

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

Please Note: Semiannual Progress Reports are due on October 1 or April 1 (whichever comes first) after the contract start date, and then every semester thereafter until the contract is completed. If the first report comes due before substantial progress has been made, please just note that in your initial report. If progress reports are delinquent, current and subsequent invoices will not be paid until programmatic requirements are met. Note that this report will be posted on the Board's BSIERP web site and is what Board members, the Science and Advisory Panels, other researchers and the public will see as representational of your research and its quality.

Email electronic copy to tvanpelt@nprb.org using **this subject line format:**
BSIERP Project XXX Progress Report

If you have questions, please contact Thomas Van Pelt at (907) 644-6715 or tvanpelt@nprb.org

[Please be concise; aim for 2-5 pages depending on the scope of your project]

Project #: B62

Title: Fish Forage distribution and ocean conditions

Principal Investigator(s) and Recipient Organization(s): (Include email contact information)

Lead PI: Dr. Anne B. Hollowed
NOAA/AFSC/REFM
7600 Sand Point Way NE
Seattle, WA 98115
Anne.Hollowed@noaa.gov

PI: Mr. Steve Barbeaux
NOAA/AFSC/REFM
7600 Sand Point Way NE
Seattle, WA 98115
Steve.Barbeaux@noaa.gov

PI: Dr. Patrick Ressler
NOAA/AFSC/RACE
7600 Sand Point Way NE
Seattle, WA 98115
Patrick.Ressler@noaa.gov

PI: Dr. Edward D. Cokelet
NOAA/PMEL
7600 Sand Point Way NE
Seattle, WA 98115
Edward.D.Cokelet@noaa.gov

PI: Dr. Chris Wilson
NOAA/AFSC/RACE
7600 Sand Point Way NE
Seattle, WA 98115
Chris.Wilson@noaa.gov

PI: Dr. Phyllis Stabeno
NOAA/PMEL
7600 Sand Point Way NE
Seattle, WA 98115
Phyllis.Stabeno@noaa.gov

PI: Mr. Stan Kotwicki
NOAA/AFSC/RACE
7600 Sand Point Way NE
Seattle, WA 98115
Stan.Kotwicki@noaa.gov

Contract Period and Amount of Funding:

Report Period:

1 October 2008 - 30 March 2009

Report Date:

1 April 2009

Lead Author of Report:

Dr. Anne B. Hollowed

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

Proposed timeline and milestones within report period: (simply paste in the relevant part of the first-year of your work plan; work plans are posted at http://bsierp.nprb.org/proj_mgt/sow.html)

2009 Tasks, Assignments, Timeline

<i>What</i>	<i>Who</i>	<i>Start</i>	<i>Other key dates</i>
Participate in BSIERP Lead PI meetings	Anne Hollowed	~ Monthly	
Attend BSIERP Retreat	All	October 13, 2008	
Prepare and present preliminary results at Alaska Marine Science Symposium	Anne Hollowed	January 20-23, 2008	
Equip vessel with temperature sensor, and fluorometer	Cokelet, Ned	December 2008 – January 2009	Equip vessel with temperature sensor, and fluorometer
Collect temperature, and chlorophyll information on commercial vessel	Cokelet, Ned	January 2009	Collect temperature, and chlorophyll information on commercial vessel
Evaluate status of nitrate sensor and dissolved oxygen sensor on Oscar Dyson.	Cokelet, Ned	Winter 2009	Evaluate status of nitrate sensor and dissolved oxygen sensor on Oscar Dyson.
Make underway surface temperature, salinity and chlorophyll measurements aboard F/V <i>Aldebaran</i> during the Pollock A Season	Cokelet, E. D.	20 Jan-31 Mar 2009	Data delivery March 2010
Obtain release of data from <i>Aldebaran</i> owner	Cokelet, E. D.	February 2009	
Write manuscript describing results from 2008	Ressler, Pat, Wilson, Chris and Hollowed, Anne	March 2009	Write manuscript describing results from 2008
Fish Component PI meeting. Review results of all related projects.	Hollowed and others	February 26, 2009	
Plan MACE cruise	Ressler, Pat and Wilson, Chris	Winter/Spring	Plan MACE cruise
Distribute special request form for groundfish trawl cruise.	Kotwicki, Stan and Lauth, Bob	March 2009	Distribute special request form for groundfish trawl cruise.
Renew funding for RACE research assistant	Wilson, Chris	Prior to May 15, 2008	Renew funding for RACE research assistant
Analyze euphausiid distribution and abundance	Ressler, Pat and MACE support person	August – December 2008	
Analyze vertical distribution of pollock	Kotwicki, Stan and Ressler, Pat	August 2008 – March 2009	

