1. PROJECT INFORMATION

<table>
<thead>
<tr>
<th>GOA IERP Project Number:</th>
<th>G82</th>
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<tr>
<td><strong>Title:</strong></td>
<td>Middle Trophic Level: Temporal and spatial axes of variability in the structure of Gulf of Alaska forage fish communities</td>
</tr>
<tr>
<td><strong>Overall project duration</strong></td>
<td>October 1, 2010 to January 31, 2015</td>
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<td><strong>Overall project funding</strong></td>
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<td><strong>Report period</strong></td>
<td>April 1, 2013 to November 30, 2013</td>
</tr>
<tr>
<td><strong>Report submission date</strong></td>
<td>December 2, 2013</td>
</tr>
<tr>
<td><strong>Lead Author of Report</strong></td>
<td>Olav A. Ormseth</td>
</tr>
</tbody>
</table>

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

Lead PI: Dr. Olav A. Ormseth, Alaska Fisheries Science Center, Olav.Ormseth@noaa.gov  
Co-PI: Dr. Alex DeRobertis, Alaska Fisheries Science Center, Alex.DeRobertis@noaa.gov  
PI: Dr. John K. Horne, University of Washington, jhorne@u.washington.edu  
PI: Shiway Wang, Sedna Ecological, Inc., sedna.ecological@gmail.com  
PI: Dr. Suzanne Budge, Dalhousie University, suzanne.budge@dal.ca

2. PROJECT OVERVIEW

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

Forage fish link primary and secondary producers to upper trophic level (UTL) predators. The forage fish community includes small, fast-growing species such as capelin and sand lance, as well as juvenile stages of groundfishes (e.g. walleye pollock and Pacific cod). The MTL seeks to understand the ecosystem role of forage fishes as well as their predators, prey, and competitors by studying how forage fish communities and the GOA ecosystem varies over time (seasonally and annually) and through space (variation within regions and between regions). Sampling is being conducted in spring, summer, and fall of two years (2011 and 2013). The study area includes two main regions (eastern, comprising the outer coast of southeast Alaska, and western, comprising the east side of Kodiak Island and the southern coast of the Kenai Peninsula). Nearshore surveys are focusing on 5-6 sampling sites within each main region; offshore acoustic surveys throughout each region are being conducted aboard the UTL vessel; and diet and energetics studies are addressing relationships among species and the flow of energy among trophic levels. Oceanographic studies are being conducted aboard the nearshore surveys in collaboration with the LTL component. The MTL project is also contributing to the all-component retrospective analysis effort.
b. State the specific GOAIERP hypothesis or hypotheses that your project is addressing.

The MTL component is addressing all three of the overarching GOAIERP hypotheses:

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

3) 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.

1) Provide a synoptic view of nearshore/offshore distribution and abundance (past and present) to gain a comprehensive understanding of how GOA forage communities are structured, how this structure changes in response to the environment, and the effects of this variability on prey availability for upper trophic level species.

2) Analyze habitat associations to determine how habitat needs influence the spatial overlap among species and resulting predation and competition.

3) Use analysis of stomach contents, stable isotopes, and fatty acids to infer diets and elucidate relationships among forage community members, lower trophic level prey, and upper trophic level predators.

4) Use proximate analysis to assess nutritional condition of community members and relate condition to spatial and diet overlaps among species.

3. PROGRESS SUMMARY

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

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<td></td>
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<td>preliminary data analysis – FA/SI</td>
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b. Describe report period progress.

Objectives 1 & 2
Research activities: nearshore surveys, offshore acoustics surveys, retrospective analysis

Progress:
- Six inshore surveys were completed during the reporting period (spring, summer, and fall in the eastern and western GOA regions). All sites were visited during the spring and summer surveys, although sampling was limited somewhat at a few sites in the spring due to weather. The fall surveys were both curtailed due to the federal government shutdown and ensuing complications. In the eastern region, 3 sites (Salisbury Sound, St. Lazaria, Whale Bay) were sampled completely but the Oct. 1 shutdown occurred mid-survey and Islas Bay, Torch Bay, and Graves Harbor could not be sampled. The survey effort in the western region was delayed by the shutdown and its aftermath, and the delay resulted in scheduling conflicts for the science crew and the chartered vessel. As a result the survey was shortened to ten days and only two of the sites were visited (Kiliuda Bay and Port Dick). At all sites visited nearshore sampling (seining), acoustic transects, and oceanographic sampling were conducted. Surface trawls were also conducted at some sites.

