FY 2011 Accomplishments and FY 2012 Plans

July 2011

Alaska Fisheries Science Center and

Pacific Marine Environmental Laboratory

FY 2011 Accomplishments

North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) in FY 2011 helped NOAA and the United States understand how varying climate conditions affect marine ecosystems of the North Pacific Ocean. NPCREP's mission is to conduct research on climate variability and ecosystem response in the North Pacific, focusing on the productive waters of the eastern Bering Sea, Gulf of Alaska, and the Chukchi Sea. The intent of this research is to improve scientific understanding and provide guidance for resource managers on strategies for climate adaptation. NPCREP has two long-term goals that address its mission. The first goal is to observe, understand and predict relationships between climate and ecosystems. The second goal is to help society plan for and mitigate potential impacts of climate change on our living marine resources.

NPCREP is a highly collaborative program that works with other NOAA marine research programs such as Fisheries-Oceanography Coordinated Investigations (FOCI), Ocean Acidification (OA), Loss of Sea Ice (LOSI) and institutions such as the University of Washington, University of Alaska, Fairbanks, and Oregon State University.

PRIORITIES

For FY 2011, NPCREP established the following priorities:

- Maintain long-term observation network
- Increase our understanding of climate change in the Arctic
- Incorporate environmental data into forecast and stock assessment models

ACCOMPLISHMENTS

Specifically during 2011, NPCREP worked to accomplish the following tasks, generally classified into broad categories of *observe*, *understand*, and *predict*.

Observe

FY 2011 MILESTONE: Maintain the NPCREP Climate and Ecosystem Observing Network, and distribute data to our stakeholders.

NPCREP preserved and expanded NOAA's only existing Arctic biophysical observing system to detect climate impacts on marine ecosystems in FY 2011. The following tasks were completed:

- Delivered to our stakeholders long-term observations of the Bering Sea using biophysical moorings (M2, M4, M5, M8), and shipboard measurements of physical, chemical, and biological variables important to ecosystem health and to the recruitment of commercial fin- and shellfish stocks of the eastern Bering Sea. This year, 2011, marks the 17th consecutive year of these observations, further strengthening our understanding of both quasi-decadal and annual trends in atmospheric forcing, oceanography and fisheries recruitment in the Bering Sea. It also continues to be one of the only sources of data for physics, climate and lower trophic levels available for an integrated ecosystem assessment.
- NPCREP has partnered with NOAA/PMEL's Ocean Acidification group to include the first pCO_2 sensor in the Arctic on mooring M2.

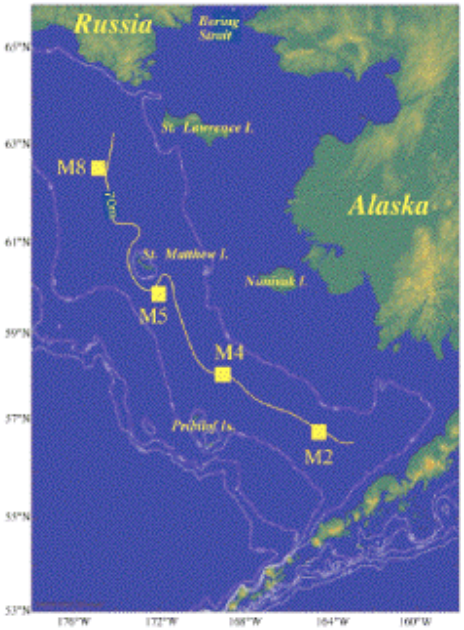

Figure 1. NPCREP's 4 sentinel moorings in the eastern Bering Sea located along the 70m isobath.

FY 2011 MILESTONE: Conduct a research cruise to investigate physics, chemistry, and lower trophic levels of the southeast Alaskan shelf, a subarctic ecosystem.

The purpose of this research is to describe the physical and biological oceanographic conditions in the highly productive eastern Gulf of Alaska and integrate this information with concurrent surveys of upper trophic levels as part of the Gulf of Alaska Integrated Ecosystem Research Program (GOA IERP). This first cruise took place during 30 April – 21 May 2011 (Seattle – Kodiak-Seattle) aboard the R/V *Thomas G. Thompson* and deployed CTD, bongo, neuston, and

MOCNESS nets, and satellite-tracked drifters. Progress was documented by a cruise report and distribution of data to GOA IERP program databases (http://www.ecofoci.noaa.gov/cruiseWeb/tn263_April2011/).