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

Project Summary:

Our study focuses on the importance of considering the effect of ocean forcing on fish and euphausiids at different spatial and temporal scales. The objective of Project B62 is to understand the response of fish (including forage fish) and euphausiids to shifts in the characteristics of ocean habitat and use that understanding to model the impacts of climate change on their spatial and temporal distribution. This project focuses on spatial patterns of walleye pollock, euphausiids, myctophids, Pacific cod, arrowtooth flounder and capelin.

We will simultaneously sample ocean habitat conditions during acoustic mid-water trawl surveys and groundfish and shellfish bottom trawl surveys during summer and on commercial fishing vessels during summer and winter in order to understand the relation between pollock, euphausiids, Pacific cod, arrowtooth flounder, myctophid and capelin distributions and ocean habitat. Products will include time series, maps and data files for other BSIERP projects. **The major product of this effort will be scientific discoveries that will define the seasonal movement rules for fish that will be used to construct spatial models of the Bering Sea ecosystem.**

Specific hypotheses addressed by this project include:

1. Climate-induced changes in physical forcing will modify the availability and partitioning of food for all trophic levels through bottom-up processes. Specifically:
 - b. Reduced frequency and intensity of summer storms will reduce surface mixing and increase sea surface temperature, thereby increasing stratification. A substantial decrease in summer winds will result in a mixed layer that is shallower than the euphotic zone, extensive subsurface primary production and depletion of nutrients in the entire water column. There will be no fall phytoplankton bloom. A moderate decrease or no change in the intensity of summer storms will reduce replenishment of nutrients to the euphotic zone, lowering summer primary and secondary production. Both scenarios will reduce juvenile fish production by reducing their condition (energy density) and over-wintering capability.
2. Climate and ocean conditions influencing water temperature, circulation patterns and domain boundaries impact fish reproduction, survival and distribution, the intensity of predator-prey relationships and the location of zoogeographic provinces through bottom-up processes. Specifically:
 - a. As heat content increases, the area suitable for spawning and foraging by subarctic species will expand northward and subarctic species will occupy areas formerly occupied by Arctic species.
 - b. Reduced cold pool extent will increase overlap of inner domain forage fish and outer domain piscivores.
 - c. Strength of frontal boundaries will weaken due to absence of the summer cold pool, allowing expansion of the inner domain and juvenile and forage fish habitat there. Weaker winds will enhance this effect.
 - e. Expected decreases in benthic productivity will negatively affect feeding and survival of small flatfish and crab thereby lowering population levels.
3. Later spring phytoplankton blooms as a result of early ice retreat will increase zooplankton production, thereby resulting in increased abundances of piscivorous fish (pollock, cod and arrowtooth flounder) and a community controlled by top-down processes [Oscillating Control Hypothesis] with the possible trophic consequences:
 - a. Competition with abundant, piscivorous fish species for forage species will lead to a decline in murre, kittiwakes and fur seals.
 - c. In a top-down control community, fishing will reduce the degree of top-down control of forage species (including juvenile pollock) by adult pollock, cod and arrowtooth flounder. Owing to light exploitation rates, top-down control by arrowtooth flounder will increase, as will their level of competition with piscivorous fish, seabirds and marine mammals. As a result of these two processes, arrowtooth flounder will determine ultimate community composition, such that the climax community will be arrowtooth flounder-dominated (similar to the Gulf of Alaska).

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

4. Climate and ocean conditions influencing circulation patterns and domain boundaries will affect the distribution, frequency and persistence of fronts and other prey-concentrating features and thus the foraging success of marine birds and mammals largely through bottom-up processes. Specifically:
 - a. Climate-ocean changes will displace predictably located, abundant prey (hot spots).
5. Climate-ocean conditions will change and thus affect the abundance and distribution of commercial and subsistence fisheries. Specifically:
 - a. For commercial fishermen, these changes will lead to: 1) a change in home ports and distribution of fishing vessel rents, 2) vessels traveling further, incurring greater fuel costs and peril at sea and 3) greater burden on smaller vessels.

