North Pacific Research Board
Gulf Project Semiannual Progress Report: Middle Trophic Level (MTL) Component

1. PROJECT INFORMATION

GOA IERP Project Number:	G82
Title:	Middle Trophic Level: Temporal and spatial axes of variability in the structure of Gulf of Alaska forage fish communities
Overall project duration	October 1, 2010 to January 31, 2015
Overall project funding	$1,858,400
Report period	April 1, 2011 to November 30, 2012
Report submission date	December 1, 2012
Lead Author of Report*	Olav A. Ormseth

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.

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 GOA IERP 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.

	2012							
	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
preliminary analysis of nearshore fish catch data	x	x	x	x				
preliminary analysis of nearshore oceanography data							x	x
processing of all 2010 & 2011 inshore acoustics data					x	x	x	x
processing of all 2011 offshore acoustics data	x	x	x	x	x	x	x	x
zooplankton samples shipped to UAF				x				
first set fatty acid samples (Kiliuda Bay summer) analyzed					x	x	x	
diet sampling plan finalized							x	

b. Describe report period progress.

Objectives 1 & 2

Research activities: nearshore surveys, offshore acoustics surveys, retrospective analysis

Progress:

- Preliminary analyses of inshore fish catch data are complete.
- All oceanography data have been processed and incorporated into an Access database; preliminary analyses of oceanography data are underway.
- A NOAA Technical Memorandum describing the results of the 2011 inshore field work is currently being prepared and is scheduled to be completed by January 2013.
- Zooplankton samples have been organized and shipped to Fairbanks and are awaiting analysis in the Hopcroft lab.
- Processing of 2011 acoustic data set and 2010 pilot studies completed
- 38 kHz data set corrected for field damage to transducer cable by calibration to the bottom echo (report describing this correction is complete)
- Acoustic discrimination of fish and zooplankton signal based on 38/120 kHz frequency response is complete
- Pre-processing of all offshore acoustic data completed
- Classification scheme to partition backscatter devised and tested using representative data
- Summary backscatter plots for three depth zones (15-30, 30-250, 250-500) were plotted for each transect within legs
- Surface and midwater trawl catch data has been checked for consistency among files. Trawl catch data was plotted form for all 2011 cruise legs and was summarized to facilitate classification of acoustic data.
- A Ph.D. proposal for graduate student David McGowan at the Univ. of Washington was accepted by his newly formed Supervisory Committee (Horne is chair; Ormseth is a committee member). His thesis research incorporates the offshore acoustics work and will examine if spatial and temporal variability in densities and distributions of forage fish influences the transfer of energy to both higher and lower trophic levels.
- A plan has been finalized for three projects/manuscripts regarding the retrospective data. These are: 1) retrieval of historical nearshore data and comparison to GOAIERP results; 2) using multiple indices to monitor population status of capelin and eulachon in the GOA; 3) changes in nearshore community structure in the western GOA, 1972-2012.

Objective 3

Research activities: analysis of stomach contents and tissues

Progress:

- Fatty acid (FA) analysis has been performed for all samples from Kiliuda Bay in the summer.
- Based on the Kiliuda FA results, a final sampling design for the 2011 field season has been completed.
- Analysis of the remaining FA samples for 2011 is underway.
- A laboratory has been identified and arrangements made for analysis of stable isotopes (SI) for 2011 samples. The SI analysis will use the same samples as for the FA analysis (because they are already lipid-extracted), so these analyses have not yet begun.

- Analysis of stomach contents has not yet begun but is planned for the winter months of 2012/2013.

Objective 4

Research activities: proximate analysis of fish tissues

Progress:

- Due to personnel changes and other delays, the energetics works has not yet begun. We anticipate this will be performed during the winter of 2012/2013.

c. Describe preliminary results.

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

Distribution of acoustic backscatter in the inshore GOA
The post-processing of the 2011 MTL inshore acoustic data and 2010 pilot study cruises is complete. A 38/120 kHz dual-frequency technique (De Robertis et al., 2010) has been used to partition the acoustic return into signals consistent with fish and zooplankton. The data are available at 10m deep by 100m along-track intervals. Maps of along-track backscatter for each survey site have been generated and shared with the lead PI (e.g. Figure 1), and additional analyses of the data are underway.

One clear trend in the data is the strong depth-dependence of the acoustic measurements both in the aggregated dataset (Figure 2), and within a bay. In general, the median abundance (circles in figure XX) increases with depth, indicating that the probability of encountering high fish and zooplankton abundances increases substantially with bottom depth. However, in the case of fish, the maximum abundances in the data set are at ~100 m (see small dots in Figure 2). This is due to the influence of rare but dense aggregations of herring at these depths (e.g. Figure 1).

