

## **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)

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**Contract Period and Amount of Funding:**

**Report Period:**

1 November 2007 - 30 September 2008

**Report Date:**

25 September 2008

**Lead Author of Report:**

Dr. Anne B. Hollowed

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**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](http://bsierp.nprb.org/proj_mgt/sow.html))

2008 Tasks, Assignments, Timeline

<i>What</i>	<i>Who</i>	<i>Start</i>	<i>Other key dates</i>
Equip F/V <i>Aldebaran</i> with underway surface seawater temperature, salinity and chlorophyll fluorescence instruments	Cokelet, E. D.	December 2007	
Equip NOAAAS <i>Oscar Dyson</i> underway seawater system with nitrate and dissolved oxygen sensors	Cokelet, E. D.	January 2008	
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 2008	Data delivery March 2009
Obtain release of data from <i>Aldebaran</i> owner	Cokelet, E. D.	March 2008	
Make underway surface temperature, salinity, nitrate, chlorophyll and dissolved oxygen measurements aboard NOAAAS <i>Oscar Dyson</i> during the mooring cruise and the Spring Ichthyoplankton cruise	Cokelet, E. D.	May 2008	Data delivery May 2009
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 2008	Data delivery July 2009
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 2008	Data delivery July 2009
Collect temperature and salinity CTD profiles on bottom trawl head rope of F/Vs <i>Aldebaran</i> and <i>Arcturus</i> during the Eastern Bering Sea Crab and Groundfish Survey	Cokelet, E. D.	June-July 2008	Data delivery July 2009
Write announcement for MACE support person	Ressler, Pat, Wilson, Chris and Hollowed, Anne	March 2008	
Purchase XBTs.	Ressler, Pat	April 2008	

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Plan groundfish trawl cruise	Kotwicki, Stan and Lauth, Bob	April – May 2008	
Hire MACE support person	Wilson, Chris	Prior to May 15, 2008	
Hire technicians for Cokelet project. (Anthony Jenkins already hired)	Cokelet, Ned	Winter /Spring 2008	
Plan MACE cruise	Ressler, Pat and Wilson, Chris	Spring 2008	
Distribute special request form for groundfish trawl cruise.	Kotwicki, Stan and Lauth, Bob	March 2008	
Conduct groundfish trawl survey	Kotwicki, Stan and Lauth, Bob, Buckley, Troy	May 29 2008 – July 28, 2008	
Work with industry to obtain roe quality information	Barbeaux, Steve and Hollowed, Anne	June – September 2008	
Provide satellite sea surface temperature to project members	Hollowed, Anne and Greig, Angie	March – September 2008	
Analyze Pollock data from MACE cruise	Ressler, Pat and Wilson, Chris	August - September	
Analyze pollock arrowtooth and cod data from groundfish trawl cruise	Kotwicki, Stan and Lauth, Bob	August - September	
Participate in BSIERP Lead PI meetings	Anne Hollowed	~ Monthly	
Analyze euphausiid distribution and abundance	Ressler, Pat and MACE support person	August - December	
Analyze vertical distribution of pollock	Kotwicki, Stan and Ressler, Pat	August – March 2009	
Collect acoustic and catch data during Basis cruise	Parker-Stetter, Sandra and Horne, John	September	
Analyze acoustic and catch data from Basis cruise	Parker-Stetter, Sandra, and Horne, John	October – March 2009	
Attend BSIERP Retreat	All	October 13, 2008	
Prepare summary reports for NPRB	All	October 1, 2008	

**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,

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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).
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 of the milestones were met on time.**

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We instrumented F/V *Aldebaran* with underway oceanographic instruments to measure the near-surface seawater temperature, salinity and chlorophyll fluorescence in water pumped from the ship's sea chest. Measurements were made during the winter 2008 Pollock A Season, and graphs are available on the BSIERP website (<http://bsierp.nprb.org/fieldwork/2008/winter-ocean.html>). The underway instrument suite on NOAA's *Oscar Dyson* already included instruments to measure the ocean's near-surface temperature, salinity and chlorophyll fluorescence. We replaced the fluorometer with one that automatically cleans itself via a mechanical wiper. We also added nitrate and oxygen sensors. In so doing, we reconfigured parts of the system and added flow sensors as well. Measurements were recorded during all of *Dyson's* cruises in the Bering Sea. The Summer 2008 Bottom Trawl Survey was conducted on two contract survey vessels, F/Vs *Aldebaran* and *Arcturus*, during June and July 2008. We purchased two ruggedized CTDs to mount on the headropes of the bottom trawl nets to make ocean temperature and salinity measurements. We wrote instructions on how to use the CTDs, conducted a training session, and set them up on the two fishing vessels in Dutch Harbor. Over 400 net trawls were made with the CTDs aboard. Data processing and evaluation will begin in FY09.

