

1. PROJECT INFORMATION

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|---------------------------------|---|
| GOA IERP Project Number: | Retrospective Components of all GOA IERP projects |
| Title: | Gulf of Alaska Retrospective Data Analysis |
| Overall project duration | October 1, 2010 to September 30, 2014 |
| Overall project funding | (Included in UTL, MTL, LTL, and Modeling budget) |
| Report period | October 1, 2010 to 31 March 2011 |
| Report submission date | April 28, 2011 |
| Lead Author of Report | Franz Mueter |

Principal Investigator(s), Co-Principal Investigators and Recipient Organization(s):

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2. PROJECT OVERVIEW

a. Briefly (4-5 sentences) describe the core purpose of your project, and the underlying need for this research.

Retrospective analyses are an integral part of each of the major components of the GOA IERP. The overall goal of these analyses is to examine physical and biological characteristics across the Gulf of Alaska to (1) provide historical context for new observations and measurements, (2) quantify spatial and temporal variability in key physical and biological characteristics of the coastal GOA, (3) elucidate relationships between physical and biological drivers of recruitment and upper trophic level variability, (4) test *a priori* hypotheses about these relationships, and (5) develop new hypotheses for field biologists and modelers to test in the future.

b. State the specific GOA IERP hypothesis or hypotheses that your project is addressing.

The retrospective analyses cut across all project components and will address to various extents each of the three overarching project hypotheses:

The gauntlet: The primary determinant of year-class strength for marine groundfishes in the GOA is early life survival. This is regulated in space and time by climate-driven variability in a biophysical gauntlet comprising offshore and nearshore habitat quality, larval and juvenile transport, and settlement into suitable demersal habitat.

Regional comparison: The physical and biological mechanisms that determine annual survival of juvenile groundfishes and forage fishes differ in the eastern and western GOA regions.

Interactions: Interactions among species (including predation and competition) are influenced by the abundance and distribution of individual species and by their habitat requirements, which vary with life stage and season.

c. List the specific objective(s) of your research project.

The retrospective component will address at least two of the overall list of objectives that were developed to address the three overarching project hypotheses.

(4) Use a comparative approach to assess spatial and temporal variability in the ecosystem, primarily between the eastern and western Gulf of Alaska regions among spring, summer, and fall.

(8) Use historical datasets to analyze temporal variability in potential climatic, oceanographic, or biological drivers influencing the early life survival of key groundfish species.

Specific objectives are addressed within each of the different retrospective components and are listed separately by component:

1) Upper Trophic Level (UTL) component:

- a) Collate relevant life history information for the five focal species and other linked species such as time of spawning, development, growth, recruitment histories, and habitat preferences.
- b) Compile available datasets to characterize spatial and temporal variability in the physical and biological environment of the GOA shelf and slope regions, including adjacent offshore regions, and identify datasets that represent potential drivers of recruitment variability of the five focal species in the study region.
- c) Develop spatial maps of mean conditions for representative datasets by trophic category to identify long-term patterns and delineate a faunal or physical break between the eastern and central GOA.
- d) Quantify, by region, the temporal variability in potential climatic, oceanographic, or biological drivers influencing the early life survival of the five target groundfish species.
- e) Link variability in these drivers to observed recruitment variability using a generalized modeling approach informed by available information on potential mechanisms.
- f) Compare temporal trends in estimated recruitment trajectories between regions and across species to identify successful life history strategies under different climate regimes.

2) Forage fish or Mid Trophic Level (MTL) component:

- a) Collate historical information on forage community structure in the coastal GOA.
- b) Analyze how community structure has changed over time and relate observed changes to variability in the environment and to the abundance of upper level predators.
- c) Collect and analyze data on historical habitat associations and compare to environmental information to investigate how climate affects habitat.
- d) Compare current predator-prey relationships involving forage fish, as inferred from diet compositions, to historical food web information.

3) Lower trophic Level (LTL) component:

- a) Characterize scales of inter-annual and longer-term variability in phyto- and zooplankton.
- b) Examine egg and larval distributions and abundances of target species in relation to topographic features and local physical oceanography to infer ontogenetic drift patterns of target species.

