

1. PROJECT INFORMATION

GOA IERP Project Number:	G84
Title:	Exploring temporal and spatial variability in Gulf of Alaska groundfish dynamics with integrated biophysical models
Overall project duration	May, 2010 - February, 2015
Overall project funding	\$999,995
Report period	November 1 2011 to May 1 2012
Report submission date	May 11, 2012
Lead Author of Report	Georgina Gibson and Sarah Hinckley (co-Lead PIs)

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

Georgina Gibson: gagibson@alaska.edu

Ken Coyle: coyle@ims.uaf.edu

Albert J Hermann: Albert.J.Hermann@noaa.gov

Carolina Parada: cparada@inpesca.cl

Sarah Hinckley: Sarah.Hinckley@noaa.gov

Carol Ladd: Carol.Ladd@noaa.gov

William Stockhausen: William.Stockhausen@noaa.gov

Kerim Aydin: Kerim.Aydin@noaa.gov

Kate Hedstrom: kshedstrom@alaska.edu

2. PROJECT OVERVIEW

A. BRIEFLY (4-5 SENTENCES) DESCRIBE THE CORE PURPOSE OF YOUR PROJECT, AND THE UNDERLYING NEED FOR THIS RESEARCH.

Groundfish recruitment in the Gulf of Alaska is thought to be controlled by physical processes (i.e. climate and transport) and biological processes (i.e. growth and predation) experienced between offshore spawning sites and the end of the young of year (YOY) stage. We will use the Regional Ocean Modeling System (ROMS), a Nutrient-Phytoplankton-Zooplankton (GOANPZ) model, and Individual-Based Models (IBMs) to examine recruitment mechanisms and derive indices related to recruitment for five ground fish species; arrowtooth flounder, walleye pollock, Pacific cod, Pacific Ocean perch, and sablefish. We will also incorporate the indices in a multispecies model (MSM) to explore the consequences of recruitment variability on the GOA ecosystem and fisheries. Indices produced, and conclusions about the effects of physical and biological processes on the GOA ecosystem under different physical regimes will aid in the management of these important fish stocks.

B. STATE THE SPECIFIC GOAIERP HYPOTHESIS OR HYPOTHESES THAT YOUR PROJECT IS ADDRESSING.

Our project will address two of the overarching GOAIERP hypothesis:

- 1) **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.
- 2) **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.

To achieve the objectives of our project we will address the following testable hypotheses with our suite of models:

1. *Historical environmental variability in the GOA can be characterized in terms of a few (≤ 6) distinct physical regimes and we can identify these regimes from ROMS simulations.*
2. *Recruitment variability of the five focal species is primarily influenced by variability in the proportion of young fish transported from offshore spawning areas to nearshore nursery areas (connectivity) due to interannual differences in the strengths of the physical regimes that characterize the GOA environment.*
3. *Recruitment variability is secondarily influenced by the survival of young fish successfully transported to nursery areas, which varies due to differences in physical factors (wind speed and direction, water temperature, runoff, mixing) and biological processes (prey abundance, competition, predation) encountered along the transport pathways.*

C. LIST THE SPECIFIC OBJECTIVE(S) OF YOUR RESEARCH PROJECT.

The objective of this project is to identify how recruitment of five target groundfish species in the GOA is affected by environmental variability in the region. We will project the effects of different environmental regimes, and the resulting recruitment variability, on upper trophic level ecosystem dynamics for the GOA under current fishing regimes.

- **NEP5 Regime Analysis:** Use Empirical Orthogonal Function (EOF) and other analysis tools to identify a small number (≤ 6) of distinct physical regimes that comprise the major components of environmental variability in the GOA. Categorize each year as representative of a particular regime.
- **IBM Connectivity:** Calculate the proportions of individuals that arrive at juvenile nursery areas from specific source areas (spawning regions or early larval distributions).
- **Trajectory analysis:** Examine the differences between survivors and non-survivors (or those who do not reach nursery areas) by examining correlations between physical and LTL variables and individual characteristics along individual trajectories from the IBMs through the YOY stage
- **Indices:** Calculate indices related to recruitment success from the IBM results for each of the five focal groundfish species. Transform indices into anomalies from mean recruitment biomasses.
- **MSM simulations:** Incorporate recruitment indices from the IBMs into the MSM model to test how the effects of the different environmental regimes on recruitment interact with population dynamics processes and fisheries.

3. PROGRESS SUMMARY

A. PROVIDE A TABLE SHOWING THE TIMELINE AND MILESTONES FOR THE CURRENT REPORTING PERIOD ONLY.

	2011	2012			
Research Activity Milestone	4	1	2	3	4
NEP5 Regime/Pattern Analysis PI's: Ladd & Hermann.					
Comparison between Float Tracking Tools PI's: Parada, Stockhausen, Gibson					
Construction of IBMs for the 5 target species Dependency: LTL, MTL and UTL information PI's: Parada, Stockhausen, Gibson, Hinckley					
Develop experimental design for model runs Dependency: Regime Analysis, Recruitment timeseries, UTL retrospective analysis PI's: All PIs					
Run ROMS/GOANPZ model on NEP grid for boundary conditions for CGOA grid PI's: Hermann, Hedstrom, Coyle, Gibson					
Run ROMS/GOANPZ on 3 km CGOA grid PI's: Coyle, Gibson					

B. DESCRIBE REPORT PERIOD PROGRESS.

NEP5 Regime Analysis: As planned, during this reporting period the pattern analysis work on the NEP5 model output was completed. A few additional analyses were added during this reporting period, beyond what was originally planned, and results from these activities were presented at the March 2012 PI meeting and used in the Experimental Design phase. Results from this activity are described in the Results section, below.

