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, 2011 to 31 September 31 2011
Report submission date	November 7, 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 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*
Task 1. Continue compilation and analysis of ocean color data (SeaWiFS, MODIS)	**Jason Waite**	Apr 1 – May 31, 2011	
2. Compile available datasets of physical and biological variability in the coastal GOA	**Jason Waite**	Feb 1 – Sep 31, 2011	
3. 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	
4. Conduct spatial analyses of GOA groundfish trawl survey data relative to physical and oceanographic variables	**Jason Waite**	May 1 – September 30, 2011	
5. Post summary of results with key maps and indicator time series on SharePoint site	**Jason Waite**		
6. Continue synthesis / summary of temporal and spatial (horizontal / vertical) patterns in early life history stages of target species in WGOA.	**Miriam Doyle**	May 1 – Sep 30, 2011	
7. Provide species specific early life history parameters for eggs/larvae for incorporation in the IBMs.	**Miriam Doyle**	May 1 – Sep 30, 2011	
8. 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 – Sep 30, 2011	
9. 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- Sep 30, 2011	

b. Describe report period progress.

Objective 1a)
Data have been compiled from multiple sources and general literature searches on relevant life history information for the five focal species. Brief species summaries have been completed and will be incorporated into a more extensive document to summarize what is currently known about the life history of the five focal species (Task 3).

Objective 1b)
Basic summary information for approximately 100 datasets have been posted on SharePoint.in the form of "metadata" templates. These are currently organized by name to identify individuals that will serve as contact for these data sets. Contacts have been asked to review the data description sheets and modify as necessary (Task 2).

Compilation of relevant spatial and time series data has continued. Eight-day and monthly composite Aviso sea surface height (SSH) and eddy kinetic energy (EKE) at 1/3-degree resolution have been compiled for the GOA study region for 2002-2010 and reprojected to align spatially with previously compiled sea surface temperature (SST) and chlorophyll-a (chl-a) data. Indices for coastal upwelling, freshwater discharge, and sea surface pressure (North Pacific Index) have also been compiled. (Task 2)

Objective 1c)
Analyses of the spatial and temporal patterns in chl-a has continued. A manuscript is currently being prepared that seeks to describe the spatial and temporal patterns of chl-a concentrations and the spring bloom with respect to environmental variables such as fresh water discharge, upwelling indices, NPI, SST anomalies, photosynthetically available radiation, and potentially other indices of winter mixing (e.g. winds, EKE) (Task 1).

Preliminary summaries of SST and chl-a spatial and temporal analyses have been posted on SharePoint, including monthly and annual climatologies, spatial maps of dominant EOF modes and corresponding time series, and plots of the anomaly time series (Task 1).

EOF analysis has been performed on 8-day and monthly composite SSH and EKE anomalies for 2002-2010. New EOF analyses have also been performed on monthly, 1/3-degree resolution SST and chl-a data to allow direct spatial comparison with SSH and EKE results, as well as temporal comparisons with monthly NPI, freshwater discharge, and upwelling indices (Task 1).

Preliminary analyses of data from GOA bottom trawl surveys (triennial surveys from 1990-1999 and biennial surveys from 2001-2009) have been completed. Spatial maps of species distribution based on catch-per-unit-effort (CPUE) for the five focal species have been generated, as well as maps of mean species diversity, species richness, and total CPUE. Changes in the overall community structure over time have also been explored, as well as models (GAM, NMDS) relating species richness, diversity, and CPUE to bottom depth, bottom temperature, and alongshore distance (Task 4).

Objective 1d)
Variability in some of the key drivers analyzed in 1c) has been quantified to construct annual indices of physical, oceanographic, and lower trophic level variability relevant to fish. These indices will be related to variability in fish populations.

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

Objective 2)

No work was scheduled on this objective for the current reporting period.