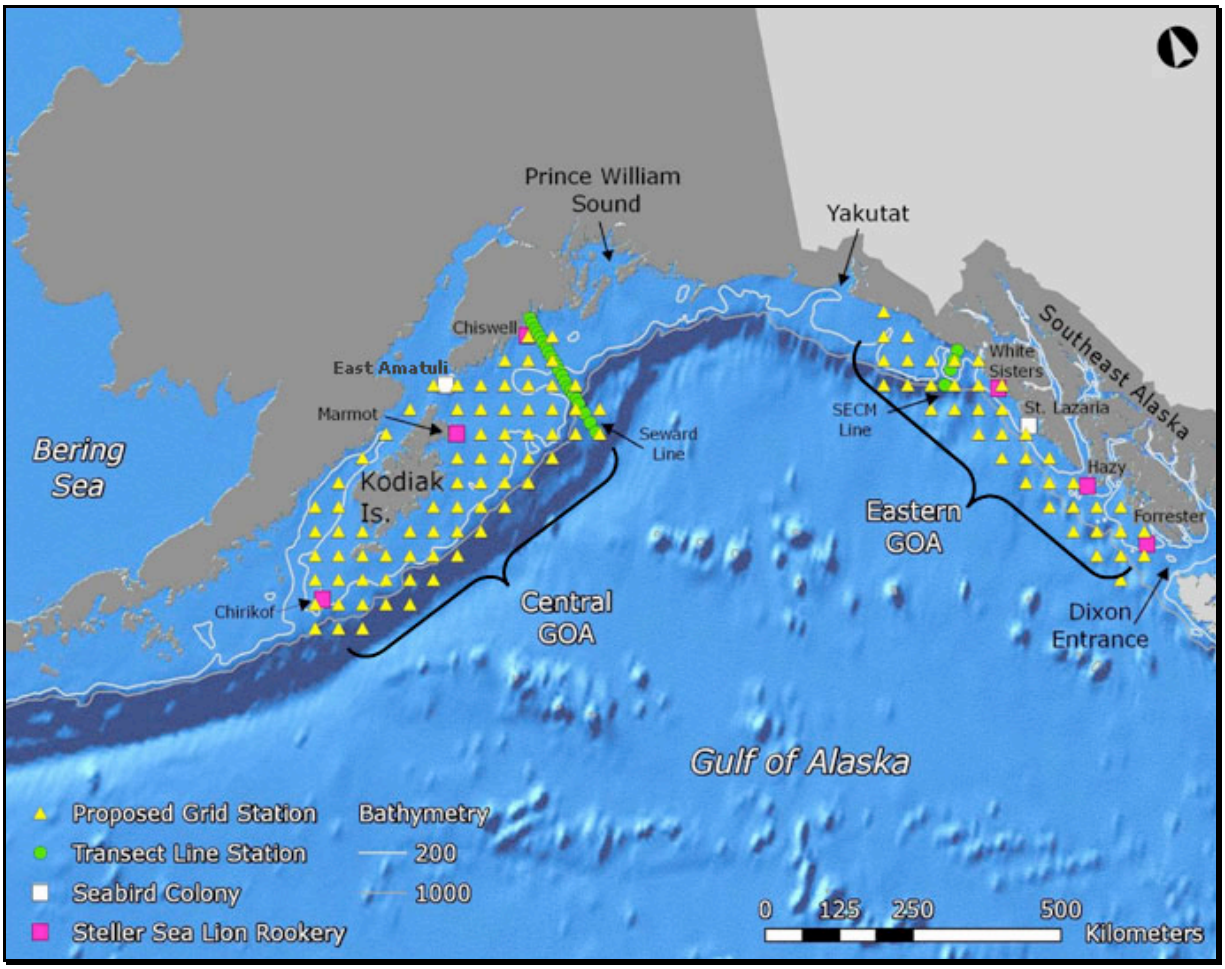

Figure 2. The established grid enables comparison of climate-mediated forcing on the eastern (narrow shelf) and western (wide shelf) portions of the Gulf of Alaska.