Comparison between Float Tracking Tools

During this reporting period we continued experiments to compare the skill of the offline IBM tools ICHTHYOP and DisMELS to track ‘floats’ relative to the ROMS online float tracking. After adjustments to the DisMELS tool, it is able to reproduce the online ROMS float trajectories well. With the rerun of the experiments done in this reporting period, inconsistencies have been found with float tracks produced by the (V.2) ICHTHYOP tool relative to online ROMS. We have obtained the most recent (V3.1) of ICHTHYOP which we anticipate will address the problems identified, and this tool is now being implemented. The float tracking comparison tests will be rerun with V3.1. Results from this activity are described in the Results section, below.

Construction of IBMs for the 5 target species:

Construction of the IBM models for each of the five target species are at different stages of development. The pollock IBM is a detailed model previously developed by S. Hinckley and C. Parada. This model is essentially fully developed, with only minor updates needed, which are being implemented. The POP, sablefish and arrowtooth IBMs will be much simpler due to the level of data availability on these species. Conceptual models for these species have been developed and construction of the code in NetBeans (Java) in under way. The POP, arrowtooth, sablefish and Pacific cod IBMs are being developed using the DisMELS software. The pollock IBM will most likely utilize the V3.1 of ICHTHYOP.

Develop experimental design for model runs:

Discussions on the exact years of model runs that will be undertaken with the ROMS/GOANPZ model (NEP and CGOA model grids) and IBMs were completed. The decision was based on results of the pattern analysis work and on historic recruitment patterns presented by Franz Mueter. It was decided that the years 1995-2005 contained sufficient contrast in physical patterns of El Niño/La Niña, fresh water input to the GOA, stratification on the shelf, cross-shelf exchange, and recruitment of the focal species so as to enable good comparisons in our modeling results. We may also run more recent years than 2005 if time allows.

Run ROMS/GOANPZ model on NEP grid for boundary conditions for CGOA grid and Run ROMS/GOANPZ on 3 km CGOA grid

Hindcast years have been selected (see above). An initial short (3-4 year) test run of hindcast years will be completed in order to determine whether a climatological nudging of nitrate and/or iron is necessary to constrain the model. If it is, nudging will be implemented and the hindcast years run. According to our project timeline this activity is expected to be ongoing through the second and third quarters of 2012. We have prepared boundary and forcing files from Climate Forecast Systems Reanalysis (CFSR) atmospheric and oceanic model output for 1995-2005, which will initially be used to drive the coarser resolution 10km ROMS/NEP5 model. Runs using the North East Pacific (NEP) grid will provide boundary conditions for the higher resolution (3km) ROMS Coastal Gulf of Alaska (CGOA)/NPZ model of Coyle et al. (2012) It is anticipated that this work will be accomplished in the next six months.

C. DESCRIBE PRELIMINARY RESULTS.**NEP5 Pattern Analysis**

We have examined physical variables from the NEP5 model output to determine how they co-vary and to what extent we can summarize variability of the physical state of the Gulf of Alaska using a limited set of patterns. The analyses suggest that El Niño (as described by the Multivariate ENSO Index, MEI) is a dominant contributor to variability in many parameters of interest in the Gulf of Alaska. Multivariate analysis suggests that El Niño years correspond to stronger northeastward wind stress, stronger Alaska Gyre circulation, high coastal sea surface height anomalies, warm sea surface temperatures, deeper coastal mixed layer depths, stronger shortwave radiation, and stronger sensible heat losses. Since our last report, the multivariate analysis has been carried out separately for eastern and western GOA regions (east and west of ~145 degrees west, respectively). In these analyses, the MEI was found to be strongly related to the multivariate behavior, with spatial patterns similar to those described above for the entire GOA (Fig. 1). In addition, for the eastern gulf region, the North Pacific Gyre Oscillation (NPGO) was found to be significantly correlated with the leading multivariate mode, which contained higher coastal sea surface height and stronger coastal flows in association with intensified northwestward wind stress, but no corresponding changes in SST (Fig 2). Weaker shortwave radiation was accompanied by sensible heat gain in this mode.

The 1997 El Niño event was one of the strongest events in recent history. In addition to the connections discussed above, 1997 was a year of particularly strong and persistent eddies, early stratification setup and strong August stratification. However, the time series of strength and timing of stratification do not appear to be strongly correlated to ENSO, suggesting that events may have to be particularly strong to influence stratification. The strength of cross-shelf velocities at the shelf break and monthly anomalies in freshwater runoff also do not appear to be correlated with ENSO (Fig. 3). However, as these parameters are likely to be important to the ecosystem, these patterns also inform the selection of model years. Based on these analyses, it was determined that the first priority in running the coastal GOA model should be to compare 1997 with a La Niña year. In addition, Franz Mueter provided an analysis of

patterns of covariation among recruitment of the 5 focal species. Franz suggested that the years 1998-2001 would be good years for model runs from a recruitment perspective as they show good contrast in recruitment of the 5 species. Thus, we have decided to begin the model runs with 1995, running forward for as many years as is feasible.