Distribution of acoustic backscatter in the offshore GOA
Unclassified acoustic backscatter was quantified in three depth layers (10-30m, 30-250m, 250-500m) for each leg. Distribution of backscatter was mapped for both regions (Figure 3 – CGOA, Figure 4 - EGOA) to illustrate spatial and seasonal changes in density. Preliminary analysis indicated that backscatter is concentrated in areas of topographic transitions and strong oceanographic mixing (e.g. edges of submarine banks and troughs, shelf-break). Seasonal differences in horizontal and vertical density distributions were also evident in both regions. In the EGOA, the fall survey observed an overall reduction in backscatter and increased aggregation along the edges of Spencer Gully.

Surface trawl catch data was compared with acoustic data to assess potential sampling bias. Preliminary results indicated that the depth of acoustic targets was highly correlated with surface trawl catches of forage fish in the CGOA region (Figure 5). Acoustic targets were consistently below 30m (depth of the surface trawl footrope) during surface trawls that resulted in catches of 10 or less forage fish (i.e. capelin, Pacific herring, and age-0 groundfish). In contrast, acoustic targets were observed above 30m during 10 of 11 trawls in which catches exceeded 10 forage fish. Midwater trawls targeting similar acoustic targets over submarine banks indicated these targets were capelin. These results support the use of surface trawls to assist in the classification of shallow acoustic targets, but also highlight the need to couple surface trawls with midwater trawl and acoustic sampling to minimize bias.

Diet patterns and oceanography in Kiliuda Bay
The whole-body fatty acid (FA) signatures of Pacific cod and saffron cod in Kiliuda Bay during the summer vary substantially by location, as indicated by a preliminary principal components analysis (Figure 5). Fish from seine hauls in the inner part of Kiliuda Bay (PS01, PS02, BS02) appear to have much different FA signatures than those from the outer seine hauls (PS03-PS06). In addition, the outer hauls have much wider variability in their FA signatures.

The oceanography of Kiliuda Bay also appears to have a strong spatial component (Figure 6), with the innermost 3 oceanography stations having markedly different profiles. When the station locations are compared with the bathymetry of Kiliuda Bay (Figure 7), it is apparent that a shallow sill-type feature in the middles of the bay (Figure 7, marked with black arrow) limits the exchange between the inner and outer sections of the bay. This "sill" also separates the two very different FA patterns, suggesting a link between the oceanography and the diet data.

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 catch data were combined with UTL and LT data to show connectivity; we are working on combining the MTL, UTL, and LTL oceanography data; and we are working with the modelers to define spatial boundaries and determine the best way to integrate MTL data in the models.

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.

Diet: Our diet work is being carried out in cooperation with UTL diet work and the needs of the modelers. We expect that this level of integration will only grow as the project proceeds.

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

We do not have any concerns about our progress beyond the fact that some of the laboratory analyses have been delayed. However, we do not anticipate that these delays will hinder the work of the other components.

f. Poster and oral presentations at scientific conferences or seminars

- **Olav Ormseth**, “Nearshore fish ecology and oceanography in the Gulf of Alaska: internal dynamics and external connections", Eastern Pacific Ocean Conference, Oregon, September 2012.

g. Education and outreach

In September 2012, Ormseth presented a GOAIERP update to the combined Plan Teams of the North Pacific Fishery Management Council. In November 2012, Ormseth participated in a PI meeting for Gulfwatch Alaska. He presented an overview of the GOAIERP and led a discussion regarding the potential for collaboration between the two programs.

4. PROGRESS STATUS

We feel our overall status is good. We are behind on some of the laboratory analysis, but have a clear plan and deadlines for completing that work. In addition, we have been spending a lot of time preparing for 2013, anticipating issues that need resolution and working to streamline our inshore operation. In the offshore, we have obtained a guarantee that we will have both 38 and 120 kHz transducers on the offshore vessel.

5. FUTURE WORKPLAN and DATA DELIVERY

Workplan

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

What	*Who*	*Start and end dates*
Preparation for 2012 field season	Ormseth/Rand	12/1/12-3/31/13
further analysis of inshore acoustic data	DeRobertis	12/1/12-2/1/13
preparation of inshore Tech Memo	Ormseth/Rand/DeRobertis	12/1/12-2/1/13
Energetics analysis	Vollenweider/Heinz	1/1/13-3/31/13
Analysis of plankton samples	Ormseth (Hopcroft/LTL)	1/1/13-3/31/13
Retrospective data collection and analysis	Ormseth/Rand	12/1/12-3/31/13
Analysis of 2011 fatty acid samples	Budge/Wang	12/1/12-3/31/13
Analysis of 2011 stable isotope samples	Budge/Wang	1/1/13-3/31/13
Analysis of stomach contents	Ormseth	1/1/13-3/31/13

Data delivery.