This was just one of twelve cruises in this inter-disciplinary project. Investigators from the Univ. Alaska, Fairbanks accomplished comparable sampling in the western Gulf of Alaska on the R/V *Tiglax* while the R/V *Thompson* was sampling the eastern Gulf. During the spring and summer other program modules (Middle and Upper Trophic Level Components) will be taking physical, chemical, and biological samples for NPCREP using charter vessels (e.g. F/V *Northwest Explorer*).

NPCREP and FOCI's previous efforts in the western Gulf helped to lay the groundwork for the current climate and ecosystem studies. For the past 25 years we have been leveraging NOAA funding and logistical support with specific project support from NSF (GLOBEC), NOAA's NOS, AOOS, and NPRB to increase our understanding of the operative mechanisms in the Gulf. Examples of two recent publications resulting from previous NPCREP work are:

Cheng, W., A. Hermann, K. Coyle, E. Dobbins, N. Kachel, and P. Stabeno (2011): Macro- and micro-nutrient flux to a highly productive submarine bank in the Gulf of Alaska: A model-based analysis of daily and interannual variability. *Prog. Oceanogr.. Submitted*

Stabeno, P and C. Paternostro, Tidal and mean currents in Cross Sound, Alaska. To be submitted in September.

Understand

FY 2011 MILESTONE: Increase our understanding of the effect of climate variability on Alaska's Arctic Large Marine Ecosystems

High latitude ecosystems respond to climate change with rapid and fundamental alterations. In recent years, summer sea ice in the Arctic Ocean has reached minima not observed in recorded history and multiple models predict the complete loss of summer sea ice by the year 2030. NPCREP and its partners have accomplished four distinct research goals in FY 2011 that increase our understanding of climate change in Arctic LMEs:

1. **Characterize ecosystem differences during warm and cold years in the eastern Bering Sea** (Stakeholders = North Pacific Fishery Management Council, North Pacific Research Board, NOAA Alaska Regional Office, university, state and federal agency, NGO scientists).

As part of the BEST / BSIERP programs, NPCREP synthesized our knowledge of ecosystem conditions during warm and cold years, in both the northern and southern eastern Bering Sea. Because BEST/BSIERP only sampled "cold" years during their 3-year field season, the synthesis would not have been possible without NOAA's support of previous and current programs such as BS FOCI, SEBSCC and NPCREP. These NOAA programs provided valuable data and interpretation expertise to assemble the hypotheses for what happens in warm and cold years.

The Bering Sea is a subarctic sea and as such sits on the boundary of the Arctic. These high latitude seas are very sensitive to changes in climate. We continue to monitor the Bering Sea through a series of biophysical moorings and research cruises. The data from these sources have been used to examine the changes which have occurred as a result of changing climate and to anticipate what the impacts on the ecosystem would be with the predicted warming. Our results are presented in a series of eight manuscripts that explore the occurrence of warm and cold years in Bering Sea during the last several decades and their impact on the Bering Sea ecosystem. Three of the papers are published, and the other five will appear in the Bering Sea special issue of *Deep-Sea Research II* in 2012.

Hunt, Jr., G. L., K.O. Coyle, L. Eisner, E.V. Farley, R. Heintz, F. Mueter, J.M. Napp, J. E. Overland, P.H. Ressler, S. Salo, and P. J. Stabeno (2011): Climate impacts on eastern Bering Sea foodwebs: A synthesis of new data and an assessment of the Oscillating Control Hypothesis. *ICES J. Mar. Sci*., 68(6): 1230–1243.

Ianelli, J.N., A.B. Hollowed, A.C. Haynie, F.J. Mueter, and N.A. Bond (2011): Evaluating management strategies for eastern Bering Sea walleye pollock (*Theragra chalcogramma*) in a changing environment. *ICES J. Mar. Sci*., 68(6): 1297–1304.

Ladd, C., and P.J. Stabeno (2011): Stratification on the Eastern Bering Sea Shelf revisited. *Deep-Sea Res. II* (special issue). *Accepted*.

Mueter, F., N. Bond, J. Ianelli, and A. Hollowed (2011): Expected declines in recruitment of walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea under future climate change. *ICES J. Mar. Sci.*, 68(6): 1284–1296.