Gap Winds

C. Ladd is also part of the LTL group, and her research will inform the modeling work, so we describe parts of it here. Pressure gradients across the mountains can result in strong “gap winds”, low-level wind jets flowing out of gaps in the mountains. Gap wind events associated with Cross Sound, Yakutat Bay, and Iliamna Lake occur most frequently during the winter months. High resolution daily scatterometer wind data were used to identify and characterize gap wind events. In the eastern Gulf of Alaska (Cross Sound), the frequency of events is significantly correlated with the Multivariate Enso Index (MEI), suggesting that gap wind events occur more frequently in El Niño winters. Alternatively, in the western Gulf of Alaska, the frequency of events is not significantly correlated with the MEI but is correlated with the Pacific/North American (PNA) Pattern. Gap wind events can influence local oceanography and ecosystems through enhanced mixing, cross-shelf transport, eddy formation, small-scale horizontal and vertical circulations, and atmospheric dust transport/deposition. The coastal GoA model is being used to examine the influence of these events on the coastal ocean. Results of this research may be particularly relevant to the individual based modeling experiments.

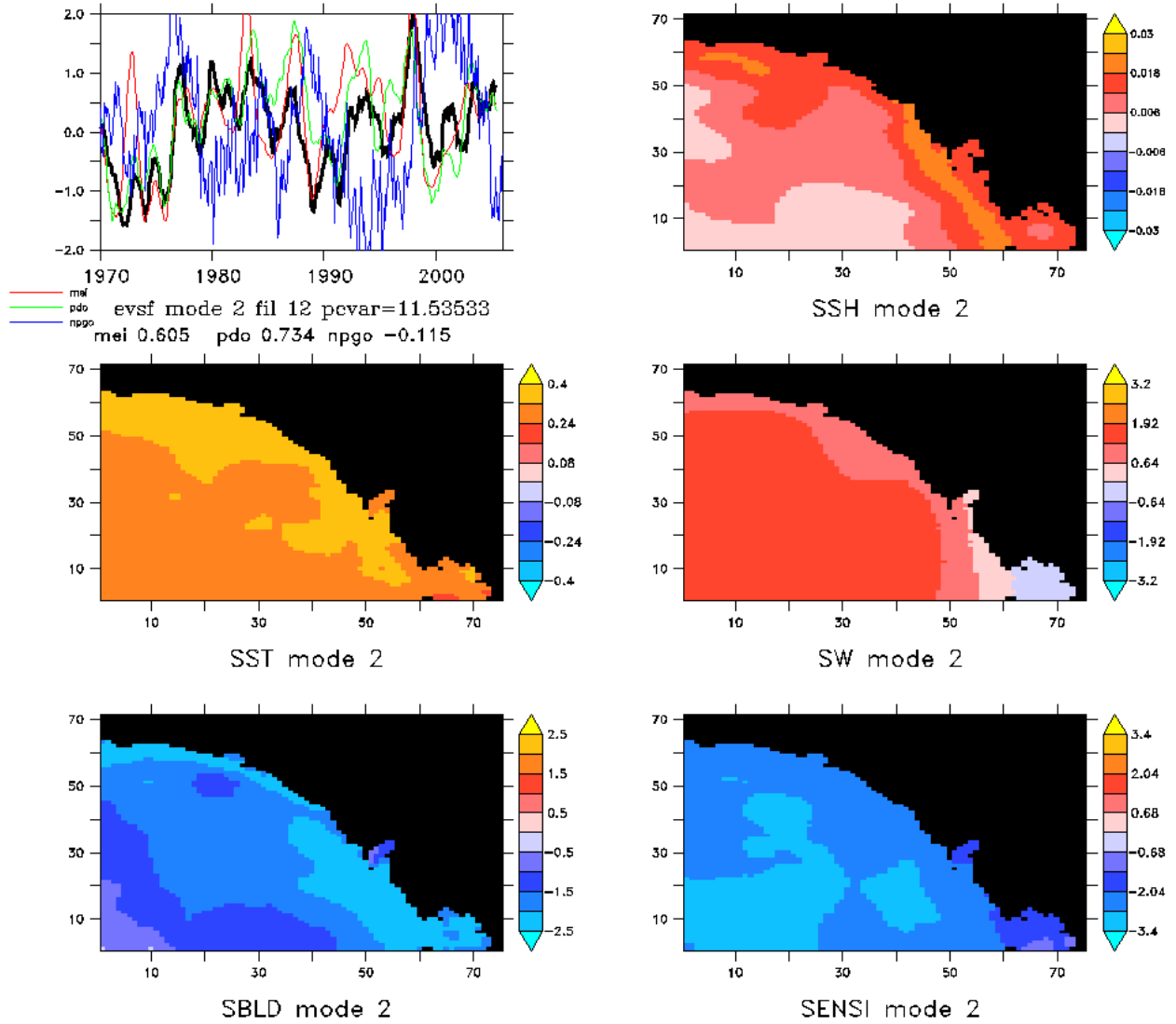


Figure 1. Results from a multivariate EOF analysis of model-derived monthly anomalies for the eastern GOA (145W to 130W, 52N to 61N). Shown are the second mode amplitude (upper left figure), compared with MEI, PDO and NPGO indices (rsquared=.65, .73 and -.12, respectively). The time series are low-pass filtered with a 12-month running mean. Spatial patterns for this mode are shown for a subset of the variables used. SSH=sea surface height (m), SST=sea surface temperature (deg C), SW=shortwave radiation (W/m²), SBLD=mixed layer depth (m; negative numbers denote mixed layer deepening), SENSI=sensible heat flux (W/m²; positive numbers denote heat flux into the ocean).