GOAIERP Data Delivery Table		
Data type for delivery	Delivery Month & Year	Person sending data, with email address
2011 fatty acid data	4/13	Olav Ormseth (olav.ormseth@noaa.gov)
2011 stable isotope data	6/13	Alex DeRobertis (Alex.DeRobertis@noaa.gov)
2011 energetics data	6/13	John Horne (jhorne@u.washington.edu)
2011 zooplankton data	6/13	Olav Ormseth (olav.ormseth@noaa.gov)
2011 stomach contents data	6/13	Olav Ormseth (olav.ormseth@noaa.gov)

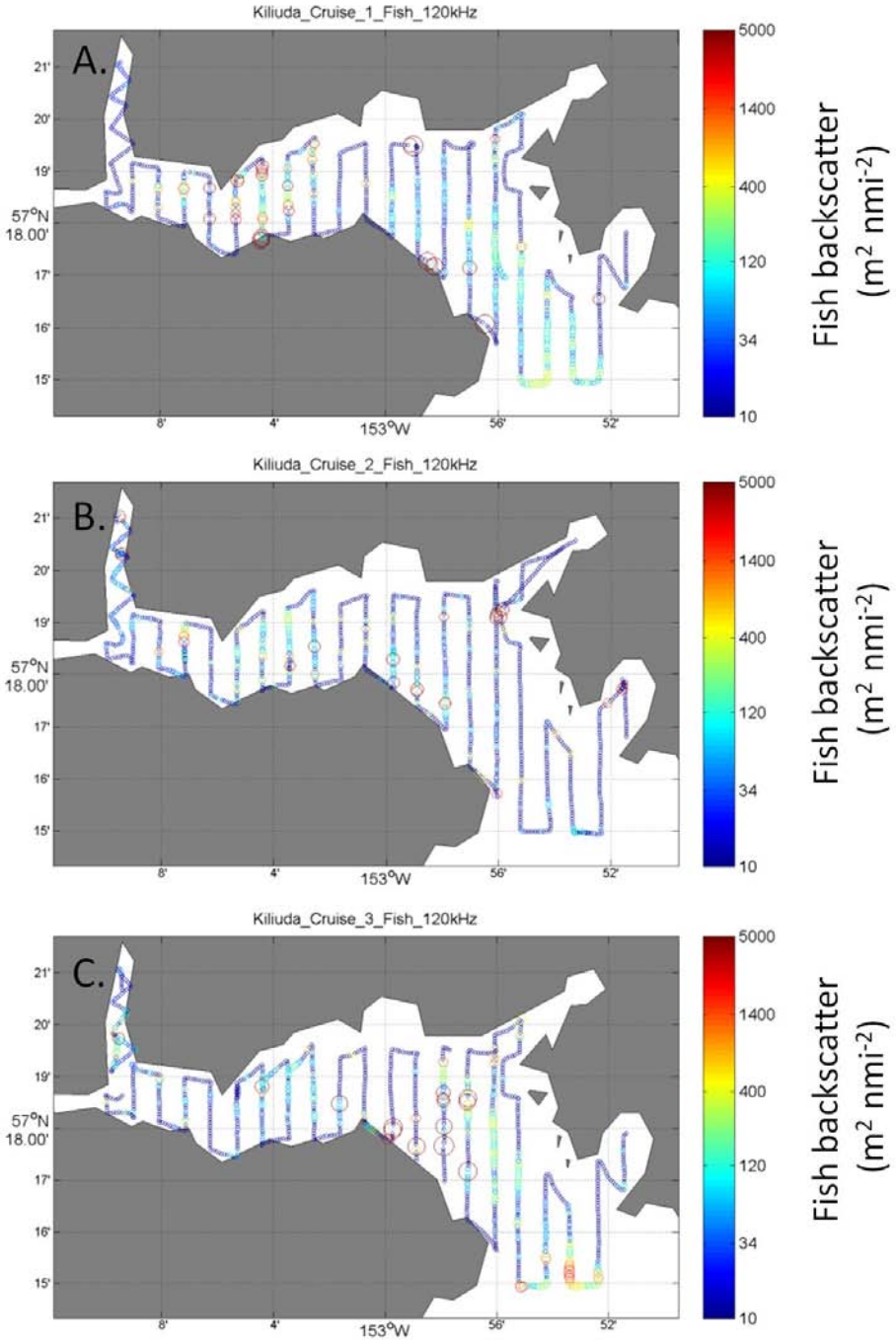

Figure 1. Example maps of acoustic backscatter from fish in Kiliuda Bay near Kodiak observed during inshore MTL cruises in A)spring 2011 B) summer 2011 and C) Fall 2011. Symbol size and color along the ship track are proportional to the logarithm of acoustic backscatter and fish abundance. The large red circles are returns from dense herring schools.