Objective 3)
Synthesis of historical GOA ichthyoplankton data continues with progress in Tasks 6-9. Task 6 progress includes a completed synthesis of prevailing seasonal patterns in distribution and abundance of eggs and/or larvae for the key species based on 60 cm bongo net collections (and neuston collections for sablefish larvae) in the western GOA from 1972 to 2009 (histograms and maps posted to SharePoint site). Species-specific early life history patterns and parameters that are needed for incorporation into the development of the IBMs continue to be provided to the Modeling Group as requested, as part of Task 7. The Shelikof region late spring time-series of ichthyoplankton species abundance (as described in Doyle et al., 2009) has now been developed for the years 1981-2009, as part of a related NOAA-NPCREP supported project by Doyle. GOA-IERP species are included in this time-series (Task 8) and these data will now be incorporated into the continuing retrospective synthesis of GOA ichthyoplankton data. Abundance and larval size data for the key species have been compiled from historical GOA MOCNESS collections, and these data continue to be synthesized (Task 9) for the purpose of elucidating patterns in vertical distribution of these species throughout early ontogeny. It is now planned to incorporate all the synthesis of the above historical GOA ichthyoplankton data into a review manuscript for submission to the NOAA/NMFS Professional Paper Series. This manuscript will provide a comprehensive review of the early life history patterns of the 5 key species in the context of the GOA-IERP program.

c. Describe preliminary results.

Objectives 1b, 1c

Examination of the GOA-wide bottom community composition suggests an overall decrease in the proportion of walleye pollock, sablefish, and arrowtooth flounder in the total groundfish biomass from 1990-2009. There was a ~100% increase in the proportion of Pacific cod and a slight increase in walleye pollock from 2007 to 2009. In the western GOA, Pacific Ocean perch (POP) increased from 1990 through 2001, experienced a ~50% decrease in 2003, and then recovered to just below 2001 levels through 2009. The total biomass of walleye pollock and Pacific cod decreased slightly each year from 1990-2007 and increased slightly in 2009. Arrowtooth flounder also remained stable, with anomalously high levels in 2003. In the eastern GOA, POP remained relatively stable. POP levels experienced an apparent decrease in 1999 but recovered in subsequent years. Pacific cod and walleye pollock remained stable at relatively low levels in the GOA throughout the entire period analyzed. As in the west, arrowtooth flounder also remained stable, but had anomalously high levels in 1999. Figure 1 illustrates the spatial patterns of the mean predicted survey CPUE for the five focal species by survey year.

Indices of species diversity and richness were estimated by haul and stratum. Depth, alongshore distance, and bottom temperature were all significant predictors for CPUE, species diversity, and species richness. Analysis of the longitudinal and alongshore distance patterns of species diversity, distribution, and CPUE suggest a geographic breakpoint at approximately 146-149°W (Figure 2). This corresponds to the possible spatial breakpoint of approximately 147°W identified in the second chl-a EOF mode. A non-metric multidimensional scaling analysis indicates clear differences in species composition by depth and region (e.g., longitude and alongshore distance).

Further analysis of the first two dominant SeaWiFS chl-a EOF modes suggests that the first mode represents the overall pattern of the annual spring bloom, while the second mode represents an alternating

pattern in the shelf vs offshore (seaward of the 1000m isobath) timing of the spring bloom in the western half of the GOA. Initial models suggest that a substantial portion of the variation in the timing and magnitude of the spring bloom in the eastern GOA can be explained by the late-winter/early-spring fresh water discharge and surface water warming. Seasonal upwelling/downwelling and NPI explain more of the variation in the western GOA, with fresh water discharge and surface warming explaining less of the variation. A manuscript summarizing these results is in preparation.