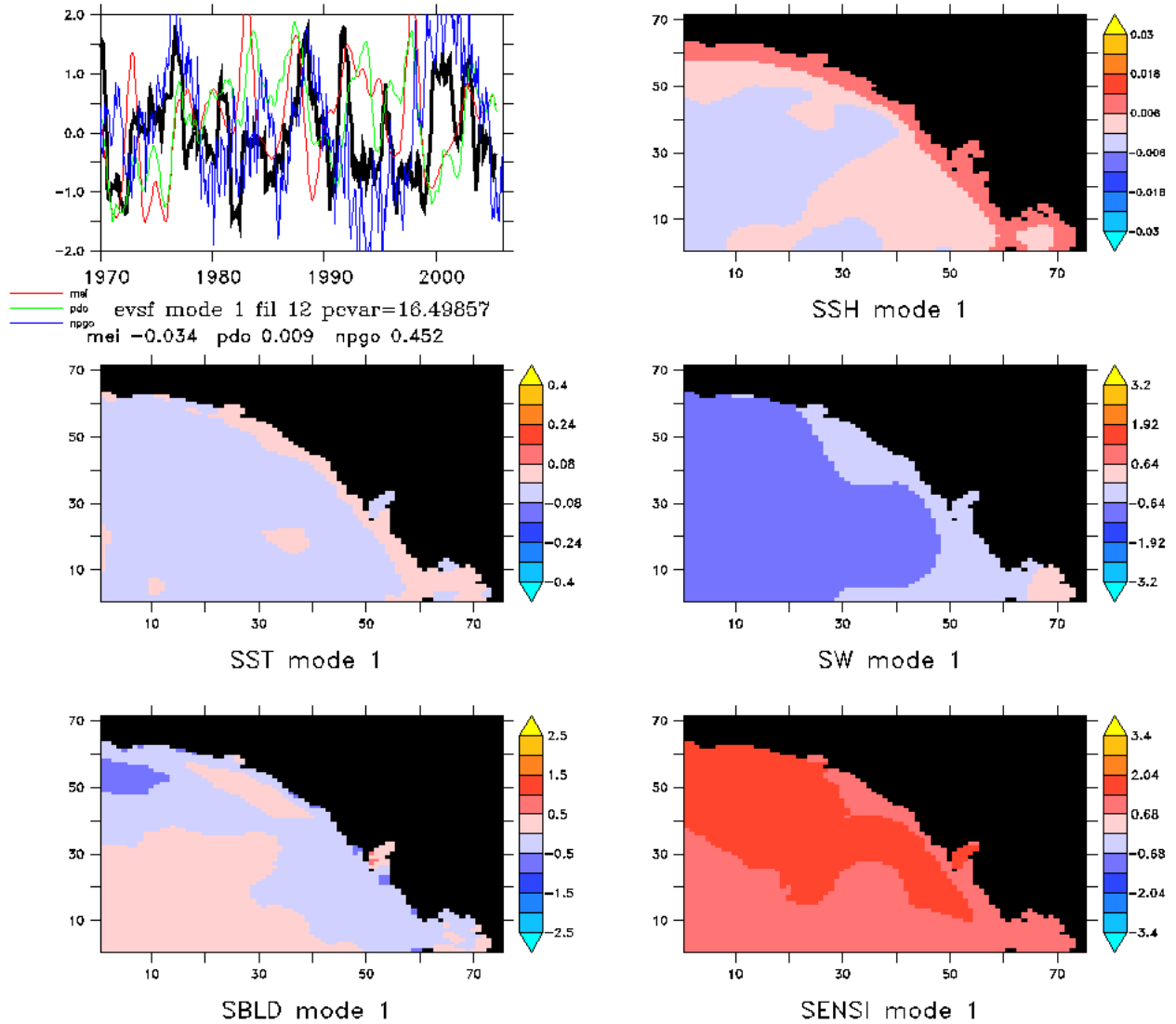


Figure 2. As in Fig. 1, results from a multivariate EOF analysis of model-derived monthly anomalies for the eastern GOA. Shown are the first mode amplitude (upper left figure), compared with MEI, PDO and NPGO indices (rsquared= -.03, .01 and .45, respectively).

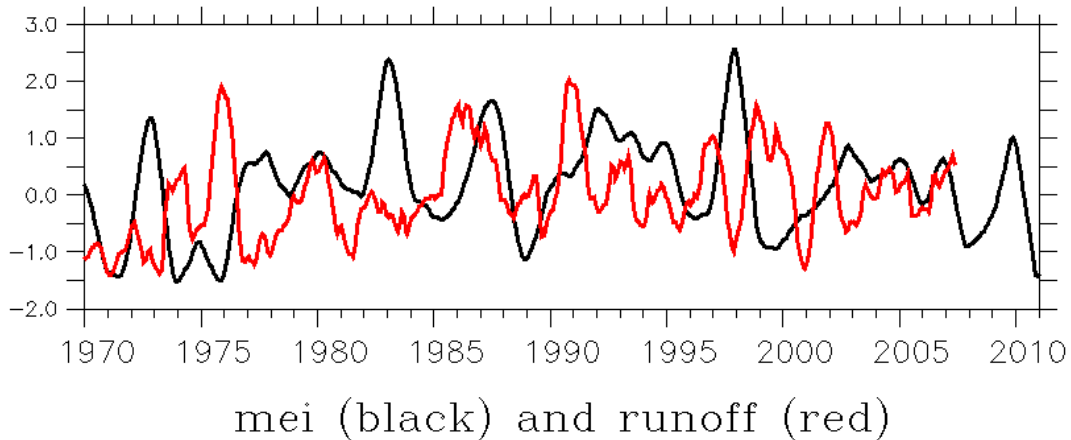


Figure 3. Comparison of the MEI (black line) with monthly runoff anomalies (red line). The time series are low-pass filtered with a 12-month running mean.

