

Project #: B68

Title: Trophic Interactions - Retrospective analysis

Principal Investigator(s) and Recipient Organization(s):

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Contract Period and Amount of Funding:

October 1, 2007 to September 30, 2009
\$ 95,325

Report Period:

1 October 2008 through 31 March 2009

Report Date:

1 April 2009

Lead Author of Report:

Franz J. Mueter

Proposed timeline and milestones within report period:

1. Compute condition indices (completed)
2. Compute indices of predation pressure (flatfish, cod) (delayed)
3. Data analysis: Covariation / correlation analysis; multivariate analysis of patterns and trends in fish, seabirds, & mammals (ongoing)
4. Data analysis: developing and testing Pacific cod hypotheses (ongoing)
5. Manuscript preparation – Covariation & trophic interactions (in preparation)
6. Formulate specific testable hypotheses for climate effects on gadids, flatfishes, crab, seabirds, and mammals (ongoing)
7. Data updates: 2008 seabird / mammal surveys, 2008 SAFE, other indices as needed (ongoing)

Project Summary:

The productivity of upper trophic level species in the eastern Bering Sea varies in response to climate variability and human forcing, although the relative contribution of these drivers and the underlying mechanisms remain poorly understood. This retrospective analysis will (1) quantify past patterns of variability and covariation among time series of productivity of selected fish, seabird, and marine mammal species; (2) test whether historical patterns and trends in these series are consistent with existing hypotheses; (3) suggest new hypotheses based on relationships among the productivity of different ecosystem components and relationships between their productivity and observed climate variability; and (4) provide functional forms and parameter estimates (and their uncertainty) that link the productivity of different ecosystem components to climate variability. The analysis will utilize existing data on productivity, including measures of recruitment, survival, and growth or condition, of major upper trophic level species. Results will contribute to the overall research program in two important ways. First, results will directly support the proposed modeling projects by providing parameters linking the productivity of individual species to climate variability, which is essential for predicting the effects of future climate variability. Second, identified relationships between climate and productivity can be incorporated into existing stock assessment models.

Progress Summary:

During this period we continued the compilation of relevant time series (monthly or annual indices) of environmental and biological variability in the eastern Bering Sea ([Milestones 1,2,6](#)). We have worked on documenting the data sources and the processing steps, if any, that were required to derive indices of interest from raw data sources. Many of the indices are readily available for downloading, while others required considerable analytical effort. Updated indices have been delivered to data management for posting on the BSIERP webpage. The data are currently posted in the form of a spreadsheet with basic information about each index.

We analyzed covariation among fish (walleye pollock, Pacific cod, arrowtooth flounder, yellowfin sole, rock sole, flathead sole), crab (Bristol Bay red king crab, snow crab), seabirds (common & thick-billed murre, red-legged & black-legged kittiwakes) and fur seal abundance and productivity (where available) using correlations, multivariate analyses, and dynamic factor analysis to detect common trends and patterns ([Milestone 3](#)). One of the notable patterns is the strong negative relationship between recruitment anomalies of gadid fishes and the four flatfish species (Fig. 1a), which showed that there has not been a single year in which both groups have experienced above average recruitment (Fig. 1b) suggesting that recruitment of these groups is affected in opposite ways by environmental variability. A manuscript on the observed patterns across all groups (fish, seabirds, mammals) is in preparation ([Milestone 5](#)). Results will be updated with seabird data through 2008 as soon as these become available.

