.A.;
- AGU/ASLO/TOS Ocean Sciences Meeting, February 23–28, 2014, Honolulu, U.S.A.

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Dr. Lisa Eisner (lisa.eisner@noaa.gov) is a Biological/Fisheries Oceanographer at the Alaska Fisheries Science Center of NOAA-Fisheries in Juneau, Alaska. *Her research has focused on oceanographic processes that influence phyto-plankton and zooplankton dynamics and fisheries in the eastern Bering Sea. Lisa has been the lead oceanographer for the U.S. component of the BASIS program (Bering Aleutian Salmon International Surveys). She is a scientific steering committee member of NOAA's Fisheries and the Environment program (FATE) and a co-PI on current (and past) Bering Sea and Chukchi Sea research programs.*