A contract solicitation entitled "Modeling the target strength of Bering Sea euphausiids" was advertised in April 2008. A contract with Dr. Joe Warren of Stony Brook University was finalized in May 2008. The contract period runs through September 2009. FY2008 monies were used to hire Dr. Joe Warren of Stony Brook University to conduct measurements on individual euphausiids that will be used to parameterize a target strength model. We can use the resulting target strength estimate to make our acoustic euphausiid index more quantitative. Joe and a graduate student, Joy Smith, participated in Leg 2 of the 2008 acoustic survey on the NOAA Ship *Oscar Dyson* and worked on euphausiid specimens collected in Methot trawls. An interim report from Joe on the work he and Joy did is due on 30 September, and Joe will make a presentation on the project in January at the 2009 Alaska Marine Science Symposium.

17 cases of Sippican Deep Blue XBTs were purchased (204 probes). 92 probes were deployed in summer 2008 to supplement CTD stations and provide several high-resolution cross-shelf sections of temperature profiles. The remaining XBT probes will be deployed in summer 2009. Additional probes will be purchased for summer 2010.

Cruise planning for the summer acoustic pollock survey occurred throughout winter and spring 2008. Plans for multifrequency acoustic and trawl sampling of adult and juvenile pollock, euphausiids, collection of physical oceanographic data, and collection of requested samples for several other BEST and BSIERP projects were formulated.

The 2008 acoustic pollock survey aboard the *Oscar Dyson* was conducted during June and July 2008 (Eastern Bering Sea shelf, between 161° W and 178° E longitude, 2 June - 31 July 2008, three survey legs. Survey extended into the Russian EEZ to 178°). Collection of acoustic and trawl data were conducted to estimate the distribution and abundance of age 1+ pollock (Fig 1). Many other types of sampling in addition to usual survey activities were conducted. Multifrequency acoustic data were collected to estimate an index of euphausiid abundance and distribution (Fig 2). 63 conductivity-temperature-depth (CTD) and 92 expendable bathythermograph (XBT) profiles of water column physical oceanographic properties were collected (Fig 3, 4). Underway seawater sampling of near-surface water properties was conducted. **When combined with physical oceanographic sampling by AFSC groundfish charter vessels, other AFSC cruise, and USCGS Healy in summer 2008, we will probably have an unprecedented picture of physical oceanography on the eastern Bering Sea shelf.** Samples of euphausiids were collected with Methot trawls to confirm the length-frequency and species composition of acoustically detected euphausiid aggregations, and to obtain samples to aid target strength modeling. Euphausiids were also preserved for Rodger Harvey (BEST) for determination of age structure and biochemical composition. Microzooplankton and phytoplankton samples were collected for Evelyn

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Sherr (BEST). Age-1 pollock specimens were collected for a study of juvenile pollock condition led by Ron Heintz (BSIERP).

Some preliminary findings from the acoustic pollock survey include:

- Pollock were detected throughout the surveyed area; most fish occurred west of the Pribilofs and particularly west from 176° W to the convention line (Fig 1).
- Pollock size composition ranged from 11 to 79 cm fork length (FL). The dominant adult length modes were 51 cm east of 170°W and 47 cm west of 170°W. Juvenile pollock (<37 cm; likely 2-3 year olds), were more abundant west of the Pribilofs. Few age-one fish were encountered. The 2006 year class (2-year olds; 18-29 cm FL) still appears to be relatively strong.
- Bottom temperatures were generally less than 1°C on the shelf between 50 and 100m and 2-3°C on the shelfbreak (Figs 3, 4).

Fish and euphausiid data collected during summer 2008 aboard the Oscar Dyson are now being analyzed. Echoview software is being used to analyze the multifrequency acoustic data. Early results will be presented at the October 2008 PI meeting.