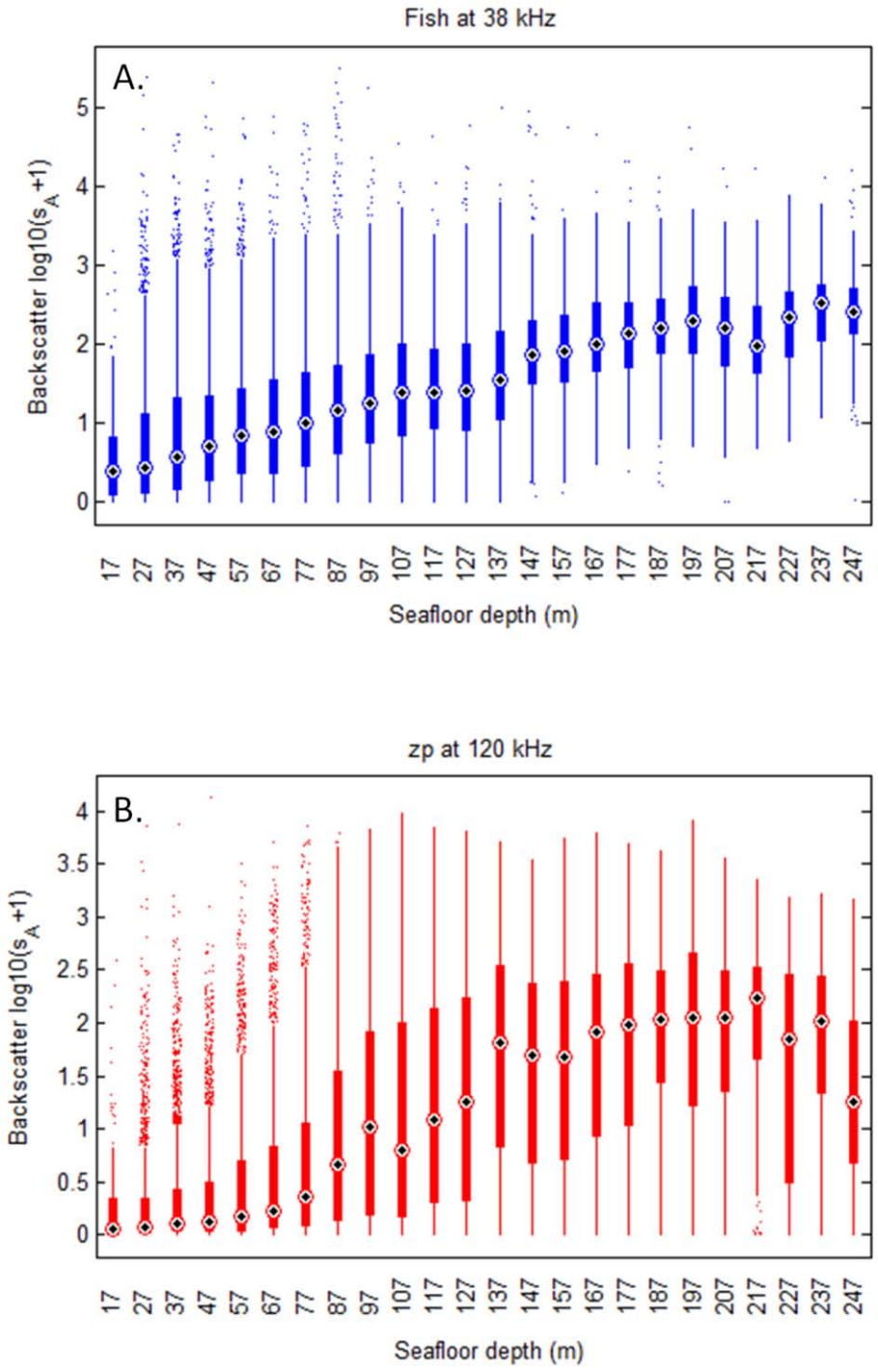

Figure 2. Acoustic backscatter from backscatter consistent with A) fish (top) and B) zooplankton (zp) recorded on GOAIERP inshore MTL surveys as a function of depth. The units on the y axis are proportional to the logarithm of fish/zooplankton abundance.