Comparison between Float Tracking Tools

The Modeling Component of the GOA IERP is developing separate early life stage Individual-Based Models (IBMs) for the five focal fish species of the Upper Trophic Level. These IBMs reflect the different early life strategies of the focal UTL fish species and consequently need to model different behaviors, mechanisms and processes. We will use output from a ROMS oceanographic model for the central Gulf of Alaska (the CGOA model) to provide the time-varying, 3-dimensional physical and lower trophic level environment forcing fields required to drive the IBMs in a realistic manner. Running ROMS, however, is very computationally expensive and modifying ROMS to incorporate the diverse IBMs we are developing is simply not feasible given time and personnel constraints.

As such, we are developing the IBMs on two modeling platforms that are more conducive to IBM development: DisMELS and Ichthyop. Both DisMELS and Ichthyop use “offline” (i.e., stored) output from ROMS (with an embedded NPZ model) model runs to provide the oceanographic and lower trophic level environments in which their IBMs are embedded. Consequently, we will be able to run the IBMs in DisMELS or Ichthyop as many times as needed, while running ROMS (and storing the output) only once for each environmental scenario we consider. This approach raises issues, however, regarding how faithfully DisMELS and Ichthyop, using stored ROMS output, reproduce transport patterns produced by “online” ROMS.

There are at least two avenues by which differences with online ROMS can arise. The first avenue is algorithmic: the IBM platforms use approaches to Lagrangian particle tracking that are different from one another, as well as from ROMS. DisMELS uses a 4th-order predictor/corrector algorithm (very similar to the algorithm used in ROMS, but not identical) whereas Ichthyop uses a much simpler, but computationally less expensive, 1st-order Euler algorithm. The second avenue is that the online and offline oceanographic current fields are different. The online ROMS model updates its state (currents, etc.) on a 20 second model time step to incorporate tides, which are important to mixing processes that affect phytoplankton and zooplankton production in the NPZ model. The requirements for storing ROMS model output at this internal time step are astronomical (~1300 TB/model year); consequently, model output must be stored on a much coarser time scale. To achieve feasible storage limits (e.g., 300 GB/model year), we adopted a daily time step for ROMS model output and incorporated a temporal

moving-average smoother on all model fields to minimize tidal aliasing effects. Thus, online ROMS currents directly include tidal effects whereas these have been averaged over in the offline results. Consequently, particle trajectories in online ROMS will exhibit tidal effects whereas those in DisMELS and Ichthyop will not. However, we expect that, under most circumstances, the trajectories of particles in DisMELS and Ichthyop will follow a “smoothed” version of the corresponding online ROMS trajectory. We also expect, though, that individual trajectories in the three models may diverge rapidly in the vicinity of rapidly-changing topography (e.g., the continental slope and shelf break) and other areas of strong horizontal or vertical current shear. Such divergence is inevitable given the strong nonlinear nature of the Lagrangian integration in these areas and does not reflect inadequate performance in the different tracking algorithms. Under these circumstances, it is not important that the trajectories of *individual* particles are similar among DisMELS, Ichthyop and online ROMS. Rather, what is important is that the general patterns formed by the trajectories of a statistical ensemble of particles are similar.

To facilitate a quantitative assessment of the float tracking performance of DisMELS or Ichthyop vis-à-vis online ROMS, we selected two reasonable performance criteria. The first was that, over intermediate time scales (days-weeks), the ensemble mean location of a group of floats released close together should not diverge more rapidly between the IBM platform and online ROMS ($\bar{R}_{MR}(t)$) than the group of floats diverged in online ROMS ($\bar{R}_R(t)$), resulting in the criteria that $\frac{\bar{R}_{MR}(t)}{\bar{R}_R(t)} \lesssim 1$. The second was that the dispersion of a group of floats about its mean position (\bar{R}) in each model (ROMS, \bar{R}_R , and DisMELS or Ichthyop, \bar{R}_M) should be similar for the online and offline models, resulting in $\frac{\bar{R}_M(t)}{\bar{R}_R(t)} \approx 1$.

Consequently, we used each model platform to simulate the dispersion of floats released at identical locations and times in each model to compare tracking fidelity across model platforms. Floats were released at 7 locations (3 onshelf, 3 near the shelf break, and 1 in a semi-enclosed area) and 3 different release times (February, April, and June 2001) in “minigrid”s of 8 floats arranged in a horizontal square (approximately 3 km x 3 km) centered on a 9th float. At each location, minigrids of floats were released at various depths (20, 50, 100 and 200 m), depending on total bathymetric depth. Initial positions were specified in ROMS grid coordinates for all models to ensure that comparable floats started in identical locations in each model. Floats were tracked for 20 days. For each minigrid, we calculated mean position time, as well as group dispersion statistics for each model and dispersion of mean positions between online and offline models.