A protocol for sample processing has been agreed upon, and our samples are being prepared for shipment to Poland with other samples from AFSC in October-November. Processing of these samples will provide species and length-frequency composition of euphausiid aggregations observed acoustically during the 2008 acoustic pollock survey on board the Oscar Dyson, supporting our multifrequency index of euphausiid abundance.

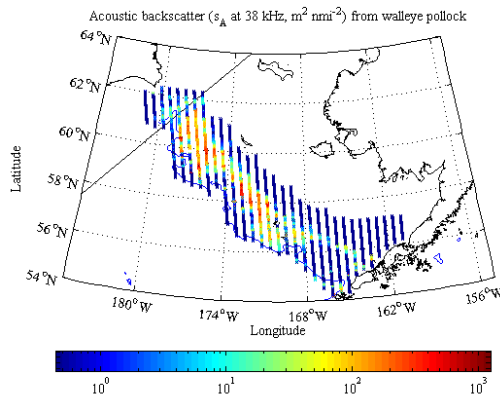


Figure 1: Preliminary map of acoustic backscatter from walleye pollock on the Bering Sea shelf, summer 2008

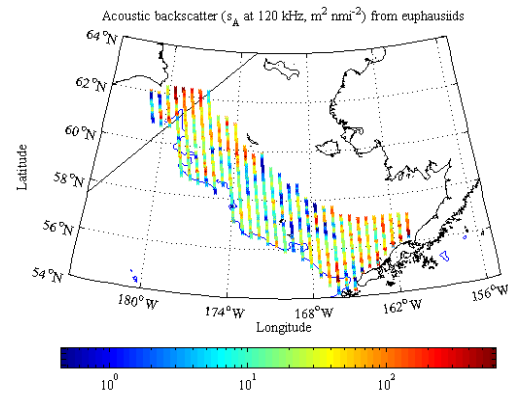
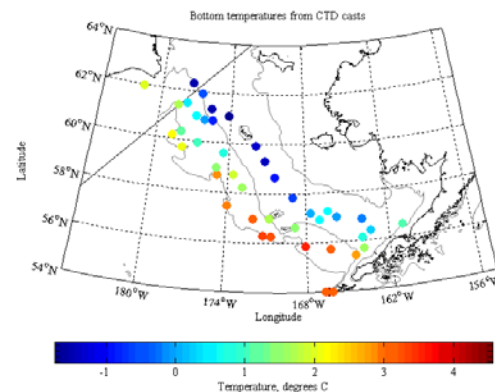


Figure 2: Preliminary map of acoustic backscatter from euphausiids on the Bering Sea shelf, summer 2008



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Figure 3: Preliminary bottom temperatures from CTD casts, summer 2008

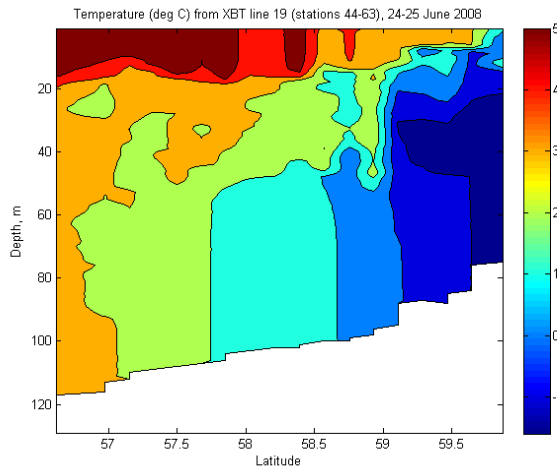


Figure 4: A preliminary high-resolution section of temperature profiles from XBT casts, summer 2008

2008 Eastern Bering Sea bottom trawl shelf survey was conducted from June 4<sup>th</sup> to July 24<sup>th</sup> 2008. Sea surface temperature (Fig 5) and bottom temperature (Fig 6) 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 (see Figures 7-9) for these three species were distributed among BSIERP PIs, and will be presented in poster form during October 2008 BSIERP meeting.