Progress Summary:

All but two of the milestones due before or within this reporting period were met and the necessary preparations to meet the future milestones have been made.

Participate in BSIERP Lead PI meetings

These meetings have been attended by Anne Hollowed and occasionally by other PIs.

Attend BSIERP retreat

Anne Hollowed, Ned Cokelet, Steve Barbeaux, and Patrick Ressler attended meeting in Girdwood, AK, October 2008, and presented posters. See list of presentations and posters.

Prepare and present preliminary results at Alaska Marine Science Symposium

Anne Hollowed, Ned Cokelet, and Patrick Ressler attended the AMSS meeting. See list of presentations and posters.

Equip vessel with temperature sensor and fluorometer; collect temperature and chlorophyll information on commercial vessel; evaluate status of nitrate sensor and dissolved oxygen sensor on Oscar Dyson; make underway surface measurements aboard F/V Aldebaran during Pollock A Season

We delivered the underway oceanographic temperature, salinity, chlorophyll and position data and the requisite metadata for the 2008 Pollock A Season (Fig. 1) and the 2008 bottom trawl survey to the BSIERP data managers on 27 March 2009.

We prepared the underway oceanographic instruments on F/V *Aldebaran* for the winter 2009 Pollock A Season. The system has been working well, and data CDs have been received for measurements to 17 March 2009. We prepared the underway oceanographic instruments NOAA's *Oscar Dyson* for the 2009 field season.

In 2008 over 400 net trawls were made with the CTDs aboard. Data processing and evaluation has been initiated.

Obtain release of data from Aldebaran owner

One milestone has not yet been met. We have not requested a release of data from the F/V *Aldebaran* owners (Trident Seafoods) for the 2009 Pollock A Season because the season is not over. We will request the release after the season ends when we can show the owners maps of the temperature, salinity and chlorophyll data for the entire season. We anticipate no problems.