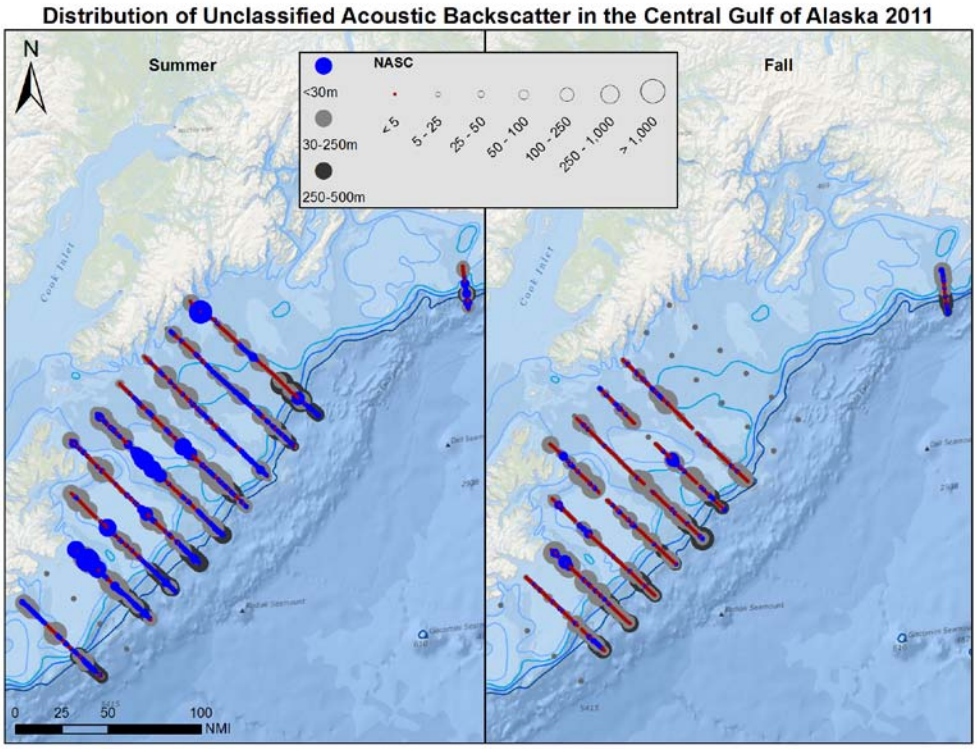

Figure 3. Acoustics backscatter from offshore cruises in the CGOA in 2011.

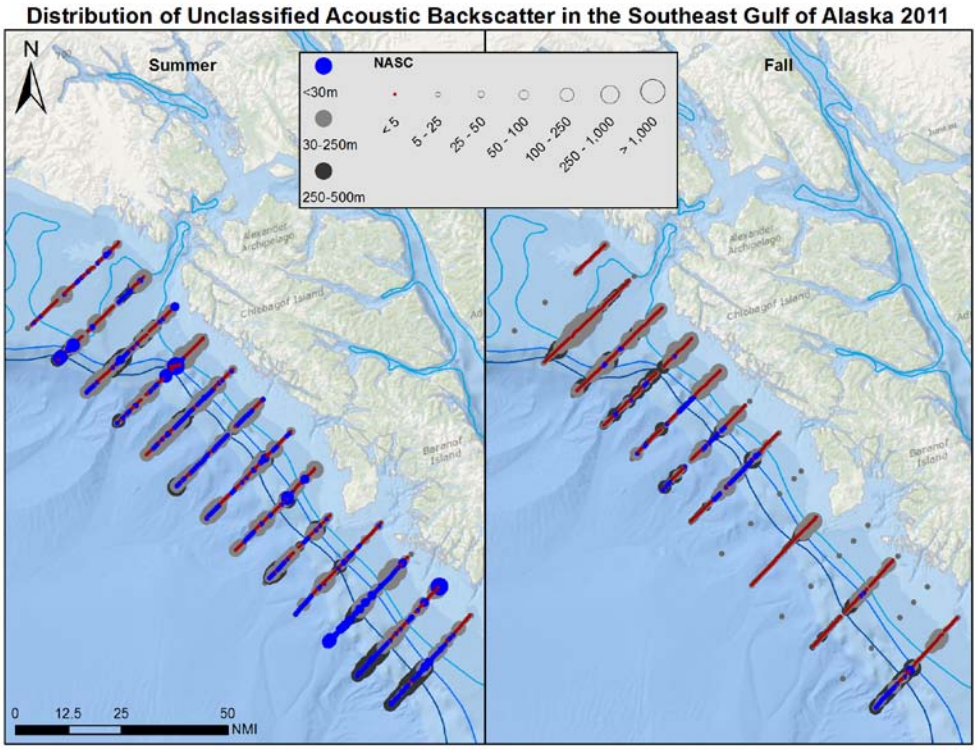

Figure 4. Acoustics backscatter from offshore cruises in the EGOA in 2011.