Overland, J.E., M. Wang, K.R. Wood, D.B. Percival, and N.A. Bond. Recent Bering Sea warm and cold events in a 95-year perspective. *Deep-Sea Res. II* (special issue). *In revision*.

Stabeno, P., N. Kachel, S. Moore, C. Mordy, J. Napp, J.E. Overland, A.I. Pinchuk, and M. Sigler (2010): A comparison of the physics, chemistry, and biology of the northeastern and southeastern Bering Sea shelf. *Deep-Sea Res. II* (special issue). *In revision.*

Stabeno, P., S. Moore, J. Napp, M. Sigler, and A. Zerbini (2010): Comparison of warm and cold years on the southeastern Bering Sea shelf. *Deep-Sea Res*. *II* (special issue). *Accepted*.

Wang, M., J.E. Overland, and P. Stabeno (2011): The projections on the climate of the Bering Sea and its vicinity by coupled global climate models. *Deep-Sea Res. II* (special issue). *Submitted.*

2. Conduct baseline ecosystem studies in the Chukchi Sea

(Stakeholders = North Pacific Fishery Management Council, BOEMRE, Department of the Interior, Alaska Regional Office, other scientists, coastal communities)

The Chukchi and Beaufort Seas contain part of the U.S. Exclusive Economic Zone (EEZ). At present there is a moratorium on commercial fishing in this region, although there is subsistence harvest of finfish, shellfish, and protected species. NPCREP has begun to study the structure and function of the Chukchi Sea ecosystem to better manage this LME and understand the potential impacts of climate change and associated human activities in the region,.