- c) Examine early life survival relative to forcing variables to illuminate potential mechanisms of environmental forcing of variability in larval abundances.
- d) Elucidate the importance of wind forcing (gap & barrier winds) to shelf circulation

4) *Modeling Component*

- a) Compile and analyze parameters needed for the models from databases and literature.
- b) Compile data to be used for model validation

3. PROGRESS SUMMARY

a. Provide a table showing the timeline and milestones for the current reporting period only.

| <i>What</i> | <i>Who</i> | <i>Start and end dates</i> | <i>Other key dates</i> |
|--|--|----------------------------|--------------------------------|
| Compile list of datasets for retrospective analyses. | All | Jan 1, 2011- Feb 15, 2011 | January 17-20: AMSS |
| Develop template for data descriptions to post on Sharepoint. | Jason Waite, Kim Rand, Franz Mueter | Feb 2011 | Feb 3-4: PI meeting in Seattle |
| Compile and analyze sea-surface temperature data (AVHRR, ERSST) | Jason Waite | Feb 1 – March 31, 2011 | |
| Compile and analyze ocean color data (SeaWiFS, MODIS) | Jason Waite | Mar 1 – May 31, 2011 | |
| Compile available datasets of physical and biological variability in the coastal GOA | Jason Waite | Feb 1 – Sep 31, 2011 | |
| Summarize egg and larval distributions / abundances of target species in WGOA | Miriam Doyle | Oct 1, 2010 – Apr 30, 2011 | |

b. Describe report period progress.

Objective 1a)

Data is being compiled from multiple sources and general literature searches for relevant life history information for the five focal species is currently ongoing.

Objective 1b)

Available datasets for retrospective analyses have been identified and a template for data descriptions has been developed. Individual copies of the template have been populated with relevant descriptive information for each of the approximately 100 identified datasets and have been distributed to the corresponding individuals for final review. Once these reviews have been performed, the data descriptions will be posted on Share Point.

Objective 1c)

Monthly- and 8-day-composite AVHRR SST (4 and 9 km resolution) data and monthly ERSST (1 degree resolution) data has been compiled for the GOA study region for 1983–2009 and 1900–2010, respectively. Monthly- and 8-day-composite SeaWiFS and MODIS surface chlorophyll-a data (9 km resolution) for the GOA study region have also been compiled for 1997–2010 and 2002–2010,

respectively. Regions obscured by cloud cover have been interpolated using multivariate DINEOF reconstructions.

Time-series and spatial maps of mean weekly (8-day), monthly, and yearly SST and Chl-a levels have been developed. EOF and preliminary time series analyses have been performed on monthly AVHRR and ERSST SST data and 8-day Chl-a data. Clustering algorithms to delineate the eastern and central GOA are being explored.

Other retrospective objectives under 1) were not scheduled to be addressed during the current period.

Objective 2a)

We have begun compiling historical datasets from nearshore surveys and process studies.

Other retrospective objectives under 2) were not scheduled to be addressed during the current period.

Objective 3)

The LTL component includes the investigation of early life history dynamics and recruitment of the five GOA-IERP target species of groundfish (*walleye pollock*, *Pacific cod*, *arrowtooth flounder*, *sablefish*, and *Pacific Ocean perch*). Compilation, analysis and interpretation of ichthyoplankton data pertaining to these species from three decades of plankton sampling (1972, 1977-2009) in the western GOA by the Recruitment Processes and EcoFOCI programs is ongoing as part of the retrospective analysis of historical data sets. Annual patterns of abundance and seasonal progression in distribution of eggs (pelagic spawners) and larvae at various ontogenetic stages are being compiled and examined. To date, data has been binned by half month periods and weighted mean abundance (stratified by year) calculated to provide the annual pattern in abundance of the target species (histogram plots) from both the 60 cm bongo net collections and, in the case of sablefish larvae, the neuston net collections. For each half-month period when eggs and/or larvae of the species occur in the GOA, ArcGIS maps have been produced to show the distribution and abundance of each species throughout a grid of 20 x 20 km squares representing the historical sampling coverage.

c. Describe preliminary results.

Objectives 1b, 1c

Pattern in the first principle component (PC1) from an EOF analysis of NOAA's extended reconstructed SST data (ERSST) over the wider study region, which includes the shelf and slope regions of the Gulf of Alaska extending to about 200 mile beyond the 1000m contour, showed a strong resemblance to the Pacific Decadal Oscillation, defined as the leading mode of SST variability over the entire North Pacific north of 20°N. Change points in the first PC, as identified by an iterative decomposition of the time series (R package 'bfast'), approximately correspond to the currently recognized PDO regime shifts (Figure 1), confirming that variability in the coastal Gulf of Alaska is closely associated with the PDO. The first mode of variability from the 4 km AVHRR SST data was strongly correlated with the first PC from the analysis of monthly 2-degree ERSST data (1982-2009) and was examined in more detail to obtain a better resolution of spatial patterns of variability.

The first 3 modes of the EOF analysis of the AVHRR SST data explain 68.4% of the total SST variability. The spatial pattern of the first EOF mode represents overall region-wide warming and cooling trends. The corresponding time series shows a cycle of warming and cooling with substantial cool periods occurring between ~1985–1995 and ~2006–2009. The second EOF mode shows an out-of phase spatial pattern between the eastern and western Gulf of Alaska with a break at ~143°W (Figure 2), implying that

periods of anomalously warm conditions in the eastern Gulf are associated with periods of anomalously cool conditions in the western Gulf and vice versa.