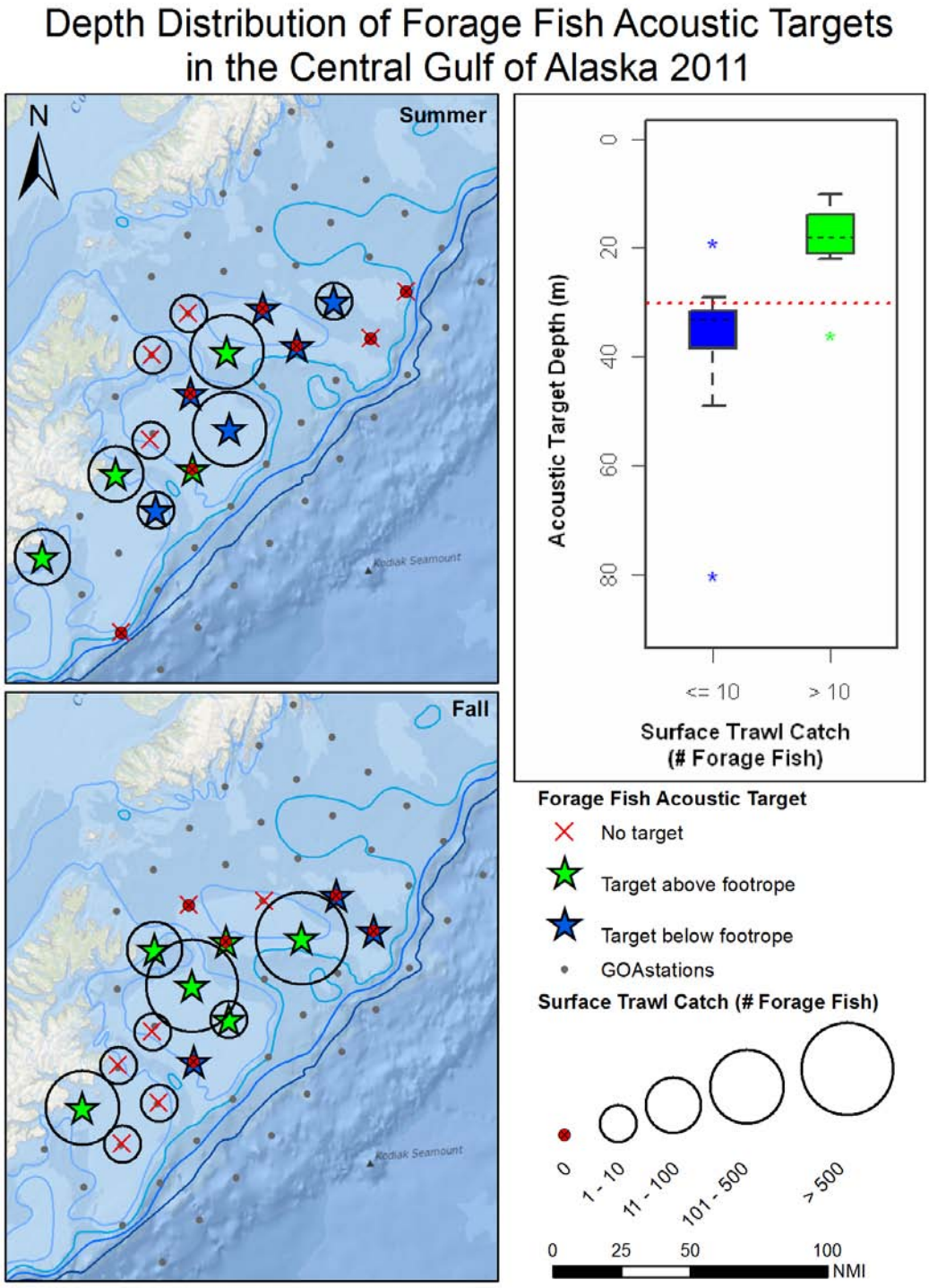

Figure 4. Comparison of surface trawl catch data and acoustic backscatter observed in CGOA offshore cruises in 2011. Maps display surface trawl catches; boxplot indicates size of catch depending on location of acoustic sign in the water column.