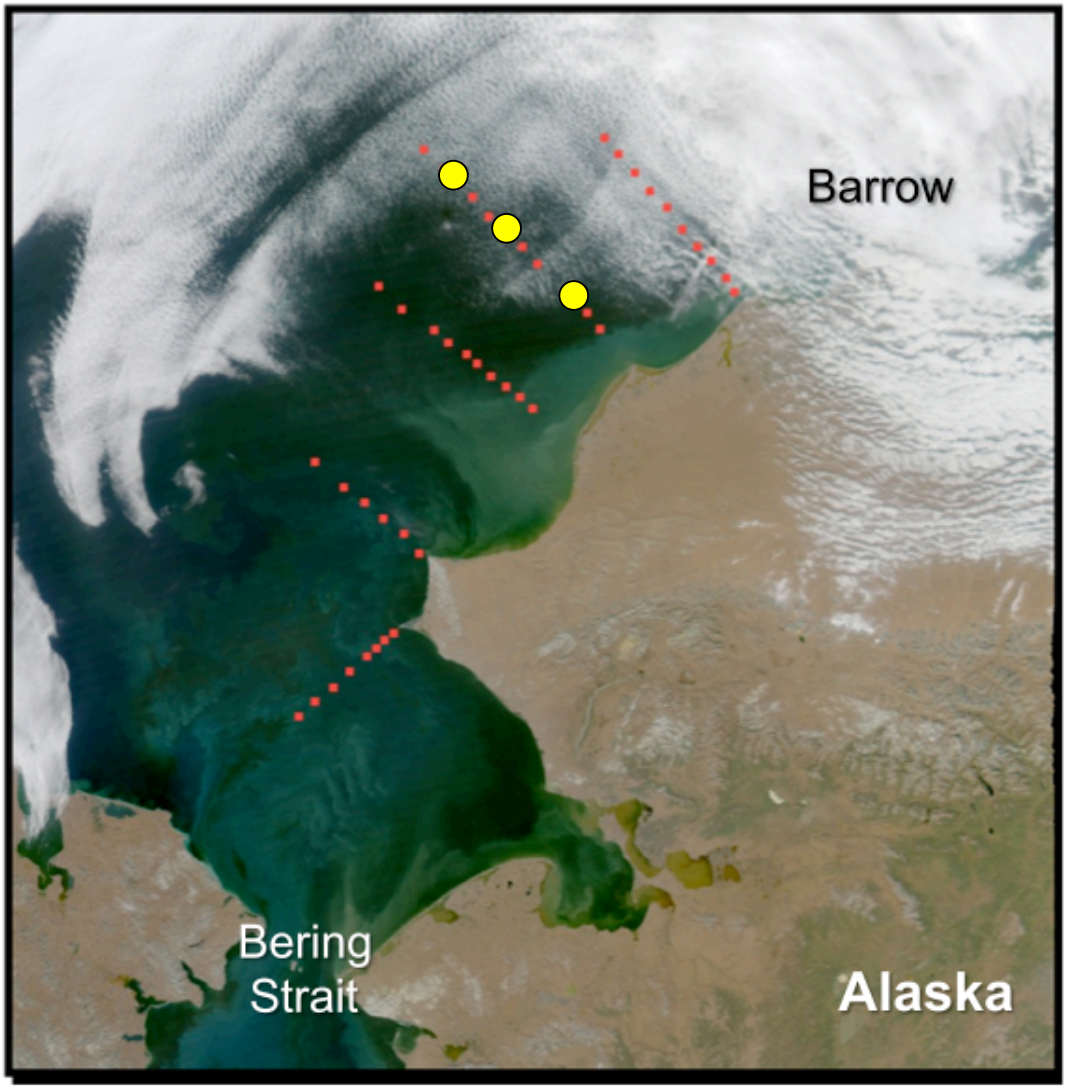

Figure 3. True color satellite image of the Chukchi Sea showing mesoscale variability in ocean color (sediment and chlorophyll). NPCREP survey stations (●), Biophysical moorings (●).

Last year NPCREP began baseline measurement of the physics, chemistry, and plankton biology of the Chukchi Sea off the north slope of Alaska with support from NOAA and the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE; Fig. 3). These studies will help provide necessary data for an Arctic Fishery Ecosystem Plan, future environmental impact statements related to oil and gas exploration in the region, and future definitions of critical habitat for protected species that use this region. One of the strengths of NPCREP that interested BOEMRE was our success with biophysical moorings and our ability to make year-round measurements. In September 2010, we deployed 7 moorings along a cross shelf transect at Icy Cape and made stations measurements along transects at Point Hope, Cape Lizborne, Point Lay, Icy Cape, and Wainwright. In August of FY11 we will return to the region recover the moored instruments and deploy 8 new moorings. We will also repeat the transect lines begun in 2010 to characterize the habitat, and examine inter-annual variability in physical, chemical, and biological oceanographic properties.

NPCREP also successfully built and calibrated its first zooplankton active acoustics instrument for deployment on moorings. This instrument, patterned after the TAPS-6NG (Tracor Acoustic Profiling System), has 6 acoustic transducers between 104 and 735 kHz to detect scattering by euphausiids in a shallow water column (ca. 40 m). The instrument will be deployed in August of 2011 and recovered August/September of 2012 and will sample every 30 – 60 minutes during the year long deployment.

3. **Characterize summer and cross-shelf transport of larval fishes in the eastern Bering Sea**
   (Stakeholders = North Pacific Fishery Management Council, North Pacific Research Board, other university, federal and stage agency, and NGO scientists).

We initially characterized summer transport of fish larvae across the outer and middle shelf using 5 years of data collected from the T/S *Oshoro Maru.* During El Niño years, the larval fish assemblage over the shelf included many more offshore species indicating enhanced onshelf transport. A subsequent analysis now includes an additional 5 years and spans years of warm and cold temperatures. This piece of work is still evolving. A draft manuscript will be complete for in-house editing and revision by the end of FY11.

We continue to examine the cross-shelf transport of a number of larval fish species, comparing and contrasting strategies of late winter/slope spawners with early spring/shelf spawners. Commercial species of interest are Greenland halibut, walleye pollock, Pacific cod, and Pacific halibut. Greenland halibut is an example of a late winter/slope spawner. There have been no directed field studies examining spawning areas and transport of Greenland halibut early life stages in the Bering Sea, nor is it known how large-scale oceanographic forcing modulates specific physical mechanisms of delivery. Results from this project are being prepared for submission to a peer-reviewed journal and presentation at the International Flatfish Symposium at the beginning of FY12. For the spring/shelf spawners, one of the interesting results was the transport of eggs to juvenile walleye pollock over the shelf in warm and cold years. In cold years, all of these early stages are found over the Outer Shelf Domain, while in warm years they are found over the Middle Shelf Domain. This differential transport in warm and cold years implies less cross-shelf transport in cold years (assuming that spawning area is fixed) and has large consequences on the types and availability of prey for the larvae.