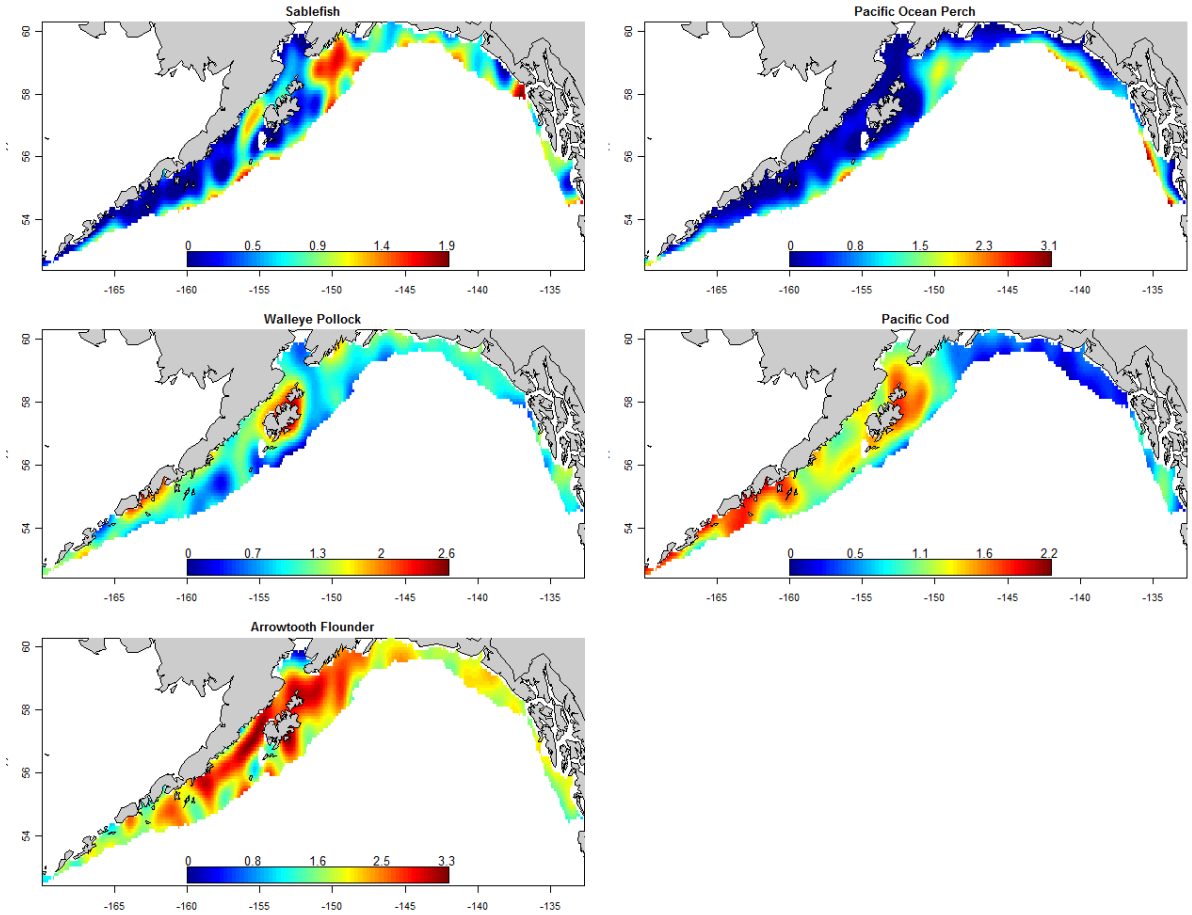

Figure 1. Predicted mean CPUE^0.25 based on GAM models for the five focal species: sablefish, Pacific Ocean perch, walleye pollock, Pacific cod, and arrowtooth flounder.