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

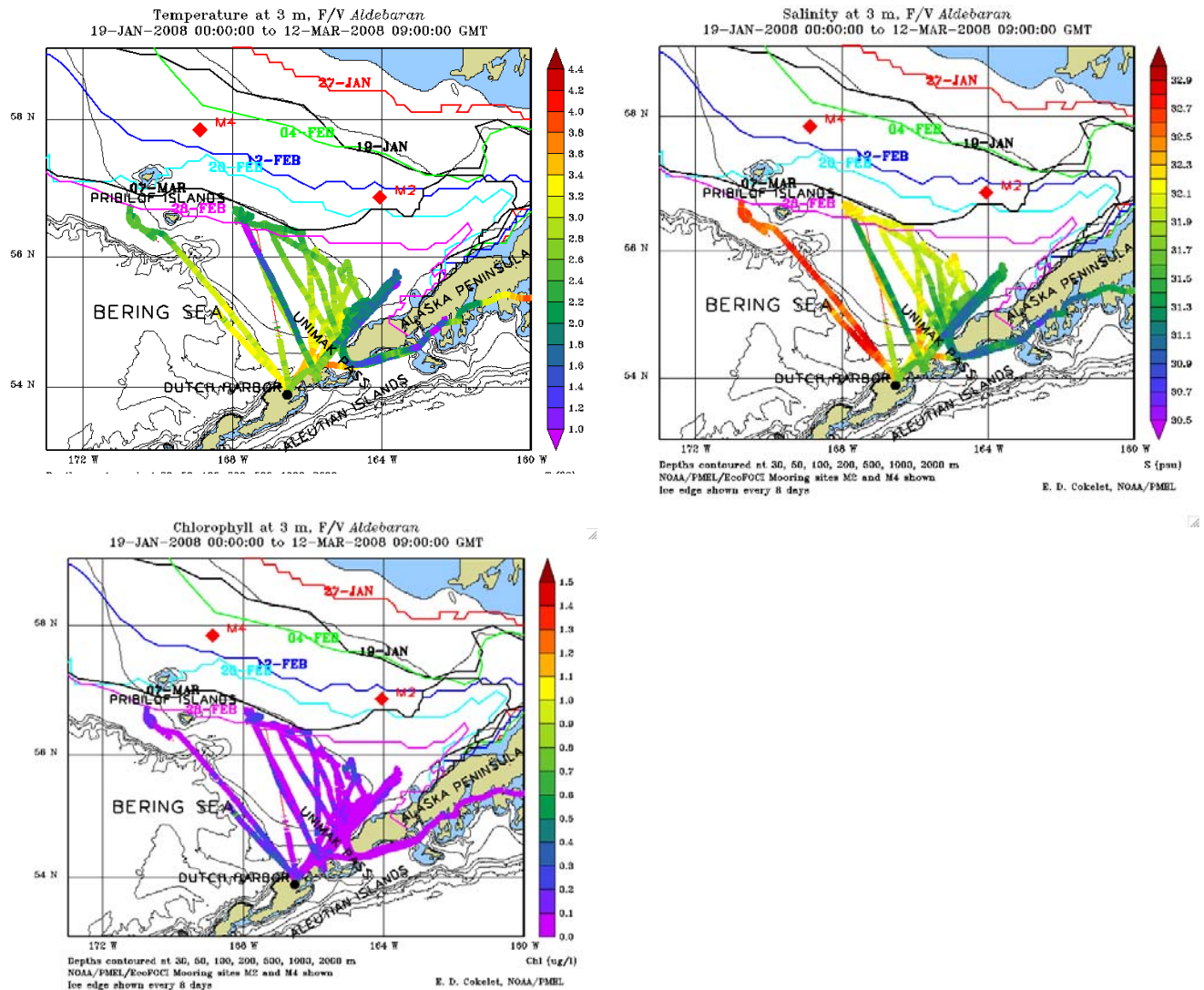


Figure 1. (a) Temperature, (b) salinity, and (c) chlorophyll concentration along the F/V Aldebaran's ship-track during the 2008 Pollock Season.

Write manuscript describing results from 2008

Anne Hollowed is preparing a manuscript describing the spatial partitioning of forage species in the Bering Sea. Manuscripts on multifrequency classification methodology, euphausiid abundance and distribution inferred from acoustic data, and euphausiid target strength are in progress. Anne Hollowed and Nicholas Bond completed edits to a manuscript that will be published in the ICES Journal of Marine Science this is BEST-BSIERP publication #2.

Fish component PI meeting

A fish component meeting was held in February 2009 to review results of all related projects.

Plan 2009 MACE cruise

Cruise planning for the summer acoustic pollock survey occurred throughout winter and spring 2009. Plans for multifrequency acoustic and trawl sampling of adult and juvenile pollock, euphausiids,

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

collection of physical oceanographic data, and collection of requested samples for several other BEST and BSIERP projects were formulated.

Distribute special request form for groundfish trawl cruise
Complete.

Renew funding for RACE research assistant

We used contract funds to fund two projects. In the first, “Modeling the target strength of Bering Sea euphausiids”, we contracted with Dr. Joe Warren of Stony Brook University and a graduate student, Joy Smith, to make material property measurements of euphausiids and other zooplankton and model their target strength. Target strength estimates are needed to make quantitative measurements of euphausiid abundance and distribution. Smith and Warren made measurements during June-July 2009 and presented early results of their work in January 2009 at the Alaska Marine Science Symposium. Further results of this research will be presented at the May 2009 meeting of the Acoustical Society of America in Portland, Oregon. This project is on track for producing a manuscript on euphausiid target strength and a target strength model by September 2009.

The second project we are planning is “Spatial analysis of the MIX1 layer in the eastern Bering Sea”. We are in the process of hiring a post-doc through UW-JISAO to investigate patterns in near-surface acoustic backscatter from unidentified, non-pollock targets (‘MIX 1’), a common feature in summer Bering Sea acoustic survey data. This post-doctoral research will help determine whether an index of backscatter in the MIX1 layer may be informative (along with other acoustic indices) for walleye pollock stock assessment and as a descriptor of walleye pollock pelagic habitat. This milestone was not been completed because the candidate that was selected for this position took a position with a different research institute (see lessons learned and changes).

Analyze 2008 pollock and euphausiid distribution and abundance

In progress. Emerging results were presented at October 2008 BSIERP PI meeting in Girdwood, AK and at the January 2009 Alaska Marine Science Symposium. This is nearly complete and data will be submitted to the data manager on the promised schedule, 6–12 months after the survey. Emerging results on pollock distribution and abundance were presented at October 2008 BSIERP PI meeting in Girdwood, AK and at the January 2009 Alaska Marine Science Symposium. See list of presentations and posters. Results suggest that euphausiid biomass has increased three-fold since 2004, while pollock biomass has declined by half. A cruise report summarizing the 2008 EIT survey (the normal AFSC survey product) was prepared. Physical oceanographic data from this survey are being analyzed.