Examples of Products:

Duffy-Anderson, J.T., W. Cheng, A.C. Materese, D.M. Blood, D. Sohn, P.J. Stabeno, L. Ciannelli and T.C. Vance. Combining field observations and modeling approaches to examine Greenland halibut (*Reinhardtius hippoglossoides*) early life ecology in the southeastern Bering Sea. *Mar. Ecol. Prog. Ser., in preparation.*

Parada, C., B. Ernst, S. Hinckley, J.M. Orensanz, D.A. Armstrong, E.N. Curchitser and A.J. Hermann. Patterns of connectivity and potential settlement regions of snow crab (*Chionoecetes opilio*) larvae in the eastern Bering Sea. *Prog. Oceanogr., accepted.*

Smart, T., J.T. Duffy-Anderson, J.K. Horne, E.V. Farley, C.D. Wilson and J.M. Napp. Influence of small- and large-scale environmental variability on walleye pollock eggs, larvae, and juveniles in the Bering Sea. *Deep-Sea Res., II* (special issue)*, accepted*.

4. **Create guidelines for plankton sampling survey design to optimize surveys (minimize the variance) and give scientists the best possible chance of detecting climate-mediated changes in these environments**
   (Stakeholders = NMFS, other scientists)

Sampling efficiency for zoo- and ichthyoplankton is an important goal in this time of shrinking ship budgets. Multiple programs within NMFS engage in plankton sampling either as part of an annual stock assessment or to provide data on ecological factors that affect the recruitment of commercial and protected species. Very few guidelines exist for how these studies should be conducted with reference to number and spacing of stations. Often these are determined solely by logistical considerations (number of vessel days, speed of vessel, area to be sampled).

In FY11 NPCREP scientists began a numerical simulation exercise to examine the statistics of these sampling efforts using actual larval fish and plankton distributions collected on eastern Bering Sea and Chukchi Sea cruises. The statistical simulations performed for this work were key to developing an FY12 midwater survey of the Chukchi Sea for NOAA's Loss of Sea Ice initiative. The simulation methods and results will be prepared in FY12 for peer-reviewed publication. This work was also invaluable when trying to negotiate a master grid of stations for the Gulf of Alaska Integrated Ecosystem Research Program (GOA IERP; Fig. 2). The master sampling grid was established in FY11 and benefited from the results and experience of NPCREP's examination of sampling variability.

Advise and inform

The primary target audience for results from NPCREP research is the members and committees of the North Pacific Fishery Management Council. NPCREP provided essential information on climate and ecosystems to the Council and other stakeholders during FY 2011.

FY 2011 MILESTONE: Deliver an eastern Bering Sea ecosystem synthesis to the North Pacific Fisheries Management Council

At the end of FY 2010 we worked with the authors of the Ecosystem Considerations Chapter (ECC) to alter the format of the annual report as requested by the Science and Statistical Committee (SSC) of the Council. We worked with the lead authors of the chapter to adopt the Committee's suggestion to make the main focus of the chapter a text synthesis rather than a reporting of indices. A series of workshops were held at the end of FY10 on how to develop the synthesis, and the synthesis was written in early FY11 in time for the Council's November meeting.

This synthesis enables an ecosystem-based approach to fisheries management in the region. The synthesis was delivered in the form of a Bering Sea Ecosystem Report Card in the Ecosystems Considerations Chapter, and reviewed by the Science and Statistical Committee of the Council. This is viewed as an ongoing commitment of NPCREP. The process of assimilating data and writing annual syntheses is part of our effort to improve prediction and reduce uncertainty in ecosystem forecasts.

In addition, NPCREP Program Leaders met with the lead authors of the individual assessment chapters (Plan Team reports) to discuss how and which climate indices to incorporate directly into the single stock assessments for 2011.

Relevant Products:
Bering Sea Ecosystem Report Card: http://access.afsc.noaa.gov/reem/ecoweb/Index.cfm

Livingston, P.A., K. Aydin, J.L. Boldt, A.B. Hollowed, and J.M. Napp. 2011. Alaska marine fisheries management: Advances and linkages to ecosystem research. In A. Belgrano and C.W. Fowler (Eds.), *Ecosystem-base Management for Marine Fisheries: and Evolving Perspective* (pp. 113-152). Cambridge University Press.