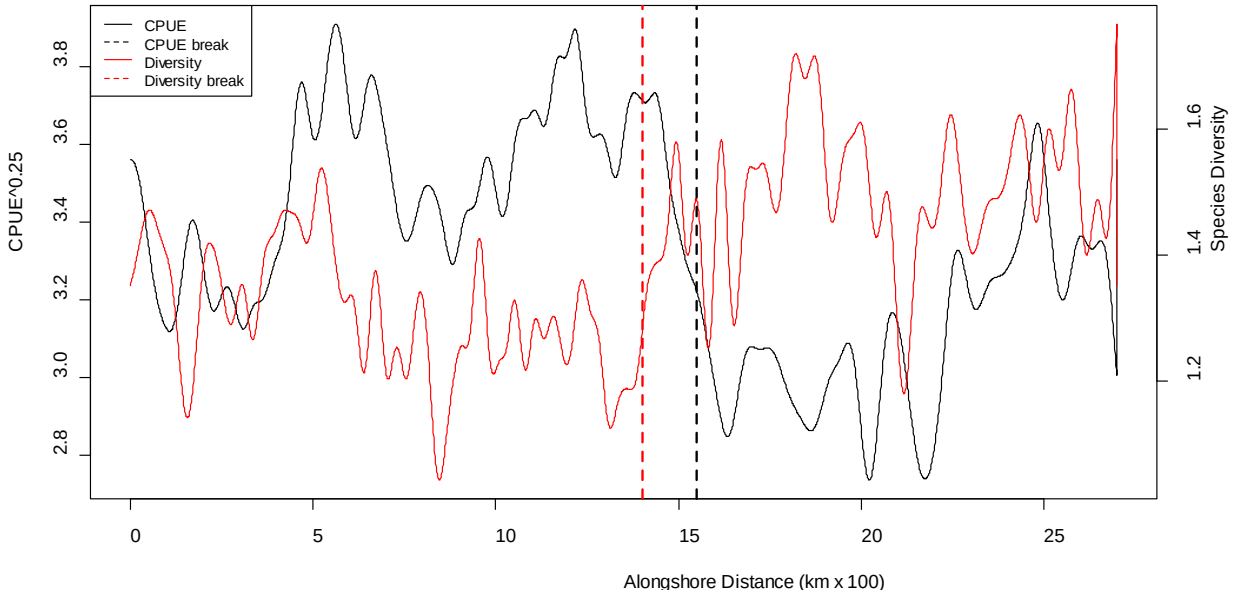

Figure 2. Trends of CPUE and species diversity vs. alongshore distance (from west to east). Dashed vertical lines represent the estimated breakpoints.

Objective 3)

As mentioned above, results from the retrospective analysis of GOA historical ichthyoplankton data are being developed into a draft review manuscript for submission to NOAA/NMFS Professional Paper Series. The format being used for this manuscript includes the following sections:

- Introduction: A summary of what the GOA-IERP project is about and thus the choice of 5 species to be covered. This will also include a brief description of the early life history work that AFSC/Eco-FOCI has been doing over the years, with reference to many of the key publications that pertain to the 5 species.
- Species Sections:
  - Reproductive information - age at 1st maturity, fecundity, spawning patterns/mode.
  - Seasonal patterns - annual patterns in abundance of eggs/larvae in plankton, seasonal progression in size (Fig. 3) and distribution patterns.
  - Horizontal and vertical patterns of distribution of eggs/larvae - will include synthesis of our 60 cm Bongo, Neuston, and MOCNESS data, and examination of distribution patterns of larvae at different ontogenetic stages (binning data by specific larval size ranges).
  - Where possible, a comparison of observed patterns from limited sampling in the eastern GOA with patterns observed in the western GOA.
  - Interannual trends in abundance of eggs/larvae from our late spring time-series.
  - Likely early life history risk/resilience characteristics based on above synthesized "exposure" patterns during early life in the context of prevailing oceanographic conditions, and relevance to recruitment variability.