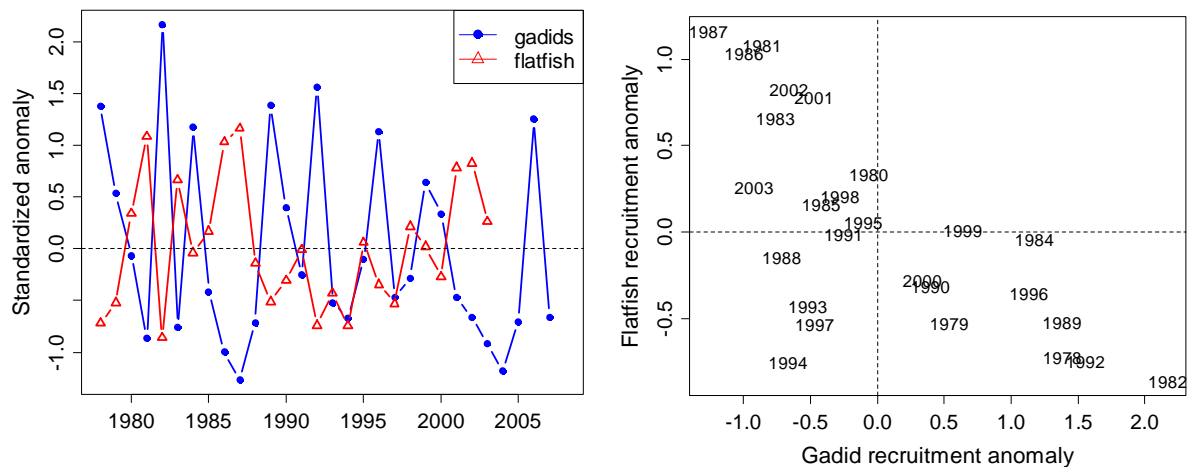


Figure 1: Annual series of standardized recruitment anomalies averaged across two gadid and four flatfish species, respectively, on the eastern Bering Sea shelf (left) and scatterplot of flatfish recruitment anomalies against gadid recruitment anomalies (right) for 1978 to 2007 year classes. Note lack of data points in upper right quadrant.

Preliminary *a priori* hypotheses for climate effects on variability in gadid, crab, flatfish, and seabird populations have been identified from the relevant literature and from discussions with other BSIERP researchers ([Milestone 6](#)). These will be refined as the analyses proceed (covariation analysis, gadid hypotheses) or as we begin the analyses for other groups.

Our original timeline was developed prior to Dr. Mueter taking a faculty position with the University of Alaska Fairbanks. Some adjustments were necessary to the timeline, primarily by shifting some of the tasks that require extended blocks of time to the summer months ([Milestones 4,5](#)). These adjustments are reflected in the revised work plan appended to this report.

In addition, there has been some delay in developing indices of predation pressure ([Milestone 2](#), intended for testing predation-related hypotheses) due to difficulties in obtaining appropriate ration estimates at predator size for small prey items. We are considering simplified ways to compute a biologically meaningful index of predation pressure.

Lessons learned and project adjustments:

Incorporating retrospective data appropriately into the BSIERP database has been challenging. We currently submit a spreadsheet with monthly and annual derived indices and a short description of each index. We are documenting processing steps required to derive specific indices and citing the original data sources, but we are not including all of the underlying data (for example NCEP/NCAR data, SST data from Climate Data Center). These do not fit well into the metadata framework and we will work with data management and/or NPRB staff to link the indices and relevant descriptions through AMIS or through the BSIERP website.

Integration activity:

We held a joint meeting with seabird and marine mammal biologists to share preliminary results and discuss ideas about appropriate hypotheses to test in conjunction with the BSIERP PI meeting in Girdwood in October 2008. A summary of the discussions is included in the final report posted at <http://bsierp.nprb.org/meetings/annual.html>. We (Mueter) have also had regular interactions with the modeling group through the BSIERP PI meeting in October 2008 in Girdwood, an EMC meeting held in conjunction with the Alaska Marine Science Symposium in Anchorage on January 19, 2009, meetings with Fairbanks-based modelers during two visits (Hedstrom, Gibson), and through recently established monthly conference calls, as well as personal communications. At previous EMC meetings we discussed the need for summarizing model output at the same spatial and temporal scales at which retrospective indices are computed to facilitate comparisons and model evaluation. In subsequent discussions with modeling team members, it became apparent that it would be more efficient to make model output available for *post-hoc* comparisons, rather than computing indices comparable to those from the retrospective analyses within the model. We have also participated in most of the monthly lead PI calls.

Education and Outreach:

We have participated in several outreach activities related to the BSIERP project during this reporting period:

- Drs. Kruse and Mueter participated in the BSIERP PI meeting held in Girdwood, AK, during 14-16 October 2008. Both Dr. Kruse and Dr. Mueter presented a summary report of one of the break-out groups.
- Dr. Mueter participated in the 17th Annual PICES meeting in Dalian, China and presented a talk entitled "From physics to fish: Climate effects on Bering Sea food webs and fisheries", co-authored with Ken Coyle.
- Dr. Mueter presented a similar talk with new results as part of the UAF Fisheries Division seminar series in Juneau on January 23, 2009, and as a lunch-time seminar at the NOAA, NMFS Alaska Regional Office in Juneau.
- Dr. Kruse also participated in the Annual PICES meeting in Dalian. He co-convened the Science Board Symposium on "Beyond observations to achieve understanding and forecasting in a changing North Pacific Ocean", convened the Fisheries Contributed Paper Session, presented an oral presentation titled "A scenario approach to forecast potential impacts of climate change on red king crabs in the eastern Bering Sea", and co-authored an oral presentation titled "Could the collapse of the Bristol Bay red king crab stock in the early 1980s have been avoided?"
- Dr. Kruse delivered an expanded talk ("A scenario approach to forecast potential impacts of climate change on red king crabs in the eastern Bering Sea") as a department seminar at the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, on November 14, 2008.
- On 4 February 2009, Dr. Kruse was interviewed by reporter Tom Kazzia for an article on the effects of climate change on Tanner crabs and other species in Alaska. The article "Crab comeback in

Kachemak Bay” appeared in Anchorage Daily News on 2/21/2009. Kruse was quoted twice in the article.

- Dr. Kruse chaired the Steering Committee for the 25th Lowell Wakefield Symposium on “Biology and Management of Exploited Crab Populations under Climate Change” held in Anchorage, AK, during March 10-13, 2009. The meeting was attended by approximately 80 participants from 6 countries. Dr. Kruse is lead editor for the proceedings from this symposium.

Workplan for Project B68, Trophic Interactions - Retrospective analysis

Co-PIs: Franz Mueter, Gordon Kruse; Contact: Franz Mueter, franz.mueter@uaf.edu, 907-796-5448

Jan 2009-2012 Tasks, Assignments, Revised timeline

<i>What</i>	<i>Who</i>	<i>Start</i>	<i>End</i>	<i>Other key dates</i>
2009				
Compile 2008 SAFE data results	Mueter	Jan	Jan	<i>January:</i> Alaska Marine Science Symposium
Update environmental data as needed	Mueter	Feb	Feb	
Updated data sets to Ken Coyle	Mueter		Feb 15	
Obtain seabird and marine mammal data through 2008	Mueter	Jan	Mar	
Document data processing steps for computing indices	Mueter	Jan	Apr	<i>April 1:</i> Report to NPRB
Formulate flatfish hypotheses and conceptual models	Mueter Kruse	May	Jun	
Compute indices of predation pressure (for flatfish, cod hypotheses)	Mueter w/ Aydin	Jun	Jun	<i>June:</i> Modeling group meeting (Seattle)
Manuscript preparation – Covariation & trophic interactions	Mueter Kruse	Jan	Jul	
Data analysis: test flatfish hypotheses with empirical data	Mueter	Jul	Aug	<i>July:</i> Report findings to modeling group
Formulate crab hypotheses and conceptual models	Mueter, Kruse, w/ Zheng	Jun	Jul	
Data analysis: test crab hypotheses with empirical data	Mueter, Kruse, w/ Zheng	Jul	Aug	
	Mueter			<i>October 1:</i> Report to NPRB; <i>October:</i> BSIERP PI meeting
Manuscript preparation – climate & cod / flatfish / crab productivity	Mueter, Kruse	Aug	Jan '10	
2010				
Data updates (2009 seabird / mammal surveys, as necessary)	Mueter w/ Byrd, Trites			<i>January:</i> Report to NPRB; Presentation at AMSS
Updated data to Ken Coyle	Mueter		Feb 15	
	Mueter			<i>April 1:</i> Report to NPRB
Data analysis: Developing & testing seabird & mammal hypotheses	Mueter w/ Byrd, Trites	Jan 1	Aug 15	<i>July:</i> Report findings to modeling group

			Oct	<i>October 1: Report to NPRB</i> <i>October: PICES Annual meeting</i>
Manuscript preparation – climate & prey availability for seabirds / fur seals	Mueter w/ Byrd, Trites	Aug	Dec	
2011				
Synthesis manuscript preparation	Mueter, Kruse (w/ others)	Jan	Aug	<i>January: Presentation at AMSS</i> <i>April 1: Report to NPRB</i>
	Mueter		Oct	<i>October 1: Report to NPRB</i> <i>October: PICES Annual meeting</i>
Provide input to correlative biomass dynamics model	Mueter, Kruse, Student	Jan	Dec	
2012				
Final report preparation	Kruse, Mueter	Jan	Jul	<i>January: Presentation at AMSS</i> <i>April: Report to NPRB</i> <i>July: Final report</i>