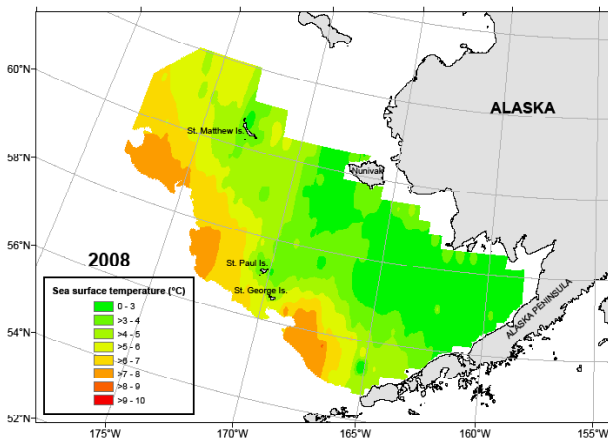


Figure 5. -- Distribution of sea surface water temperatures (°C) observed during the 2008 eastern Bering Sea bottom trawl survey.

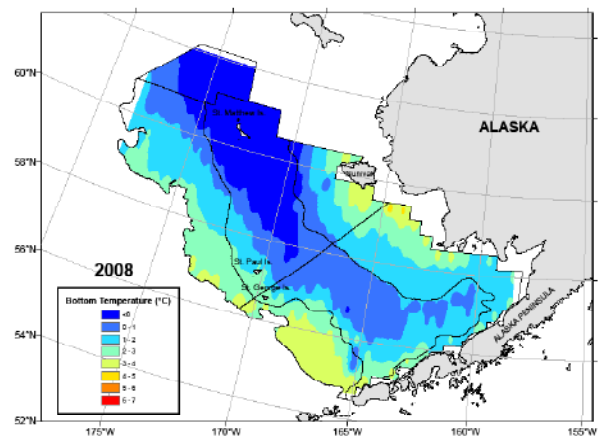


Fig. 6. Distribution of bottom temperature (°C) observed during the 2008 – Eastern Bering Sea bottom trawl survey.

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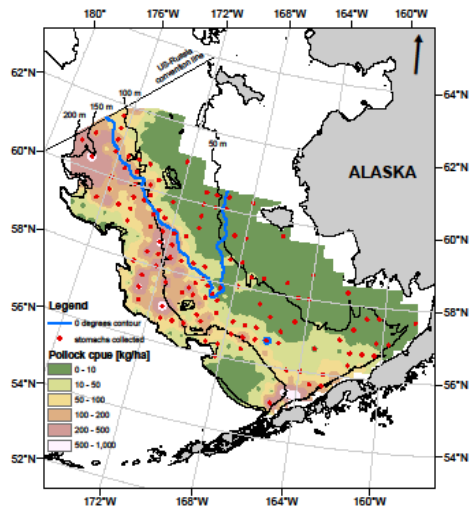


Fig7. Walleye pollock density as detected by 2008 EBS bottom trawl survey.

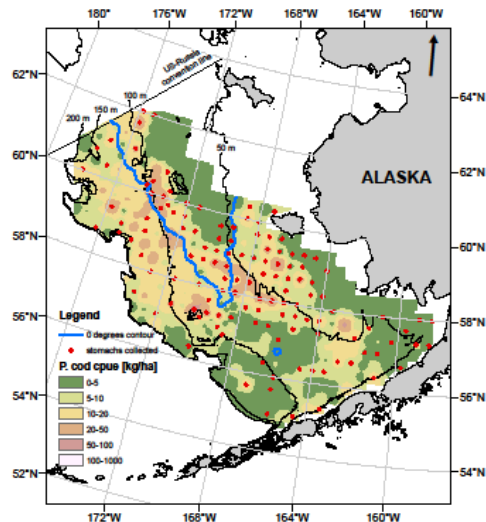


Fig 8. Pacific cod density as detected by 2008 EBS bottom trawl survey.

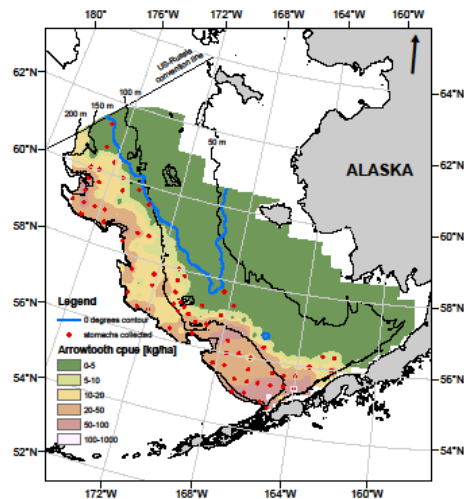


Fig 9. Arrowtooth flounder density as detected by 2008 EBS bottom trawl survey.