We found that, in general, float tracks from both DisMELS and Ichthyop were qualitatively similar to those from online ROMS. High frequency (sub-daily) tidal effects were evident in the online ROMS tracks but were missing (as expected) from the offline models results. However, these effects appeared to consist mainly of oscillations in the positions of the online ROMS floats around their offline counterparts. Compared with Ichthyop, DisMELS did a “better” job of reproducing the ROMS track patterns. In most cases, DisMELS float tracks closely approximated the float tracks from online ROMS while those from Ichthyop did not. The horizontal divergence (mean and standard deviation) from the corresponding online ROMS float locations was always smaller for DisMELS than Ichthyop, particularly over short time periods (< 10 days). Additionally, divergence from the corresponding online ROMS float depths was smaller in DisMELS than Ichthyop. We also found that the actual release depths for floats could be several meters different from the intended depths in Ichthyop, whereas they were nearly identical for DisMELS. These errors in initial depth for floats in Ichthyop probably contributed substantially to the rapid horizontal divergence of floats in Ichthyop from those in ROMS.

Using the statistical performance criteria we developed (see above), the results of the float tracking comparisons (Fig. 4) indicate that using daily, tidally-averaged model output from ROMS, when coupled with a high-order particle-tracking algorithm (a 4th-order predictor/corrector algorithm as in DisMELS),

produces transport patterns acceptably similar to those obtained from “online” ROMS over moderate time scales (days to weeks). We obtained somewhat poorer performance using the simpler particle tracking algorithm in Ichthyop. We consider the particle tracking performance in DisMELS, driven by daily, tidally-averaged ROMS model output, to be acceptable whereas it was not acceptable in the version of Ichthyop (2.0) we tested.

A new version of Ichthyop (3.1) is now available that includes a higher-order particle tracking algorithm (Runge-Kutta) and that reportedly fixes the problem specifying initial depths. We expect this will improve the performance of Ichthyop’s particle tracking relative to ROMS and are currently in the process of implementing this tool to test it. In addition to identifying these deficiencies in Ichthyop, this exercise has been useful because it uncovered at least one other discrepancy or peculiarity: in ROMS, the initial depth of a float is not set based on the bathymetry interpolated to its initial horizontal location (as might be expected), but rather it is based, somewhat arbitrarily, on the bathymetry at the “upper left” corner of the grid cell in which the float is located.

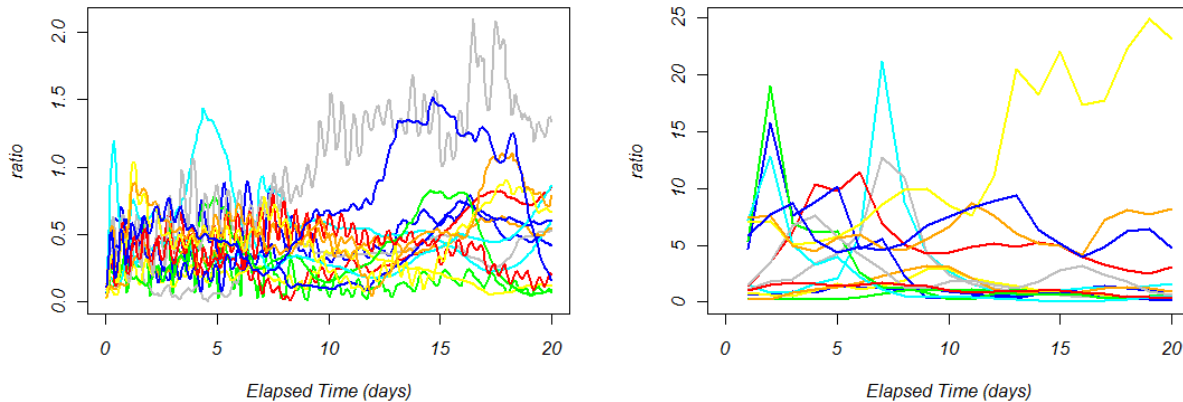


Figure 4. Comparison of the temporal evolution of \bar{R}_{MR}/\bar{R}_R ratio for all minigrids (various colors) using the February, 2001 float release scenario. Results are shown separately for DisMELS (left plot) and Ichthyop (right plot).

Eddy Identification Project

One of the goals of the modeling component is to examine conditions along the simulated trajectories of larval and juvenile fish, to see whether the environment (acting on the fish) differs significantly between those that reach the nursery areas and those that do not. Entrapment in eddies has been thought to affect larval survival through either enhanced transport to suitable nursery areas, and/or through modification of the food and predator environment. Dr. Parada (and her team at INPESCA) have developed a method of identifying eddies in the output of the ROMS. This method characterizes eddy spatial structure based on calculation of the Okubo–Weiss parameter (W), which allows separation of the flow into different regions (Isern-Fontanet et al., 2004). A vorticity-dominated region ($W < W_0$), a strain-dominated region ($W > W_0$), and a background field, characterized by small positive and negative values of W ($|W| \leq W_0$) are calculated, where $W_0 = -0.2\sigma_w$, with σ_w being the standard deviation in the whole domain. The eddy core edge can then be identified by the closed lines where $W = 0$. This separation of the field in terms of the sign of W has been proven to be a robust criterion for discerning eddy cores in complex fluid flows. Based on this, anticyclonic and cyclonic eddies can be identified.

