1. PROJECT INFORMATION

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	April 1, 2012 to September 31, 2012
Report submission date	November 1, 2012
Lead Author of Report*	Jason Waite

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 GOAIERP. 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 GOAIERP 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

3. PROGRESS SUMMARY

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

What	*Who*	*Start and end dates*	*Other key dates*
1. Characterize spatial, seasonal and interannual variability in upwelling in eastern and western GOA (Obj. 1b, d)	**Brendan Coffin, Franz Mueter**	Nov. 1, 2011 – Dec 31, 2012	
2. Characterize seasonal and interannual variability in discharge in eastern and western GOA (1b, d)	**Brendan Coffin**		
3. Continue validation of Chl a from SeaWiFS/MODIS with available in-situ measurements (1c)	**Jason Waite**	Nov. 1, 2011 – Dec 31, 2012	
4. Submit manuscript on Chl *a* variability to Deep Sea Research or Progress in Oceanography (1c,d)	**Jason Waite**	By July 31, 2012	
5. Post data and results from analysis of environmental variability and Chl. a to GOA IERP Ocean Workspace (1b,c,d)	**Jason Waite**	Apr 20 - May 31, 2012	
6. Continue and complete analysis of groundfish survey data (1b)	**Jason Waite / Franz Mueter**	August 1, 2012 – December 31, 2012	
7. Continue to compile seabird and marine mammal diet and abundance data from published and unpublished sources (1b).	**Jason Waite**	April 1, 2012 – December 31, 2012	
8. Complete analysis of available seabird diet data, and begin analysis of seabird abundance data and marine mammal diet data (1c).	**Jason Waite**		
9. Post summary data and results from synthesis of historical GOA ichthyoplankton data for target species to GOA IERP Ocean Workspace (1a, 3).	**Miriam Doyle**	April 30 – September 30 2012	
10. Continue to collaborate with Modeling group by providing early ontogeny information for target species relevant to the	**Miriam Doyle**	April 30 – September 30 2012	

development of the IBMs.			
11. Complete a draft of the manuscript describing the early life history exposure profiles of the target species and submit for internal review at AFSC, Seattle. Follow up with preparation for submission to NOAA NMFS professional papers.	**Miriam Doyle**	April 30 – September 2012	

b. Describe report period progress.

Objective 1b)

All data on seabird diet and abundance currently available from the North Pacific Seabird database has been obtained and summarized. Additional data collected by USFWS is being entered and will be made available this quarter. Once this data has been merged with our existing dataset, a complete analysis of seabird diet and abundance trends will be made for index sites for which sufficient sample sizes are available and for species for which an east-west comparison can be made. Compilation of marine mammal (sea lion and harbor seal) diet and abundance data from published sources is ongoing. Analysis of unpublished sea lion diet and abundance data for the north GOA coast (Prince William Sound, Resurrection Bay, and surrounding sites) is in progress.

We have completed our examination of regional chlorophyll variability with respect to SST, PAR, SSH, coastal upwelling, and freshwater discharge anomalies. Correlations with these variables were examined separately for the “spring” (March – June) and “fall” (July – October) periods. A final draft of the chlorophyll manuscript is nearing completion and we expect to submit for publication before the end of the quarter.

Daily upwelling data were compiled for 1967 – 2011 from the Southwest Fisheries Science Center’s Pacific Fisheries Environmental Laboratory (PFEL). Spatial and seasonal variability in upwelling in the Gulf of Alaska have been characterized using hierarchical cluster analysis of monthly upwelling time series. Cluster analysis results were mapped into Ward’s dendograms, from which groups were identified. Interannual variability in seasonal and annual means was characterized by region and potential relationships between upwelling and several climate variables (Pacific Decadal Oscillation, PDO; Northern Oscillation Index, NOI; and North Pacific Gyre Oscillation; NPGO) were investigated.

Monthly discharge data were compiled for 1931 – 2011 from the University of Alaska Fairbanks Institute of Marine Science (IMS) as updated by Tom Royer (pers. comm.). Seasonal variability was characterized for the eastern and western Gulf of Alaska using hierarchical cluster analysis; results were mapped into Ward’s dendograms to identify months that had similar variability. Interannual variability was characterized and potential relationships with climate variables were investigated.