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

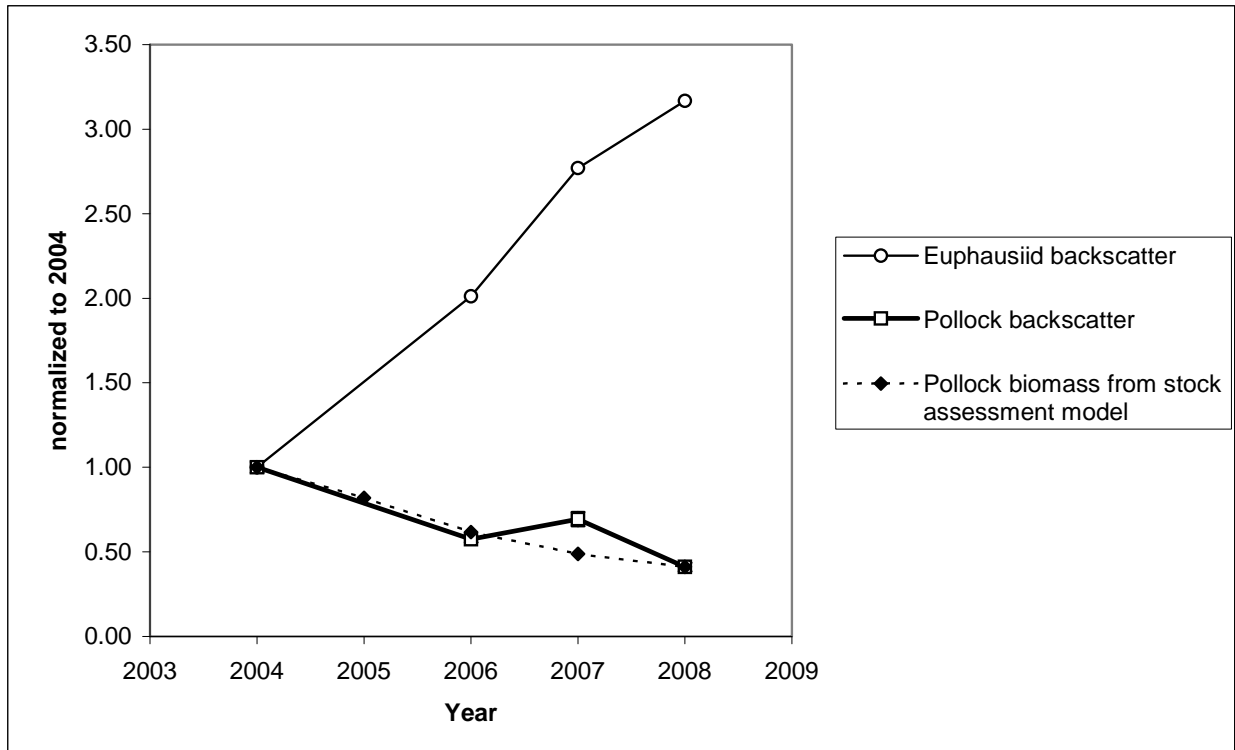


Figure 2. Preliminary results presented at Alaska Marine Science Symposium on trends in summer midwater pollock and euphausiid abundance in the EBS, inferred from acoustic backscatter data. Backscatter values (proportional to euphausiid and pollock abundance) were normalized to 2004 for each time series to show relative changes.

Analyze vertical distribution of pollock

Acoustic ES-60 data from groundfish charter vessels has been stored and currently a data querying system is being developed for future analysis of pollock vertical distribution. The first set of data from 2008 should be available in April 2009. Similarly data acquisition techniques are being developed to acquire oceanographic and climatic data (from oceanographic measurements, satellites, weather databases, and oceanographic models) that will be used to assess the effect of environmental variables on pollock vertical distribution.

Analyze data from 2008 groundfish trawl survey

Between October 2008 and March 2009, data collected from the 2008 Eastern Bering Sea Groundfish/Crab trawl survey was processed and analysis commenced. Sea surface temperature and bottom temperature were collected during the survey. Catch data, environmental data (CTD, light), and acoustic data (ES60) were successfully collected during the survey. Catch and temperature data was scrutinized and recorded into the survey database (racebase). CPUE, size composition, population and biomass for arrowtooth flounder, Pacific cod and walleye pollock were calculated for these three species were distributed among BSIERP PIs, and were presented in poster form during October 2008 BSIERP meeting.