In addition a method to identify the trajectories of eddies over time has been developed and applied using an image processing algorithm which uses the recognition of bi-tones (white and black) patterns (Causa, 2008). This analysis was applied to the filtered information for the cyclonic and anticyclonic eddies recognized using the Okubo parameter and vorticity criteria. The algorithm was applied to the eddies at each time step with a correlative identifier assigned to each eddy. In the following time step, the algorithm allows inheritance of the properties of the identified eddies. New eddies are also searched for at each time step. Once eddies are identified, the following step is the calculation of eddy centroids with the computation of the averages of longitudinal and latitudinal components of each cyclonic and anticyclonic eddy identified at each time step. Our next step with this work is to test it using ROMS output from the GOA and related pollock IBM output (transport patterns) from a prior NPRB study (523). This method will then be applied to ROMS and IBM output from the GOAIERP program.

Construction of IBMs for the 5 target species

Construction (and in the case of the pollock model, adaptation) of the species IBMs is actively underway. The current Pollock model considers development of eggs and temperature-dependent growth functions for yolk sac larvae. Previously developed feeding larval and juvenile algorithms will be reviewed as well as the bioenergetic equations. Vertical and horizontal active movement methods will be reviewed for all stages. Mortality functions and superindividuals will remain in the model, but the mortality rates will be updated according with new studies. The DisMELS graphical user interface (GUI) has been completely redesigned and a new application platform (Netbeans) has been adopted. Significant new features include the ability to plot ROMS model fields on the same map that individuals in the model are displayed. While this new application GUI facilitates setting up and running DisMELS models, it does not affect the underlying algorithmic structure of DisMELS (e.g., Lagrangian particle tracking). It does, however, anticipate the need to be able to specify non-standard ROMS model fields, such as the various NPZ components, in a generic but straightforward manner for use in the IBMs. Progress has also been made in developing a generic way to incorporate functions governing various biological processes into DisMELS. Preliminary tests of algorithms to be included in the Pacific cod and sablefish IBMs have been run using Ichthyops V2 and DisMELS.

Additional Activities

Predation on the focal species: Stomach scans and bucket samples were collected from GOAIERP, groundfish, and MACE cruises for potential use in generating mortality rates on the five focal species by fish predators. The UTL group is analyzing some of these samples, and the AFSC stomach lab is analyzing the others. An inventory of the scanned samples is being analyzed at present to determine whether sufficient information is available for generating mortality rates is available, or whether it would be worthwhile to analyze samples collected in buckets brought back to AFSC. Note that if the latter seems necessary and worthwhile, that funds for these analyses has not been allocated.

Computing Resources: A 16 processor Linux server has become available at AFSC for use by the IBM modelers. The machine previously used for IBM work is now out of date and must be replaced. The new server, Orion, is outside the AFSC firewall and therefore can be used by scientists not at AFSC. Further plans for expanded computing resources (the NPRB supported “Beast” cluster of servers) which will be available for GOAIERP work after modeling for the BSIERP program concludes are under discussion, as is the idea of putting this cluster outside the AFSC firewall for use by NPRB GOAIERP modelers not located at AFSC.

Pollock IBM Validation Work: Ongoing work by S. Hinckley and C. Parada to compare distributions of pollock larvae and juveniles from FOCI surveys versus distributions derived from Pollock IBM runs done for the NPRB 523 project, are progressing. Various methods of comparison are being tested, such as

centroids, the Syralia method, EOFs and spatial statistics methods (developed and performed by M. Woillez) are being examined. Initial work indicates that according to some of the methods applied, the model and data compare very favorably. Whichever of these methods appears best will be used in GOAIERP IBM model validation tests.

Published Paper: A paper has been accepted for publication on comparison of the GOANPZ model (which is being used in GOAIERP modeling work) with Seward Line data:

Coyle, K.O., Cheng, W., Hinckley, S., Lessard, E.J. Whitley, T., Hermann, A.J., and Hedstrom, K. Model and field observations of effects of circulation on the timing and magnitude of nitrate utilization and production on the northern Gulf of Alaska shelf. *Progress in Oceanography*, in press.

d. Describe integration activity.

- Hinckley attended the GABI and field face-to-face meetings in November, 2011.
- Monthly telephone calls of the modelers group have been held. Additional phone calls of all modelers have been held to deal with specific issues as needed.
- Modeling PIs attended the face-to-face GOAIERP PI meeting in March, 2012. Contributions by various PIs to Topic Session talks at the PI meeting were made, updates to modeling work presented, and talks were held between modelers and all other components.
- Gibson, Parada, Hinckley and Stockhausen worked together on the IBMs during the March PI meeting. Additionally, Parada, Hinckley and Stockhausen worked on IBM development and other modeling topics in Seattle after the PI meetings.
- Stockhausen has provided Gibson with several face-to-face and WebX tutorials on the implementation of the DisMELS tool.
- Many of the GOAIERP modeler PIs regularly attend the All PI GOAIERP monthly phone meetings.
- Hinckley has participated in numerous discussions with PIs from the other GOAIERP components with respect to survey results (for example, fish distributions and predator stomach samples collected).
- Hinckley has received Pacific cod data from the Ichthyoplankton group to aid in the development of parameters for the IBM.
- Mueter advised the modeling group about recruitment variability by year for the five focal species and which years might be best to choose for hindcast years.
- Ladd is working on gap winds with the LTL component as well as being a PI on the modeling project. This work is directly relevant to the modeling, especially the IBMs.
- Hinckley has participated in GABI activities.