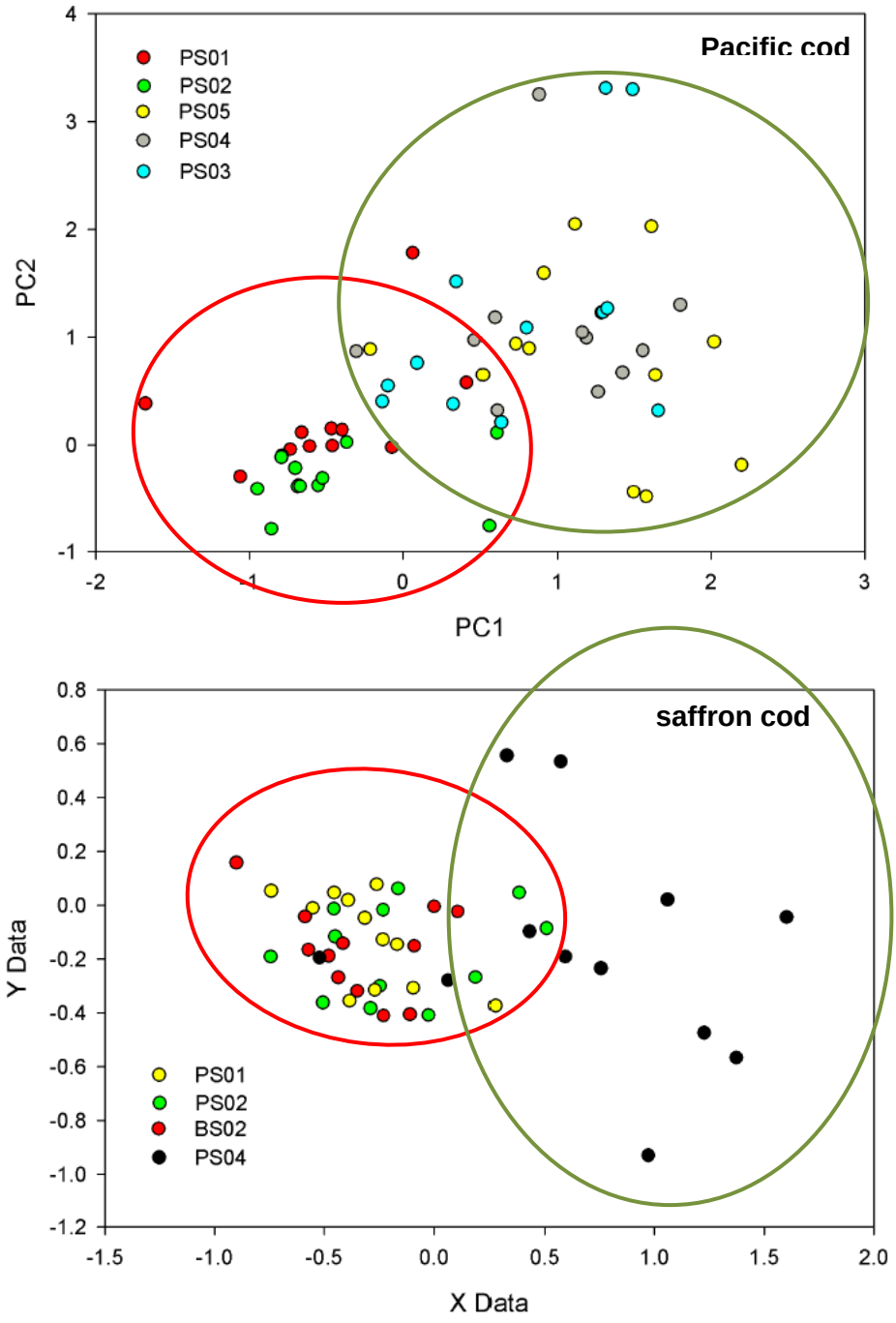

Figure 5. Preliminary principal components analysis of whole-body fatty acid signatures in Pacific cod (top) and saffron cod (bottom) in Kiliuda Bay, summer 2011. Circles indicate approximate spatial orientation (red = inner Kiliuda, green = outer Kiliuda).