The 2009 Eastern Bering Sea Bottom trawl survey is planned to take place between May 28th and July 31st 2009, and preparations are ongoing. A request for a special project that would allow collection of the underway acoustic data and deployment of the CTDs was submitted to the RACE Division.

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

Lessons learned and project adjustments:

We did a careful and thorough job designing and installing the underway instruments for *Aldebaran* and *Dyson* last year. That diligence paid off this year when we were able to redeploy these systems without difficulty.

Reallocation of project B58 funds to projects B61 and B62 was requested. NPRB awarded \$154,499 to NOAA-Alaska Fisheries Science Center (AFSC) for BSIERP Project B58 (Acoustic Survey). BSIERP funding was necessary because RACE acoustic surveys to assess walleye pollock stocks are typically conducted biennially during even years in the EBS and odd years (e.g., 2009) in the Gulf of Alaska (GOA). The AFSC added an off-year (2009) survey in the EBS so that EBS acoustic surveys would be conducted all three years of the BEST-BSIERP study (biennial surveys in 2008 and 2010 and off-year survey in 2009). The AFSC requested funding from NPRB for Project B58 because AFSC funding was insufficient to cover the 2009 EBS acoustic survey that addresses BSIERP objectives as well as the simultaneous GOA acoustic survey. However, the 2009 GOA acoustic survey was cancelled due to competing ship needs within NMFS and NOAA. As a result, the AFSC funding intended to support the 2009 EBS acoustic survey are now available to support other BSIERP objectives and were reallocated to 1) cover BSIERP-related sampling during the summer 2009 EBS acoustic survey and 2) expand research effort of Project B62.

We learned on 27 March 2009 that the post-doctoral researcher we had planned to hire for the project “Spatial analysis of the MIX1 layer in the eastern Bering Sea” had instead accepted another position. Since we were in a very late stage in the hiring process, it will take some time to identify and hire an alternate candidate for this work. We plan to complete this selection and hiring process as soon as possible.

Integration activity:

We delivered the underway oceanographic temperature, salinity, chlorophyll and position data and the requisite metadata for the 2008 Pollock A Season and the 2008 bottom trawl survey to the BSIERP data managers on 27 March 2009. Delivery of 2008 acoustic data to data manager will be done on time (6-12 months subsequent to completion of each year’s survey). Data templates for B62 have been submitted. We presented posters at the BSIERP PI meeting in October 2008 and the Alaska Marine Science Symposium in January 2009.

Education and Outreach:

We interacted with two PolarTREC teachers at sea on the July BEST USCGC *Healy* cruise, answering questions that students asked on the website and providing background information. We also worked with professional photographers covering the BEST/BSIERP research on the April-May and July *Healy* cruises. One, Galea Rosenwaks, maintains a website about her adventures (<http://arctic.globaloceanexploration.com/>).

As in 2008, we plan to host one to three NOAA Teacher-at-Sea appointments during summer 2009 MACE cruise.

We completed planning for hosting an undergraduate intern in June-July 2009 through the Alaska Fisheries Science Center (AFSC) internship program. The intern will use a multi-net plankton sampler to estimate the relative density of euphausiids in acoustic “dead zones” near the ocean surface and the seafloor, which will improve the multifrequency acoustic index of euphausiid abundance produced by B62. Funding for this internship was made possible by reallocating funds from project B58. http://www.afsc.noaa.gov/internships/2009_internships/intern_ressler.htm

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

Poster presentations:

Cokelet, E. D., C. W. Mordy, P. J. Stabeno, N. Kachel, P. Proctor and D. Righi, A Comparison of Oceanographic Sections Across the Bering Sea Shelf: Spring and Summer 2008, BSIERP PI Meeting, 14-16 October, Girdwood, AK.

Hollowed, A. B., E. Farley, C. Wilson, S. Kotwicki and E. D. Cokelet, Biogeography of Forage Fish in the Eastern Bering Sea, BSIERP PI Meeting, 14-16 October, Girdwood, AK.

Cokelet, E. D., C. W. Mordy, P. J. Stabeno, N. Kachel, P. Proctor and D. Righi, Evolution of the Bering Sea Shelf's Mixed Layer and Photic Zone: Ice to Summer, Alaska Marine Science Symposium, 19-22 January 2009, Anchorage, AK.