An analysis of the spatial partitioning of pollock, cod and arrowtooth flounder summer feeding locations and their association with physical features of the Bering Sea shelf will be presented at the October retreat.

An analysis of the location of winter pollock spawning locations relative to oceanographic features will be presented at the October retreat (also see Ciannelli et al).

Satellite data were delivered to project members upon request.

### Lessons learned and project adjustments:

The primary lesson learned is that it is very important for funding to arrive early in order to allow time to procure instruments, set them up and test them before deployment. The late arrival of funds rushed the field program this year. We hope that with MOUs in place, funding will arrive on time in future years.

### Integration activity:

As the time schedules indicate, our data are not ready yet. It is too early to comment on the other issues.

### 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

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with professional photographers covering the BEST/BSIERP research on the April-May and July *Healy* cruises. One, Galean Rosenwaks, maintains a website about her adventures (<http://arctic.globaloceanexploration.com/>).

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

**Next year's Work plan:**

**Project B62**

Anne Hollowed, 206-526-4223, [Anne.Hollowed@noaa.gov](mailto:Anne.Hollowed@noaa.gov)

2009 Tasks, Assignments, Timeline

<i>What</i>	<i>Who</i>	<i>Start</i>	<i>Other key dates</i>
Analyze vertical distribution of pollock	<b>Kotwicki, Stan and Ressler, Pat</b>	August 2008 – March 2009	
Prepare and present preliminary results at Alaska Marine Science Symposium	<b>Hollowed or her designee</b>	January 2009	
Equip vessel with temperature sensor, and fluorometer	<b>Cokelet, Ned</b>	December 2008 – January 2009	
Collect temperature, and chlorophyll information on commercial vessel	<b>Cokelet, Ned</b>	January 2009	
Evaluate status of nitrate sensor and dissolved oxygen sensor on Oscar Dyson.	<b>Cokelet, Ned</b>	Winter 2009	
Collect temperature, chlorophyll, nitrate and dissolved oxygen from acoustic survey	<b>Cokelet, Ned</b>	May 31 – July 31 2009	
Write manuscript describing results from 2008	<b>Ressler, Pat, Wilson, Chris and Hollowed, Anne</b>	March 2009	
Purchase XBTs.	<b>Ressler, Pat</b>	April 2009	
Plan groundfish trawl cruise	<b>Kotwicki, Stan and Lauth, Bob</b>	April – May 2009	
Renew funding for RACE research assistant	<b>Wilson, Chris</b>	Prior to May 15, 2008	
Renew funding for technicians for Cokelet project. (Anthony Jenkins already hired)	<b>Cokelet, Ned</b>	Winter / Spring	
Plan MACE cruise	<b>Ressler, Pat and Wilson, Chris</b>	Winter/Spring	
Distribute special request form for groundfish trawl cruise.	<b>Kotwicki, Stan and Lauth, Bob</b>	March 2009	
Conduct groundfish trawl survey	<b>Kotwicki, Stan and Lauth, Bob, Buckley, Troy</b>	May 29 2009 – July 28, 2009	
Work with industry to obtain roe quality information	<b>Barbeaux, Steve and Hollowed, Anne</b>	June – September 2009	
Submit paper on winter Pollock	<b>Barbeaux, Steve</b>	Summer 2009	

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spawning distribution	<b>and others</b>		
Complete draft paper on forage fish niche partitioning in EBS	<b>Hollowed, Anne and others</b>	Summer 2009	
Provide satellite sea surface temperature and wind as requested	<b>Hollowed, Anne and Greig, Angie</b>	March – September 2009	
Prepare summary reports for NPRB	<b>All</b>	July 15, 2009	
Analyze Pollock data from MACE cruise	<b>Ressler, Pat and Wilson, Chris</b>	August - September	
Analyze pollock arrowtooth and cod data from groundfish trawl cruise	<b>Kotwicki, Stan and Lauth, Bob</b>	August - September	
Attend BSIERP PI meetings	<b>All</b>	TBD	
Analyze euphausiid distribution and abundance	<b>Ressler, Pat and MACE support person</b>	August - December	
Attend BSIERP Retreat	<b>All</b>	Fall 2009	