- The activities of the inshore acoustic portion of the MTL group focused primarily on logistics for and data collection during the six MTL cruises that occurred between April and November 2011. The equipment was overhauled and a towbody and new data cables were assembled prior to the start of the field season. Acoustic data were collected with a calibrated 3-frequency (38, 120, 200 kHz) towbody from the MTL vessel, and from an inflatable skiff at 38/200 kHz in shallower water. Acoustic data were successfully collected in all bays visited on these surveys. Acoustically observed aggregations were sampled with jigs and filmed with an underwater camera.

- Offshore acoustics work was performed during 4 offshore surveys (summer and fall in the eastern and western survey regions). The summer cruises and the fall eastern region surveys were largely completed, but the fall western region survey was severely curtailed by weather and the government shutdown (see “preliminary results” section for more detail).

- Fine-scale nearshore habitat mapping was performed at several of the inshore sites in both regions.

- Small seasonal oceanographic moorings (“minimoorings”) were deployed and recovered at 2 sites (Salisbury Sound in the east and Port Dick in the west). Each minimooring comprised a CTD at the surface and a CTD at ~60m depth. Minimoorings were deployed during the spring surveys, recovered and redeployed in the summer, and recovered again in the fall. The east minimooring was redeployed until May 2015 in order to collect a full year of data; the west minimooring was not redeployed. All data were recovered and a preliminary analysis indicated that the sensors performed flawlessly, with the possible exception of fouling of the east-side surface salinity sensor for a brief period during the summer.

- Numerous fish samples were collected during all surveys for use in the diet and energetics work.
• CTD data as well as physical and biological samples were collected in Kiliuda Bay during the summer survey for use in an ongoing collaboration with Mayumi Arimitsu (US Geological Survey) regarding landscape patterns in stable isotopes.

• Otoliths from juvenile Pacific cod were collected for use in an ongoing collaboration with the AFSC Age & Growth group regarding spatial patterns of otolith microchemical signatures.

• Work continues on retrospective projects.

Objective 3
Research activities: analysis of stomach contents and tissues

Progress:
• Stable isotope (δ^{15}N & δ^{13}C) analysis has been completed for all 2011 samples and preliminary data analyses have been completed.

• Preliminary data analyses of fatty acid data for 2011 samples have been completed.

Objective 4
Research activities: proximate analysis of fish tissues

Progress:
• Preliminary analyses suggest that it may be possible to use information from the fatty acid and stable isotope analysis (e.g. % lipid, % nitrogen) to infer proximate composition, allowing an expanded study of energetics at the inshore sites.

• Samples for energetics analysis of forage fishes were collected during the 2013 offshore surveys.

• Energetics analyses are under way at the Auke Bay Laboratory.

c. Describe preliminary results.

The following are a selection of preliminary results from various component research activities.

Inshore surveys - general
The inshore surveys were completed on November 12 and no data from the surveys have been analyzed. Impressions of the 2013 surveys were as follows:
• There were fewer age-zero Pacific cod and walleye pollock observed in 2013 relative to 2011, and patterns of abundance were somewhat different.
• In contrast, substantially greater numbers of juvenile (likely age-1 and age-2) Pacific cod were observed relative to 2011.
• Age-zero Pacific herring were observed in greater abundance and over wider spatial distribution that in 2011.
• Abundance and distribution of many nearshore fishes (e.g. shiner perch) differed from 2011.
Oceanography data have not yet been sufficiently reviewed, but it appears that at least some of the notable features observed in 2011 (e.g. the presence of low-oxygen waters in the inner part of Kiliuda Bay) were also present in 2013.

The vegetation that likely provides nearshore habitat for juvenile fishes (e.g. eelgrass and kelp) are abundant throughout the inshore sites but appear to be patchy or limited to certain areas and depths (e.g. eelgrass is common throughout some bays but in many places occurs as a narrow, strongly depth-dependent band along the shoreline).