The first 3 modes of the EOF analysis for the SeaWiFS Chl-a data explain 48.7% of the total variability. The spatial pattern of the first EOF mode shows areas of intensified chlorophyll concentration along the 1000 m depth contour west of $\sim 136^{\circ}\text{W}$ longitude, apparently corresponding to the region of enhanced eddy kinetic energy. The first principle component time series shows a general seasonal cycle with chlorophyll peaks occurring in spring and fall and considerable interannual variability in both the timing and magnitude of the peaks. The spatial pattern of the second EOF mode shows a strong, out-of phase pattern inshore and offshore of the 1000 m depth contour west of $\sim 145^{\circ}\text{W}$ (Figure 2), whereas the pattern in the eastern Gulf of Alaska is coherent between inshore and offshore regions. A similar pattern was previously reported and we are currently exploring relationship between anomalies and patterns in Chl. a and potential environmental drivers.

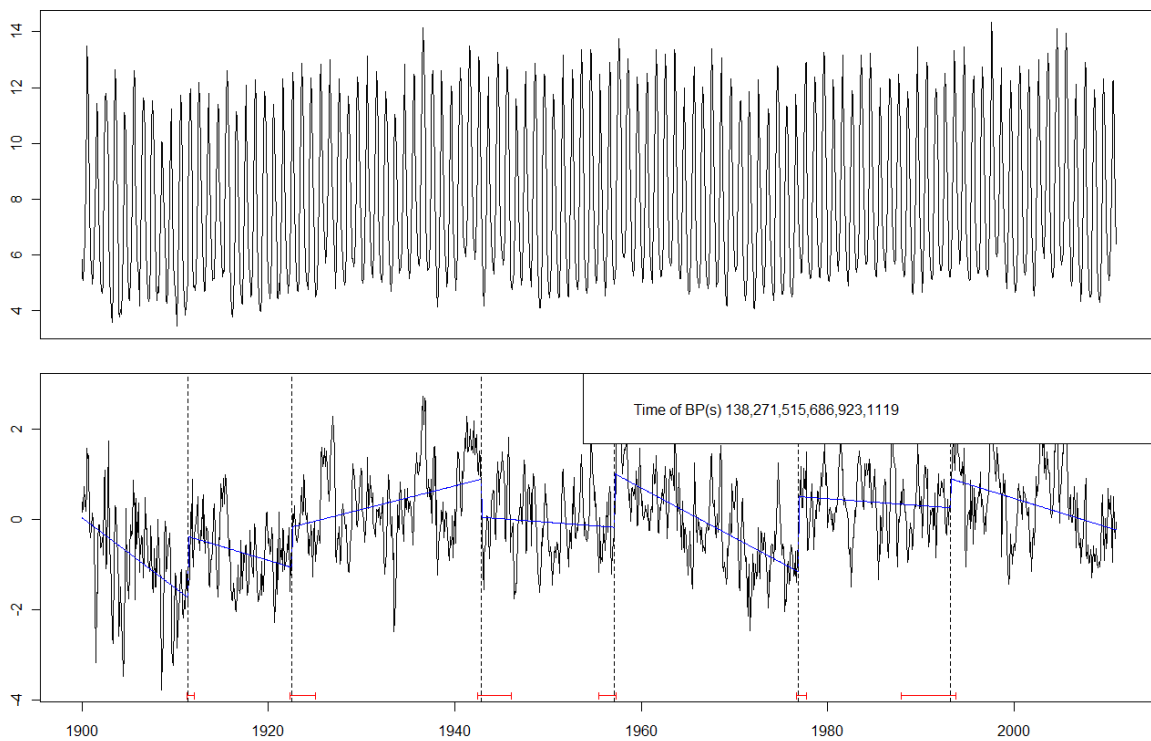


Figure 1. ERSST time series of GOA study region <200 km shoreward of the 1000 m depth contour (upper panel) and first principle component of SST anomalies with breakpoint detection (lower panel).