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

The Modeling component work is on track, and we have few specific concerns. However, it is possible that mortality estimates due to predation by fish and other predators (seabirds) may be difficult to obtain due to paucity of data, especially for the hindcast years.

f. Poster and oral presentations at scientific conferences or seminars

Coyle, K., Gibson, G.. 2012. Processes controlling on-shelf transport of *Neocalanus* populations in the northern Gulf of Alaska. Alaska Marine Science Symposium, Anchorage, 16-20 January 2012.

- Georgina Gibson, Sarah Hinckley, Russ Hopcroft, Jamal Moss, and Olav Ormseth (2012) The Gulf of Alaska Project: An Integrated Ecosystem Research Project. Keynote address at the 2012 Alaska Marine Science Symposium, Anchorage, Alaska.
- Gibson, G, Hinckley, S., Hopcroft, R. Moss, J., and Ormseth, O. The Gulf of Alaska Project: An Integrated Ecosystem Research Project. Alaska Marine Science Symposium, Anchorage, AK, January 2012.
- Hermann, A.J., Ladd, C., Cheng, W., Curchitser, E.N., Hedstrom, K. Sources and patterns of interannual oceanic variability of in the Gulf of Alaska. Gulf of Alaska Integrated Ecosystem Research Project PI meeting, Juneau, AK, 6 March 2012. (poster).
- Hermann, A.J., Ladd, C., Cheng, W., Curchitser, E.N., Hedstrom, K. Sources and patterns of interannual oceanic variability of in the Gulf of Alaska. Alaska Marine Science Symposium, Anchorage, AK, January 2012. (poster).
- Ladd, C., W. Cheng, Characteristics of "Gap Winds" in the Gulf of Alaska and their effects on regional oceanography. Gulf of Alaska Integrated Ecosystem Research Project PI meeting, Juneau, AK, 6 March 2012. (poster).
- Ladd, C., W. Cheng, Characteristics of "Gap Winds" in the Gulf of Alaska and their effects on regional oceanography. Alaska Marine Science Symposium, Anchorage, AK, 19 January 2012.
- Mueter, F., Doyle, M., Waite, J., Shotwell, K., Rand, K., Hinckley, S. 2012. Gulf of Alaska IERP Retrospective Data Project. Alaska Marine Science Symposium, Anchorage, 16-20 January 2012.
- Parada, C., Gibson, G., Hinckley, S. 2011. Eddy identification and transport in the Gulf of Alaska: Links to simulated particles, retention and transport patterns. Alaska Marine Science Symposium, Anchorage, 16-20 January 2012.
- Parada, C., Hinckley, S. 2012. Modelling growth and bioenergetics of young pollock in the Gulf of Alaska: Problems, needs and gaps. GOA IERP PI meeting, 6-8 of March 2012, Juneau.
- Stockhausen, W., Hinckley, S., Gibson, G., Parada, C. 2012. Modeling the "Gauntlet" from spawning grounds to juvenile nurseries: individual-based models for the early life stages of 5 focal fish species in the Gulf of Alaska. Alaska Marine Science Symposium, Anchorage, 16-20 January 2012.

g. Education and outreach

Al Hermann was interviewed about the modeling work by Dr. Cynthia Suchman at the March PI meeting in Juneau. This video will be made available for education and outreach by NPRB staff.

4. PROGRESS STATUS

We are pleased with the progress of our project to date. With the exception of the slight delay in finalizing the comparison of offline float tracking tools to the ROMS online model (due to discoveries during the process) this reporting period's activities are completed or well under way. A major milestone has been the completion of the Pattern Analysis work by C. Ladd and A. Hermann. The results of this work have led to identification of major physical patterns in the GOA over the past several decades, the most important being El Nino/La Nina. We have used this information, plus recruitment patterns of the five

focal species given to us by F. Meuter, to complete another milestone, ie. the Experimental Design phase, ie. choice of the hindcast years that we will model to investigate the recruitment response to physical patterns for the five focal species. The comparison of the offline and online tools is nearly complete. Discoveries of problems with algorithms in both DisMELS and Ichthyop, when corrected, will allow better float tracking performance and comparability. Final tests with the new Ichthyop V3.1 will soon be completed. The final decision of whether to use Ichthyop in our IBM work will depend on these final tests. Physical and NPZ model runs for the hindcast years will be completed over the next 6 months. Development of the IBMs is well underway, and initial versions will be complete at the end of the next reporting period.

5. FUTURE WORKPLAN and DATA DELIVERY

Workplan

<i>What</i>	<i>Who</i>	<i>Start and end dates</i>	<i>Other key dates</i>
Comparison between Float Tracking Tools	Parada, Stockhausen, Gibson	Oct 2010-June 2012	
Construction of IBMs for the 5 target species	Parada, Stockhausen, Gibson, Hinckley	Oct 2010-Sept 2012 (with extension to Dec 2013)	
Run ROMS/GOANPZ model on NEP and CGOA grids	Hermann, Hedstrom, Coyle, Gibson	Oct 2011-Mar 2013	
Validation of ROMS/GOANPZ	Ladd, Hermann, Coyle	June 2012 – Mar 2013	

Data delivery.

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