CHALLENGES

A major and growing concern for NPCREP remains ship time. The Program is a frequent user of OMAO and UNOLS vessels to maintain the observation network and to conduct process studies. With removal of the NOAA Ship *Miller Freeman* from the NOAA fleet, the only NOAA oceanographic/fisheries boat in Alaskan waters is the FSV *Oscar Dyson*. The *Dyson* consistently sails fewer days than the *Freeman* did, because of a combination of insufficient funds and continued equipment and staffing problems. Historically, we have used the NOAA West Coast Charter funds to supplement the decreasing NOAA ship time. These are funds granted to OAR to replace the three Class-I vessels retired from the fleet some years ago. This year, a considerable portion of those funds was reprogrammed to supplement the NOAA fleet. This resulted in the loss of a cruise on the *R/V Thompson* to the Bering Sea. While the *Dyson* was made available to recover moorings, we were unable to accomplish the complete scope of work planned on the *Thompson,* because of the *Dyson*'s smaller size. In addition, the West Coast Charter funds have not increased for the last decade, while the cost of ship time has almost doubled due to rising labor and fuel costs.

FY 2012 Plans

STATEMENT OF WORK

North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) in FY 2012 will continue to help NOAA and the United States understand how varying climate conditions affect marine ecosystems and living marine resources of the North Pacific Ocean. NPCREP's mission is to conduct research on climate variability and ecosystem response in the North Pacific, focusing on the productive waters of the eastern Bering Sea, Gulf of Alaska, and most recently, the Chukchi Sea. The intent of this research is to improve scientific understanding and provide guidance for resource managers on climate adaptation. NPCREP has two long-term goals that address its mission. The first goal is to observe, understand and predict relationships between climate and ecosystems. The second goal is to help society plan for and mitigate potential impacts of climate change on our living marine resources.

NPCREP is a highly collaborative program that works with other NOAA marine research programs such as Fisheries-Oceanography Coordinated Investigations (FOCI), Ocean Acidification (OA), Loss of Sea Ice (LOSI) and institutions such as the University of Washington, University of Alaska, Fairbanks, and Oregon State University.

PRIORITIES

For FY 2012, NPCREP has priorities that build upon our past successes:

- Operate our observation network and recruit new users and stakeholders.
- Increase understanding of mechanisms linking climate and ecosystem productivity.
- Incorporate environmental data into forecast/stock assessment models.

Specifically during 2012, NPCREP will work to accomplish the following tasks, generally classified into broad categories of *observe*, *understand*, and *advise and inform*.

Observe

NPCREP monitors changes in coastal and marine ecosystems through a network of *in-situ* and remote observing systems. For FY 2012, NPCREP will continue the NPCREP portion of EcoFOCI's existing biophysical observing system to detect climate impacts.

FY 2012 MILESTONE: Maintain the NPCREP Climate and Ecosystem Observing Network, and distribute data to stakeholders.

Deliver to our stakeholders long-term observations of the Bering Sea using biophysical moorings (M2, M4, M5, M8), and shipboard measurements of physical, chemical, and biological variables important to ecosystem health and the recruitment of commercial fin-

and shellfish stocks of the eastern Bering Sea. This year (2012) will mark the 18th consecutive year of these observations, further strengthening our understanding of both quasi-decadal and annual trends in Bering Sea atmospheric forcing, oceanography and fisheries recruitment. It will also continue one of the only sources of data for atmosphere, physics, and lower trophic levels available for an integrated ecosystem assessment. The longer we are able to continue our time series, the more valuable they become and the more power we have to detect low frequency climate-mediated forcing of the ecosystem.