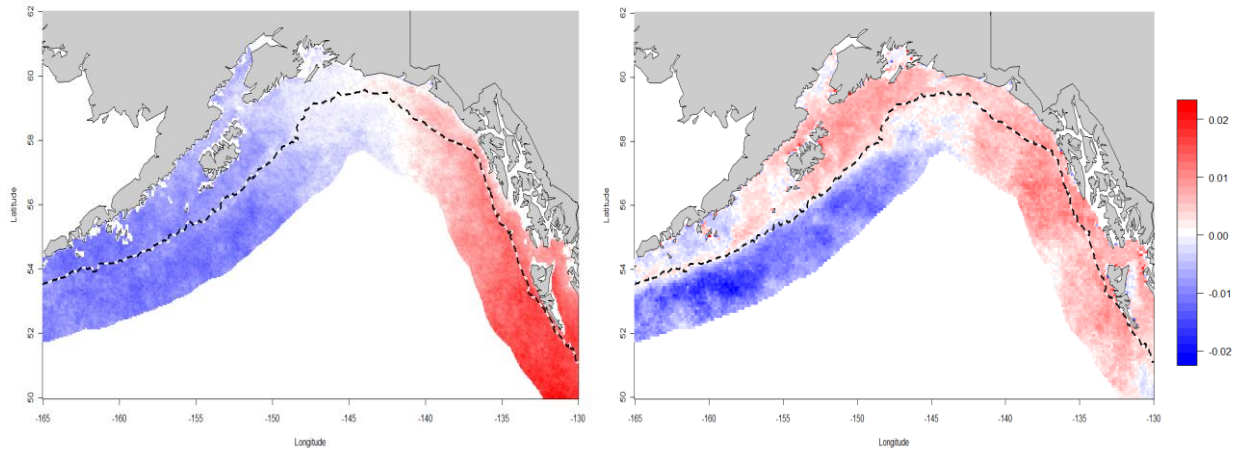


Figure 2. Second EOF modes for AVHRR SST (left) and SeaWiFS log Chl-a (right).

Objective 3)

The species annual abundance pattern plots and the associated ArcGIS maps are providing important information on timing and locations of occurrence of the early life history stages of the key species, including association with certain geographic features and likely larval transport pathways. They have been added to the Species Information section of the GOA-IERP SharePoint website. Synthesis of the historical data has also been providing species specific life history parameters for the egg and larval stages that is being incorporated into the initial development of the Individual Based Models for each of the key species (Modelling component).

d. Describe integration activity.

All PIs participated in the PI meeting in Seattle on Feb 3-4 to coordinate retrospective analyses and clarify responsibilities among the different GOA IERP components. The PIs involved in the retrospective analyses also participated in monthly conference calls. A structure was put in place to facilitate sharing of data and data summaries via the SharePoint website.

e. Describe any concerns you may have about your project’s progress.

None

f. Poster and oral presentations at scientific conferences or seminars

Goals and objectives of the retrospective analyses were presented at the the GOA IERP PI meeting in Seattle in February 2011.

g. Education and outreach

None

4. PROGRESS STATUS

We have made good progress overall in achieving some of our objectives in a relatively short amount of time. The UTL group successfully recruited a very capable post-doc who has hit the ground running and a

M.S. student in Juneau. We expect continued good progress as they become familiar with the Gulf of Alaska ecosystem and move from acquiring and checking data to analyzing it and testing hypotheses.

5. FUTURE WORKPLAN and DATA DELIVERY

Workplan

| <i>What</i> | <i>Who</i> | <i>Start and end dates</i> | <i>Other key dates</i> |
|---|--|----------------------------|------------------------|
| Continue compilation and analysis of ocean color data (SeaWiFS, MODIS) relative to | Jason Waite | Apr 1 – May 31, 2011 | |
| Compile available datasets of physical and biological variability in the coastal GOA | Jason Waite | Feb 1 – Sep 31, 2011 | |
| Collate life history information for target species and post to SharePoint website | Kalei Shotwell, Franz Mueter, Brendan Coffin, Jason Waite | May 1 - June 30, 2011 | |
| Conduct spatial analyses of GOA groundfish trawl survey data relative to physical and oceanographic variables | Jason Waite | May 1 – September 30, 2011 | |
| Post summary of results with key maps and indicator time series on SharePoint site | Jason Waite | | |
| Continue synthesis / summary of temporal and spatial (horizontal / vertical) patterns in early life history stages of target species in WGOA. | Miriam Doyle | May 1 – Nov 30, 2011 | |
| Provide species specific early life history parameters for eggs/larvae for incorporation in the IBMs. | Miriam Doyle | May 1 – Nov 30, 2011 | |
| Develop Shelikof late spring time-series of abundance of eggs and larvae 1981-2009 (continuation of time-series used in Doyle et al., 2009) | Miriam Doyle | May 1 – Nov 30, 2011 | |
| Post synthesis information and summary plots / maps showing seasonal variation in abundance and distribution of ELH stages of target species in the Western GOA and vertical distribution patterns for larvae of target species at different developmental stages from historical MOCNESS collections in the Western GOA. | Miriam Doyle | May 1- Nov 30, 2011 | |

Data delivery.

| GOAIERP Data Delivery Table | | |
|-----------------------------|-----------------------|---|
| Data type for delivery | Delivery Month & Year | Person sending data, with email address |
| NONE | | |