Objective 1c,d)

Gap-filled chl-a, PAR, and SSH data for 1998-2011 and SST data for 1998-2010 at 8-day temporal and quarter-degree spatial resolution have been uploaded to the GOA IERP Ocean Workspace in netCDF format. Time-series data (including anomalies, mean levels, principle components) for the same variables have also been uploaded. Other specific indices will be added as they are identified. Data is being reorganized as improvements are made to the Ocean Workspace site.

Validation of MODIS/SeaWiFS chl-a data with *in situ* data has been completed and is included in the manuscript on chl-a variability. This manuscript is nearing completion and is expected to be distributed for an informal, internal review prior to journal submission before year-end.

Objective 1e)

Variability in the recruitment of Pacific ocean perch and sablefish is being examined relative to variability in upwelling and freshwater discharge by Brendan Coffin as part of his M.S. thesis.

Objective 1e)

No activity to date.

Objective 2)

No activity to date.

Objective 3)

Summary data and results from the synthesis of historical GOA ichthyoplankton data pertaining to the target species have been posted to the GOA IERP AOOS web-based workspace. These data and results are presented here in the form of tables, figures and maps that have been prepared for the synthesis manuscript describing the early life history pelagic exposure profiles of the target species. A draft of the manuscript (Doyle, in prep.) is nearing completion and will be reviewed internally at AFSC Seattle prior to submission to the NOAA NMFS Professional Paper Series. A related manuscript (Doyle and Mier, in press) that evaluates early life history aspects of the recruitment process among multiple GOA fish species includes relevant information on the target species, and has been accepted for publication in the Canadian Journal of Aquatic and Fisheries Sciences. Early life history data and advice relevant to the development of the IBMs has been provided to the GOA IERP modeling group, including vertical patterns of distribution and abundance of eggs and larvae, and gridded data that comprises the synthesized seasonal progression in horizontal distribution of the eggs and larvae in the western GOA.

c. Describe preliminary results.

Objectives 1b, 1c, 1d)

The Gulf of Alaska had two spatially distinct upwelling regimes: that of the eastern gulf and that of the western gulf with a breakpoint between these two regimes near 148° W (Figure 1). The eastern gulf exhibited stronger seasonality with stronger winter downwelling and a shorter period of upwelling and relaxed downwelling during summer; the western gulf exhibited weaker seasonality with a longer period of upwelling and/or relaxed downwelling (Figure 2). Upwelling in the eastern gulf showed a significant long-term trend, with a peak in the late 1980s; no statistically significant relationship was found linking this temporal trend with any of the large-scale climate variables. In the western gulf, upwelling showed no significant long-term trend, but was negatively related to the PDO at interannual time scales (Figure 3).

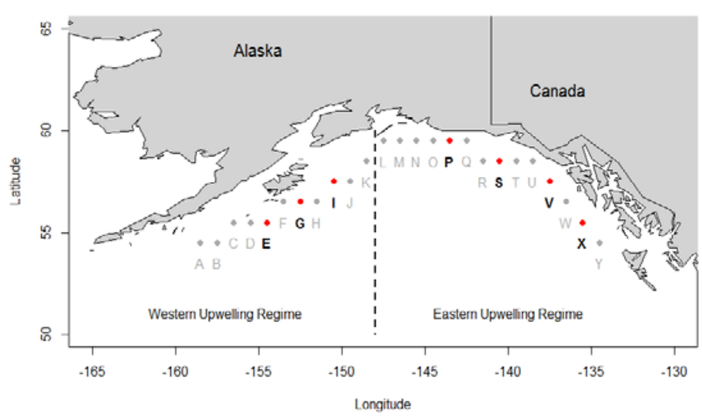

Figure 1. Map showing upwelling locations used for analysis. The dotted line marks the division between eastern and western upwelling regimes; red dots denote the locations of stations included in representative subsamples (labeled in bold).