Specifically, in FY 2012 NPCREP will:

- Continue to operate the array of moorings in the Bering Sea, NOAA's only biophysical observation network in the Arctic
- Continue to partner with UAF & PMEL's Ocean Acidification group to provide a platform for a pCO_2 sensor on M2 and to analyze the first moored data collected in the Arctic from the pCO_2 sensor in FY 2011
- Encourage other scientists to use the moorings as platforms of opportunity to leverage the amount and types of data collected at these sites
- Continue to operate a mooring in Chiniak Bay and another in Pavlof Bay (Gulf of Alaska)

Understand

FY 2012 MILESTONE: Increase our understanding of the effect of climate variability on Alaska's Arctic Large Marine Ecosystems

High latitude ecosystems respond to climate change with rapid and fundamental alternations. In recent years, summer sea ice in the Arctic Ocean has reached minima previously not observed in recorded history and multiple models predict the complete loss of summer sea ice by the year 2030. The Chukchi and Beaufort Seas contain parts of the U.S. EEZ. At present there is a moratorium on commercial fishing in this region although there is subsistence harvest of finfish, shellfish, and protected species. To better manage these ecosystems and understand the potential impacts of climate change and associated human activities in the region, NPCREP will continue to study the structure and function of the Chukchi Sea ecosystem. Progress will be documented by manuscripts, reports, text, tables, and/or figures that demonstrate advances in our knowledge of climate mediated physical – biological interactions in the EEZ of the Chukchi Sea.

Specifically, in FY 2012 NPCREP will:

For the eastern Bering Sea --

- Publish the first major synthesis of Bering Sea ecosystem science in 10 years (*Deep-Sea Research II* special issue).

- Participate in an NSF-sponsored synthesis project. Begin the second level integrative synthesis of NOAA, NSF, and NPRB-sponsored climate-ecosystem research for the eastern Bering Sea.
- Submit new manuscripts to the second special BEST/BSIERP issue that describe new understanding of climate-mediate change in this productive.

For the Chukchi Sea –

- Redeploy temporary moorings in the Chukchi Sea as part of the Chukchi Acoustics, Oceanography, and Zooplankton study (CHAOZ)
- Complete two, ship-based fall research expeditions in the Chukchi Sea as part of the CHAOZ and Loss of Sea Ice (LOSI) programs. Both will conduct midwater assessment, lower trophic level and physical oceanography studies.
- Lay the groundwork with BOEMRE to expand the Chukchi observing system to include a permanent array of moorings.
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FY 2012 MILESTONE: Develop and utilize models to better understand ecosystem dynamics in the Gulf of Alaska, Bering Sea, and Arctic

NPCREP will use both existing models and develop new models in FY 2012 to explore the physical and biological dynamics of Alaska's Large Marine Ecosystems. Specifically we will:

- Use models to explore climate-mediated nutrient replenishment on the SE Gulf of Alaska shelf, and to explore differences in current dynamics between warm and cold years
- Continue development of five individual-based models (IBM) for the commercially important walleye pollock, Pacific cod, Pacific ocean perch, and sablefish, and the ecologically important arrowtooth flounder in the Gulf of Alaska
- Evaluate models and use where appropriate to understand climate-mediated cross-shelf fluxes in SE Alaska

FY 2012 MILESTONE: Seasonal comparison of larval fish mortality and survival in the Gulf of Alaska and Bering Sea

NPCREP is forming a new partnership with NOAA's Bering-Aleutian Salmon International Survey (BASIS) group in FY12 to begin a seasonal comparison of larval fish mortality and survival from eggs to age-1. These investigations will alternate between the Gulf of Alaska and the Bering Sea. In FY12 the surveys will focus on the eastern Bering Sea.

Advise and inform

The target audience for results from NPCREP research is the members and committees of the North Pacific Fishery Management Council. NPCREP will provide essential information on climate and ecosystems to the council and other stakeholders during FY 2012.

FY 2012 MILESTONE: Deliver an eastern Bering Sea ecosystem synthesis to the North Pacific Fisheries Management Council.

This synthesis will continue as part of an iterative process to increase the level of accuracy of our forecasts and to reduce forecast uncertainty. This will enable an ecosystem-based approach to fisheries management in the region. NPCREP will work with the main authors of the Ecosystem Considerations Chapter to improve the product in 2011 based on the comments/critique of the SSC. The synthesis will again be delivered in the form of a Bering Sea Ecosystem Report Card in the Ecosystems Considerations Chapter, and will be reviewed by the Science and Statistical Committee of the Council.

In addition, NPCREP Program Leaders will meet with the lead authors of the individual assessment chapters (Plan Team reports) again in FY 2012 to re-evaluate which climate indices should be incorporated into the single stock assessments. (http://access.afsc.noaa.gov/reem/ecoweb/Index.cfm).