**Inshore surveys - acoustics**

All bays visited by the MTL were sampled on the same transects as in 2011. The data have been backed up and reviewed, and have been determined to be of high quality. A total of 15 standard sphere calibrations of the acoustic system were accomplished, which indicate that the acoustic system performed well during these cruises. Analysis of the acoustic data is currently underway and we anticipate being able to meet the data delivery schedule of these acoustic data of the 2nd Quarter of 2014.

**Inshore surveys - minimoorings**

Preliminary analysis of the minimooring data suggest multiple patterns of variability in temperature and salinity at each of the sites (Figure 1). Surface data were more variable than “deep” data, and showed different patterns. Visual inspection of the data suggests that the data vary with season and tide state, and are also affected by infrequent events that disrupt the seasonal and tidal cycles.

![Figure 1. Preliminary temperature and conductivity data from a CTD moored at the surface in Salisbury Sound. Conductivity data have not yet been corrected for instrument calibration so the values shown should not be interpreted as the final values.](image-url)
Offshore surveys – acoustics
Offshore grids were sampled using active acoustics during the 2013 summer and fall upper
trophic level (UTL) surveys (Figure 2). The southeast Alaska grid was sampled by the F/V
Northwest Explorer July 3-21 using a calibrated ES60 echosounder operating at 38 and 120
kHz. Acoustic transects extended continuously from station 0 to 70 nautical miles on all lines,
with an extra transect running parallel to shore from SE-M80 to SE-E80. A total of 11 midwater
trawls were conducted during this survey. A malfunction in the ship’s headrope sensor
prevented midwater trawls from being attempted on line I, and limited acoustic targets that could
be targeted on line M. Preliminary analysis of acoustic and midwater trawl samples indicates
that age-0 pollock were abundant in the water column across a range of depths (subsurface to
125m) throughout the study area. No forage fish were observed in midwater trawls, although
large smelts (either capelin or eulachon) were observed in Chinook stomachs caught in the SE-
M0 surface trawl.

The Kodiak grid and Yakutat/Kayak lines were sampled by the F/V Northwest Explorer August
3-22. All acoustic transects were sampled, with the exception of Line 217 that was dropped due
to time constraints. A total of 19 midwater trawls were conducted, including one on the Yakutat
line. No midwater trawls were attempted on the Kayak line due to time constraints. The ship’s
GPS feed to the echosounder malfunctioned from August 10-16, so spatial data was
independently recorded by the seabird observer’s handheld GPS August 10-11 and the ship’s
navigational GPS August 11-16. Preliminary analysis of acoustic and midwater trawl samples
indicate that age-0 pollock were abundant across the Kodiak study area, although it appears to
be more patchily distributed across the shelf compared to the southeast grid. Age-0 pollock
were also present along the Yakutat line. Age-0 Pacific cod were also observed on the Kodiak
grid, primarily over Albatross Bank (and to a lesser extent Portlock Bank). Capelin were
abundant across the Kodiak grid, both over submarine banks and in the troughs that penetrate
the Kodiak shelf.

For the fall survey, the southeast Alaska grid and Yakutat/Kayak lines were sampled by the F/V
Northwest Explorer September 6-24. All acoustic transects were sampled from station 0 to 80,
with the exception of lines C & L (no sampling from stations 40 to 80) and line I (no sampling
between stations 50 to 60). Line A was not sampled due to rough seas. A total of 10 midwater
trawls were conducted, including one on the Yakutat line. No midwater trawls were attempted
on the Kayak line due to time constraints. Preliminary analysis of acoustic and midwater trawl
samples indicate a change in species composition compared to observations and catch
compositions during the July survey. No age-0 pollock were observed throughout the southeast
Alaska grid, although they were present on the Yakutat line. Forage fish (i.e. Pacific herring,
capelin, and eulachon) were observed on the shelf and within the gully off Cross Sound
(stations 0 to 20 on lines K-M). Herring were also distributed along the shelf south of Cross
Sound.

The Kodiak grid was sampled by the NOAA Ship Oscar Dyson September 24-28 using a
calibrated EK60 echosounder operating at 18, 38, 70, 120, and 200 kHz. The survey was
canceled due to the Federal government shutdown on October 1. Rough seas limited sampling
activities to the nearshore stations closest to Kodiak Island, with only portions of four lines (181
to 193) being sampled. Only 2 midwater trawls were conducted. Despite the limited sampling,
acoustic and trawl samples were similar to the August survey, with capelin being distributed
within Barnabas trough and up on Albatross Bank, along with similar distributions of age-2 and
adult pollock being observed in Barnabas Trough. No age-0 focal species were caught in trawl
samples. Night and day acoustic transects were sampled within Izhut Bay on September 28
while taking shelter from rough seas.
Figure 2. Offshore acoustic cruise tracks (blue lines) sampled during the 2013 GOA IERP UTL survey. Green stars indicate the location of midwater trawls.