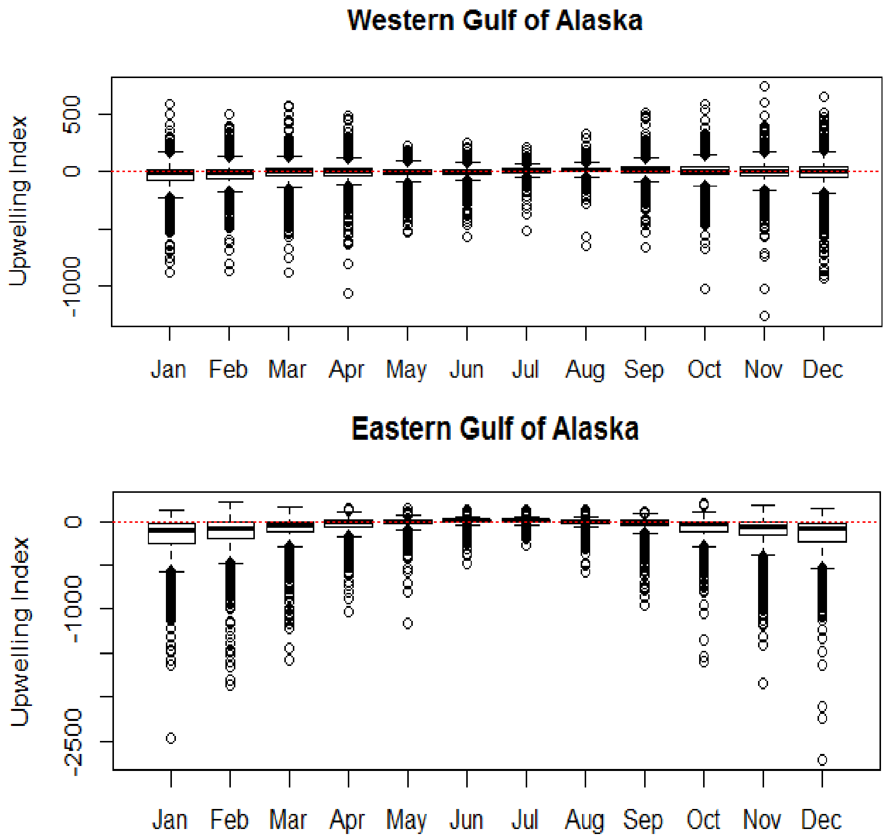

Figure 2. Boxplots of upwelling indices for each month by region. The dotted red line marks an index value of 0, which separates upwelling (positive) values from downwelling (negative) values.

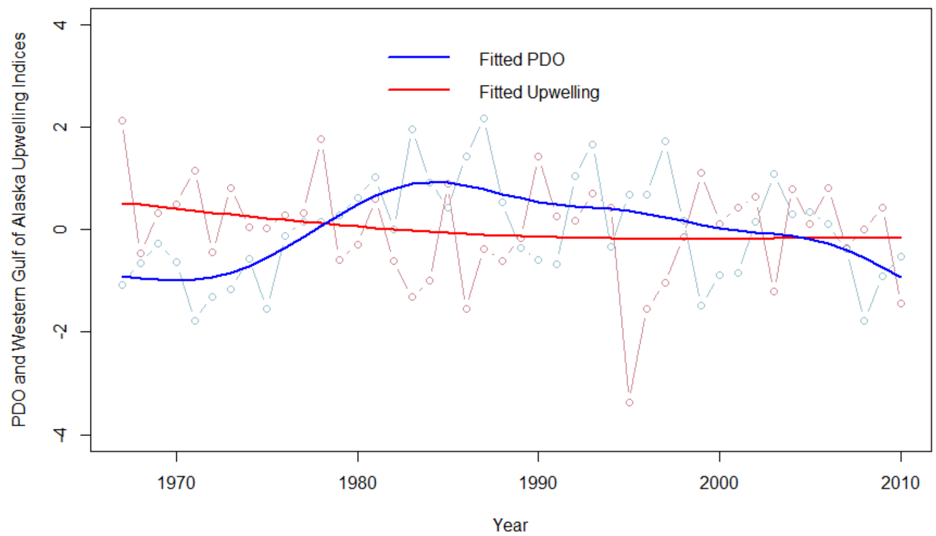

Figure 3. Timeseries plot of PDO and western Gulf of Alaska upwelling indices, including GAM smooth fits (solid curves).