Ressler, P., C. Wilson, S. Kotwicki, P. Stabeno, and A. Hollowed. Pollock and Euphausiid Distribution in the Eastern Bering Sea, June-July 2008. BSIERP PI Meeting, 14-16 October, Girdwood, AK.

Smith, J. N., P. H. Ressler, and J. D. Warren. Assessing the Variability in the Material Properties of Bering Sea Euphausiids to Improve Acoustic Scattering Models. Alaska Marine Science Symposium, 19-22 January 2009, Anchorage, AK.

Warren, J. D., J. N. Smith, and P.H. Ressler. Improving Acoustic Scattering Models for Various Bering Sea Zooplankton. Alaska Marine Science Symposium, 19-22 January 2009, Anchorage, AK.

Oral presentations:

Hollowed, A. B., E. Farley, C. Wilson, P. Ressler, S. Kotwicki, E. Cokelet. Biogeography of Forage Fishes in the Eastern Bering Sea. Alaska Marine Science Symposium, January 20-23, Anchorage, AK.

Hollowed, A. B., M. Barange, S. Kim, H. Loeng. ICES – PICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish. Alaska Marine Science Symposium, January 20-23, Anchorage, AK.

Ressler, P.H., A. De Robertis, C. D. Wilson, and P. J. Stabeno. Trends in walleye pollock and euphausiid abundance on the Bering Sea shelf since 2004. Alaska Marine Science Symposium, 19-22 January 2009, Anchorage, AK.

Publications:

Hollowed, A. B., N. Bond, T. Wilderbuer, W. Stockhausen, Z. Teresa A'mar, R. Beamish, J. Overland, M. Schirripa. In Press. A framework for modeling fish and shellfish responses to future climate change. ICES J. Mar. Sci.

Honkalehto, T., D. Jones, A. McCarthy, D. McKelvey, M. Guttormsen, K. Williams, and N. Williamson. Results of the Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) on the U.S. and Russian Bering Sea Shelf in June and July 2008. 2009. AFSC Processed Report.

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

Next year's Work plan (not part of the 5 page target length):

2009 Tasks, Assignments, Timeline

<i>What</i>	<i>Who</i>	<i>Start</i>	<i>Other key dates</i>
Make underway surface temperature, salinity, nitrate, chlorophyll and dissolved oxygen measurements aboard NOAAAS <i>Oscar Dyson</i> during the Spring Ichthyoplankton cruise	Cokelet, E. D.	May 2009	Data delivery May 2010
Make underway surface temperature, salinity, nitrate, chlorophyll and dissolved oxygen measurements aboard NOAAAS <i>Oscar Dyson</i> during the hydroacoustic surveys on the eastern Bering Sea shelf	Cokelet, E. D.	June-July 2009	Data delivery July 2010
Make underway surface temperature, salinity and chlorophyll measurements aboard F/V <i>Aldebaran</i> during the Eastern Bering Sea Crab and Groundfish Survey	Cokelet, E. D.	June-July 2009	Data delivery July 2010
Conduct groundfish trawl survey	Kotwicki, Stan and Lauth, Bob, Buckley, Troy	May 28 th and July 31 st 2009	
Conduct summer 2009 MACE cruise	Ressler, Patrick, Wilson, Chris, and other scientists from the MACE program	June – August 2009	Data delivery August 2010
Work with summer intern on near-bottom and near-surface euphausiid distribution	Ressler, Patrick	June-July 2009	
Work with industry to obtain roe quality information	Barbeaux, Steve and Hollowed, Anne	June – September 2009	
Submit paper on winter Pollock	Barbeaux, Steve	Summer 2009	
Fish Component PI meeting	Hollowed and others	August 11-13	
Initial analysis of pollock and euphausiid data from 2009 MACE cruise	Ressler, Patrick, Wilson, Chris, and other scientists from the MACE program	August – December 2009	
Fish Component – Modelers meeting	Hollowed and Aydin and others	August 11-13	
Finalize bio-geography of	Hollowed and	September 2009	

Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

forage fish manuscript	others		
Prepare summary reports for NPRB	All	October 1, 2009	
Attend BSIERP PI meetings	All	October 2009	
Complete hire of post-doc	Ressler, Patrick and Wilson, Chris	December 2009	