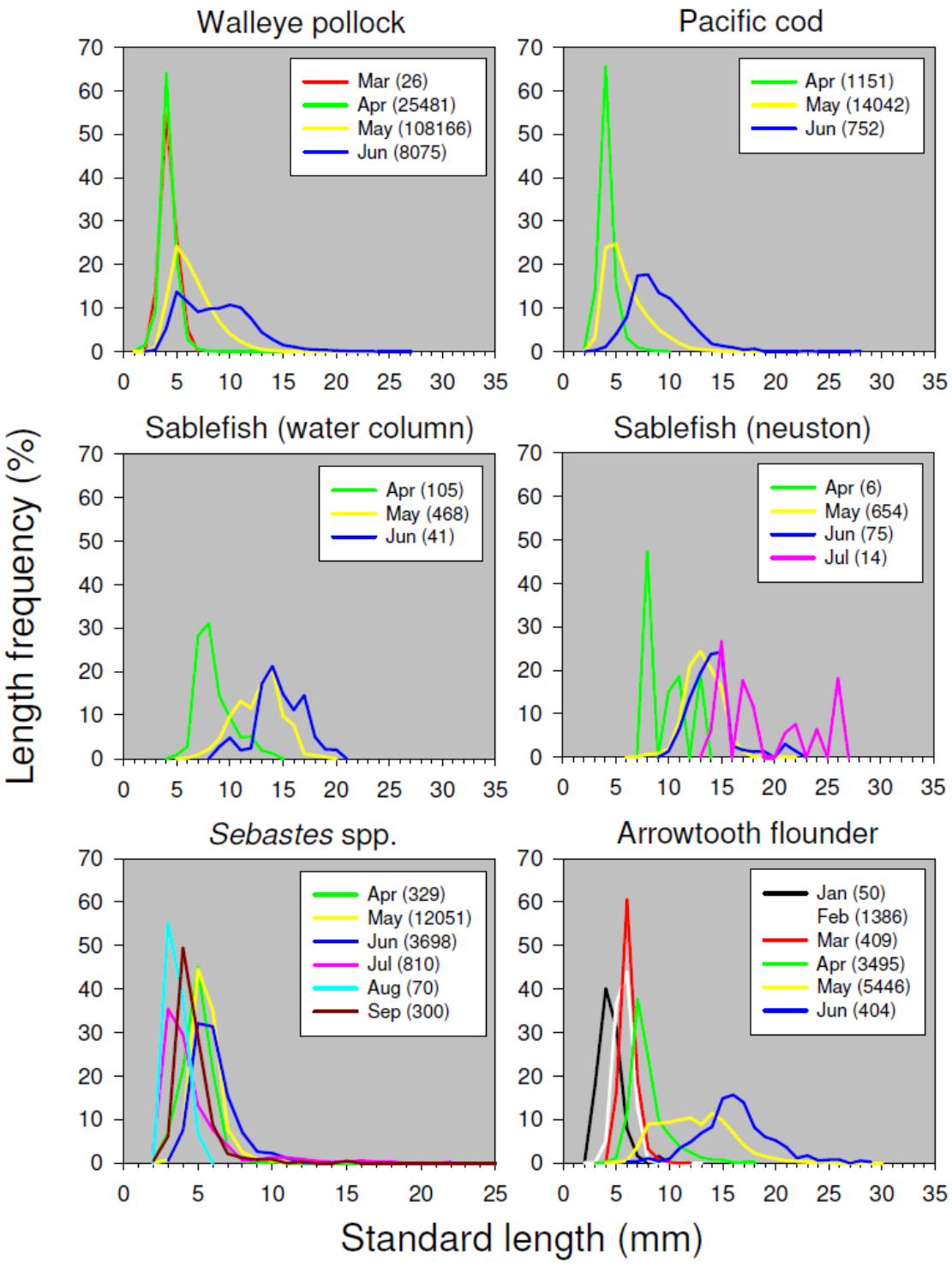

Figure 3. Length frequency distributions by month for larvae of the GOA-IERP species of interest from historical ichthyoplankton collections in the western Gulf of Alaska, 1972-2009 (60 cm Bongo net for all species and neuston net for sablefish larvae). Numbers in parentheses are the total numbers of larvae measured for each month, all years combined.

d. Describe integration activity.