For both regions, discharge was highest during autumn, lowest during winter, and intermediate during spring and summer. The timing of peak discharge differed between the two regions, occurring during October for the eastern gulf and September for the western gulf. Discharge in the eastern gulf showed no significant interannual trend and was not significantly related to any climatic variables investigated. Discharge in the western gulf showed a significant nonlinear trend with peaks during the 1950s and late 1980s, and was positively related to the PDO (Figure 4).

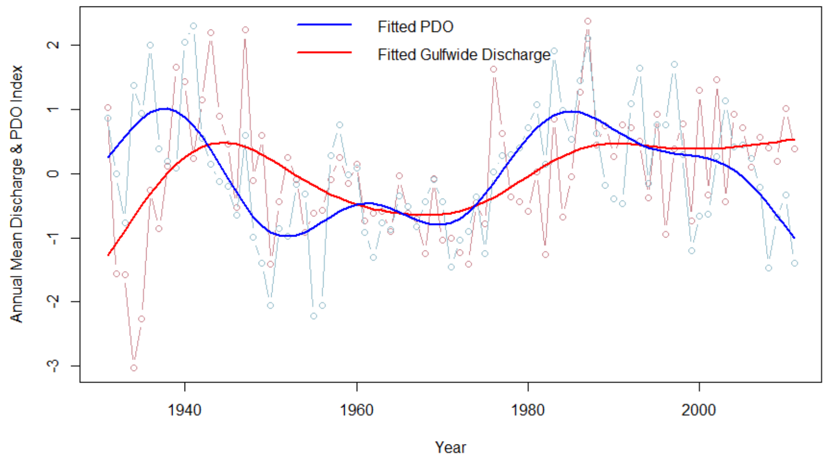

Figure 4. Timeseries plot of annual mean western Gulf of Alaska discharge and PDO index, including GAM smooth fits (solid curves).

Objective 3

A brief summary of synthesized results pertaining to seasonal and interannual patterns of abundance and distribution of eggs and larvae of the target species was included in the April 2012 GOA project retrospective component report. Since then, detailed descriptions of vertical patterns of distribution of the eggs and larvae have been added to the synthesis (Doyle, in prep). From the limited vertically discrete ichthyoplankton samples available for the GOA (historical MOCNESS data), some differences in patterns among the species are apparent. Walleye pollock eggs and newly hatched larvae occur throughout the water column from below 200 m, reflecting deep pelagic spawning primarily in Shelikof Sea Valley, and at lengths greater than 5 mm the larvae are most abundant by far in the upper 50 m of the water column reflecting an ontogenetic migration towards the surface. A similar ontogenetic migration is apparent for cod larvae although much fewer larvae are caught below 100 m as deposition of semi-demersal eggs occurs primarily in shelf waters less than 200 m depth and the newly hatched larvae seem to migrate rapidly to the upper 50 m of the water column. Unlike the gadid species, ontogenetic migration towards the surface is less apparent for *Sebastes* spp. larvae that are extruded live into the pelagic environment. Even though release of these larvae occurs mostly in deep water over the slope region, larvae are most abundant in the upper 50 m of the water column at all stages of development. Records of arrowtooth flounder larvae in MOCNESS samples were limited but larvae less than 10 mm long on average occurred significantly deeper in the water column than larger larvae reflecting the occurrence of pelagic spawning in deep water over the slope. Absence of sablefish eggs and only three records of their larvae in MOCNESS samples are attributable to the limited sampling with this gear in deep water over the slope and beyond.

Objective 1e)

Preliminary results suggest weak or no effects of upwelling and discharge on interannual variability in recruitment of Pacific ocean perch or sablefish.

Objective 2)
No results to date

Related papers submitted or in preparation
Doyle, M.J. and Mier, K.L. (in press). A new conceptual framework for evaluating the early ontogeny phase of recruitment processes among marine fish species. Canadian Journal of Fisheries and Aquatic Sciences.