**Stable isotope analysis**
The preliminary results of stable isotope (SI) patterns from 2011 suggest substantial variability in foraging ecology among different species at specified locations, as well as spatial and temporal variability of foraging patterns within species (Figure 3). These patterns will be evaluated together with the fatty acid data, and the 2013 data will have to be analyzed before interpreting the results. However the preliminary data suggest some patterns among co-occurring species. For example the SI signatures of two gadids, saffron cod and Pacific cod, appear to generally overlap but to be distinct from that of a third gadid, walleye pollock, as well as other fishes including rockfishes.
d. Describe integration activity.

*Retrospective analysis:* We are an integral part of the retrospective team that has formed to coordinate the analyses.

**General:** Overall we have pursued integration with other GOAIERP components on many fronts. Fish sampling has been coordinated to the extent possible with the UTL offshore group. Similarly, we have been working with various LTL scientists to improve our collection of scientific data and to relate those data to LTL and UTL oceanography data. We have also worked with the modelers to define spatial boundaries and determine the best way to integrate MTL data in the models.

**Habitat:** We have collaborated with Mark Zimmerman, UTL habitat, in several ways. During the inshore surveys we groundtruthed a number of places using a drop camera to compare to Zimmerman’s map products. In addition, measurements of water depth and bottom backscattering from the inshore acoustics data have been delivered to Zimmerman for verification of the habitat sediment maps made for the CGOA sites. In the near future, we will be supplying Zimmerman with other data sets to implement and evaluate a more sophisticated backscatter-based bottom habitat characterization method in collaboration with Dr. Sebastien Durand of the Canadian Hydrographic Service. Finally, we have collected information regarding the extent of nearshore habitats that will enhance the habitat suitability work being performed by the UTL and modeling components.

**Energetics:** Our energetics work is directly integrated with the UTL bioenergetics work. In addition, many of our samples will be used to determine the quality of prey available to seabirds, providing a further link to UTL work.

Figure 3. δ¹³C and δ¹⁵N biplot for all species sampled in 2011.
e. Describe any concerns you may have about your project’s progress.

The main concern we have is the effect of the federal shutdown and its impact on the fall survey effort. For the inshore work, both fall surveys were impacted but approximately half of the sites in each area were visited, and much of the core work could be performed. The main problem for the inshore surveys was the inability to sample in Islas, Torch, and Graves (east-side sites) where we had encountered abundant YOY Pacific cod and pollock during the summer. The impact on the offshore surveys was different- the fall east side survey was largely completed, but only a small portion of the fall west side survey could be completed, with only a handful of midwater tows. We will not really know the full extent of the impact until we have performed some analysis of the data. Otherwise, we realize we have a tight timeline over the coming year for finishing samples and data analysis, integration activities, etc. but anticipate meeting all of our deadlines.

f. Poster and oral presentations at scientific conferences or seminars

- Olav Ormseth, “GOAIERP update”, NPFMC Plan Team meeting, September 2013

g. Education and outreach

Ormseth contributed multiple posts to the “field blog” section of the website and Facebook page during the reporting period. We have also contributed a significant amount of effort to the GOAIERP videos project, including facilitating videotaping of inshore survey activities during the summer east cruise, participating in interviews (Ormseth), and contributing video shot by crewmembers during surveys. Ormseth has also corresponded regularly with Lisa Busch and Danielle Dickson regarding the website and other outreach activities.

4. PROGRESS STATUS

We feel our overall status is good; the fieldwork has been the main focus of the reporting period. Other than the problems described above due to the shutdown, the fieldwork went very well and we were able to accomplish a great deal of sampling effort. Our laboratory work also is providing some interesting results.
5. FUTURE WORKPLAN and DATA DELIVERY

Workplan

Note: We have included workplan dates that only include the next reporting period.

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Data delivery.

GOAIERP Data Delivery Table

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