Most PIs 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. Doyle and Hinckley have met several times to discuss information useful to the modeling work.

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.

f. Poster and oral presentations at scientific conferences or seminars

Franz Mueter gave two presentations at the American Fisheries Society Meeting in Seattle, WA, that drew in part on the datasets being assembled under this project. Miriam Doyle also gave a presentation at the AFS meeting in Seattle based on multispecies synthesis of historical GOA ichthyoplankton data, including information pertaining to the five key GOA-IERP species. A similar presentation was also given by Doyle at the ICES Annual Science Conference in Gdansk, Poland (Sept 9-23) in a special ICES/PICES joint session on Early Life History and Recruitment Processes.

g. Education and outreach

Kalei Shotwell updated the Gulf of Alaska groundfish plan team on the GOA IERP project and shared preliminary results.

4. PROGRESS STATUS

We have made satisfactory progress and completed the tasks scheduled for the current reporting period. Data compilation is ongoing and analyses to date have focused on lower trophic level dynamics, including an analysis of historical ichthyoplankton data and an analysis of satellite-based Chlorophyll estimates. These analyses will provide important baseline information for the modeling efforts, as well as time series indices of physical and lower-trophic level variability to be used in future analyses of recruitment trends of our focal species.

5. FUTURE WORKPLAN and DATA DELIVERY

Workplan

What	*Who*	*Start and end dates*	*Other key dates*
Task 1: Continue compilation and analysis of upper trophic level data (fish, seabirds, mammals)	**Jason Waite**	Oct 1, 2011 – Mar 31, 2012	AMSS, Jan 16-20, 2012
2. Characterize interannual variability in upwelling and wind mixing in eastern and western GOA.	**Jason Waite, Brendan Coffin**	Nov. 1, 2012 – Dec 31, 2012	
3. Validation of Chl. a from SeaWiFS/MODIS with available in-situ measurements	**Jason Waite**	Nov. 1, 2012 – Dec 31, 2012	
3. Draft manuscript on *Chl a* variability	**Jason Waite, Franz Mueter**	Jan 31, 2012	
4. Compile and summarize discharge data, characterize interannual variability	**Brendan Coffin**	Oct 1, 2011 – Mar 31, 2012	
5. Update analysis of groundfish survey data through 2011 to characterize trends and variability in the GOA groundfish community 1990-2011, summarize results and post to SharePoint, outline potential manuscript	**Jason Waite, Franz Mueter**	Feb 1, 2012 – Mar 31, 2012	GOA IERP PI meeting, week of March 5
6. Post summary of results with key maps and indicator time series on SharePoint site as they become available	**Jason Waite**	Oct 1, 2011 – Mar 31, 2012	
7. Continue compilation, analysis and synthesis of historical ichthyoplankton data and contribute summary information to SharePoint site.	**Miriam Doyle**	Oct 1, 2011 – Mar 31, 2012	
8. As requested, continue to provide parameter information to Modelers for development of IBMs	**Miriam Doyle**	Oct 1, 2011 – Mar 31, 2012	
9. Continue to develop a manuscript that will provide a comprehensive review of the early life history patterns of the 5 key species in the context of the GOA-IERP program	**Miriam Doyle**	Oct 1, 2011 – Mar 31, 2012	

Data delivery.

GOAIERP Data Delivery Table		
Data type for delivery	Delivery Month & Year	Person sending data, with email address
Gridded SST, EKE, SSH, and Chl. a data with common spatial/temporal resolution	Jan 31, 2011	Jason Waite jason.waite@alaska.edu
Annual indices of variability in SST, Chl.a (timing & magnitude), upwelling, discharge, and wind mixing.	Mar 31, 2012	Jason Waite jason.waite@alaska.edu