Doyle, M.J. (in prep). Pelagic early life history exposure patterns of selected commercially important fish species in the Gulf of Alaska. For submission to NOAA Professional Papers NMFS series.

Waite, J.N. and Mueter, F.J. (in prep). Spatial and temporal variability of chlorophyll-a concentrations in the coastal Gulf of Alaska, 1998-2011, using cloud-free reconstructions of SeaWiFS and MODIS-Aqua data.

d. Describe integration activity.

Principal Investigators and Jason Waite have participated in monthly conference calls. Information on retrospective datasets and preliminary results from analyses has been shared via the SharePoint website. Juneau PIs (Shotwell, Mueter) met on several occasions with Jason Waite and Brendan Coffin (M.S. student) to discuss and coordinate analyses being done at UAF and at the Auke Bay Lab and to outline potential manuscripts.

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

No major concerns at this point. Some of the datasets that were identified in initial scoping, for example seabird trends and diets, have been difficult to acquire or are not available in a format that can readily be prepared for analysis. Datasets for analysis will be prioritized as not all of the initially identified datasets can be fully analyzed within the scope of the retrospective component.

f. Poster and oral presentations at scientific conferences or seminars

B. Coffin, F. Mueter. Environmental Covariates of Recruitment of Two Demersal Fish Species, Sablefish (*Anoplopoma fimbria*) and Pacific Ocean Perch (*Sebastes alutus*), in the Gulf of Alaska. AFS Student Symposium. April 13, 2012.

g. Education and outreach

None to date

4. PROGRESS STATUS

We have continued to make good progress and have largely completed the tasks scheduled for the current reporting period. Data analyses are ongoing and several manuscript are close to completion. These analyses will provide time series indices of physical and lower-trophic level variability to be used in analyses of recruitment trends of our focal species. Analyses of upper trophic level variability, including recruitment trends of focal species, are in the beginning stages and we will be outlining potential manuscripts over the next several months.

5. FUTURE WORKPLAN and DATA DELIVERY

Workplan

What	*Who*	*Start and end dates*	*Other key dates*
Continue to collaborate with the modeling group as requested to provide information and data relevant to the development of the target species IBMs.	**Miriam Doyle**	October 1 2012 – April 30 2013.	
Complete early life history synthesis manuscript (Doyle, in prep) through internal review and submission to NOAA Professional papers, and respond to outside peer-reviews.	**Miriam Doyle**	October 1 2012 – April 30 2013.	
Present an over view of the retrospective synthesis of GOA historical ichthyoplankton data at the GOA IERP PI meeting in 2013.	**Miriam Doyle**	March 18-20 2013.	
Submit manuscript on Chl *a* variability to Progress in Oceanography (1c,d)	**Jason Waite**	By December 31, 2012	
Complete analysis of sablefish and POP recruitment trends, prepare manuscript	**Brendan Coffin / Franz Mueter**	November 1, 2012 – August 31, 2013	
Analysis of groundfish survey data (catch-per-unit-effort from bottom trawl and longline surveys for multiple species) (1b)	**Franz Mueter / Jason Waite / Kalei Shotwell**	August 1, 2012 – May 31, 2013	
Continue to compile seabird and marine mammal diet and abundance data from published and unpublished sources (1b).	**Jason Waite**	April 1, 2012 – December 31, 2012	
Complete analysis of available seabird diet data, and begin analysis of seabird abundance data and marine mammal diet data (1c).	**Jason Waite**	November 1, 2012 – June 30, 3013	
Analysis and characterization of spatial patterns (East-West comparison) across environmental variables and across all trophic levels.	**Franz Mueter, Jason Waite, Brendan Coffin, Kalei Shotwell**	February 1, 2013 – December 31, 2013	

Data delivery.

GOAIERP Data Delivery Table		
Data type for delivery	Delivery Month & Year	Person sending data, with email address
Seabird and marine mammal diet and abundance data used for analysis of trends in eastern and central/western GOA	June 30, 2012	Jason Waite jwaite3@alaska.edu
Groundfish survey data (catch-per-unit-effort from bottom trawl and longline surveys for multiple species) used for analysis of trends in coastal GOA	June 30, 2013	Franz Mueter fmueter@alaska.edu