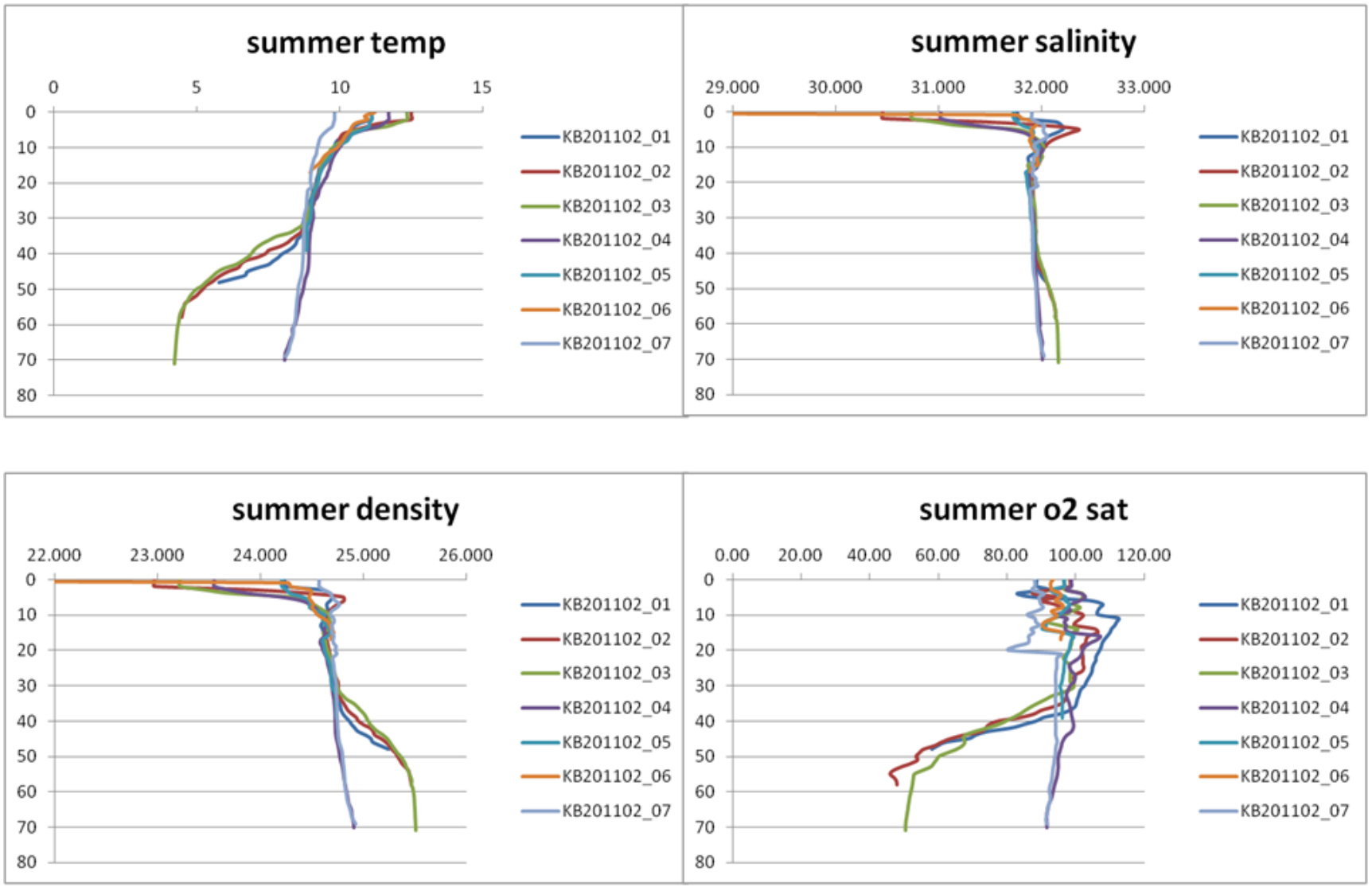

Figure 6. Oceanographic patterns in Kiliuda Bay in summer 2011. Y- axis for all plots is depth in meters. X-axis values are: top left, temperature (°C); top right, salinity (psu), lower left, density; lower right, percent oxygen saturation.

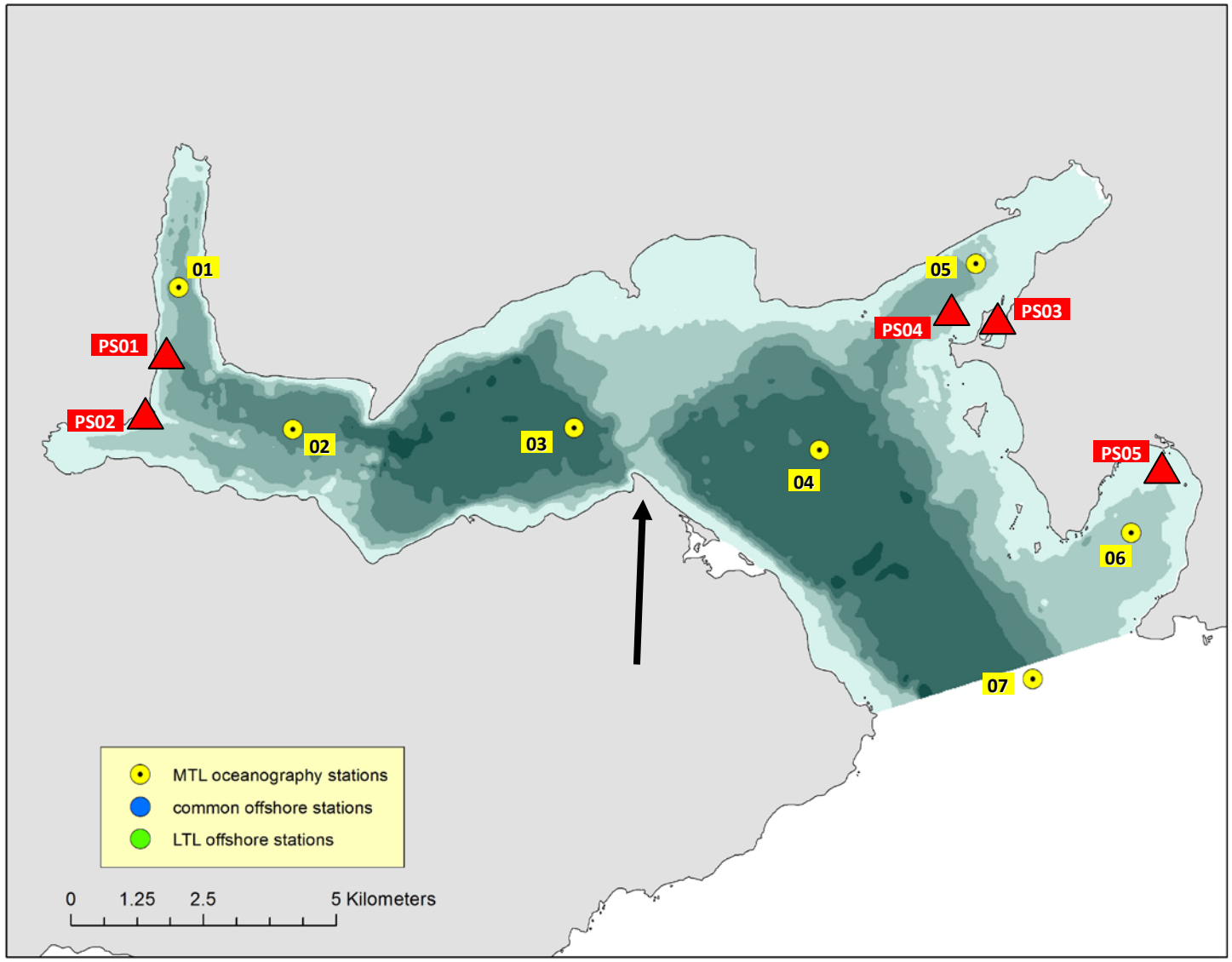

Figure 7. Map of Kiliuda Bay showing bathymetry and the locations of purse seine hauls (red triangles and labels) and oceanography stations (yellow circles and labels). Black arrow indicates location of “sill”.