Project Summary

GAP2012 represents a continuation of GAP2010 and GAP2011, synthesizing multi-year data gathered by the University of Alaska’s Gulf Apex Predator-prey (GAP) study. With long-term and interrelated studies, GAP has collected environmental, predator, and prey data needed to assess the degree of temporal variability and dietary overlap among Kodiak’s sympatric apex predators. In GAP2010, we have compiled GAP and other state and federal agency datasets to model interactions among Kodiak’s mid- and upper trophic levels and explore the impact of balaenopterids on the western Gulf of Alaska nearshore ecosystem. In GAP2011, we continue to identify and quantify the ecosystem processes, drivers, sensitivities, and variability that affect Kodiak’s marine mammal populations and their prey. In GAP2012, we are focusing on the synthesis and modeling of results gathered in these and GAP’s previous 10 years’ of studies on the seasonal distribution, residency, and foraging patterns of marine mammals in waters of the Kodiak Archipelago. Such multi-year studies are fundamental to understanding the role of marine mammals and other upper level consumers in Kodiak waters and the processes that drive populations of their prey within this dynamic marine environment. GAP2013 marks a continuation of GAP2012 with the bulk of project efforts directed at incorporating the modeling, syntheses and data compilations of GAP2012 into a series of manuscript’s to submit for publication in peer-reviewed journals.
Summary of Progress and Results

1) Data Synthesis
   a. Synthesize mysticetes stable isotope data
      i. Build a Gulf of Alaska stable isotope clearinghouse and “isoscape”

During the report period, repeated discussions were held with personnel involved in the Alaska Ocean Observing System (AOOS) and GulfWatch Alaska (GWA; a special AOOS project) to determine if there is a means to incorporate a stable isotope database within the existing AOOS framework. It was agreed that this would be favorable, but that funding was not in place to support the design or maintenance of the database. It was decided that the best way to proceed in establishing the database would be to set-up a data portal through a minimal contract with Axiom Consulting and Design, who currently maintain the AOOS and GWA websites. The portal will serve as the first step for researchers to upload and share their data. It is hoped that this will encourage more participation and leverage other funding sources to support a full database website.

   ii. Determine the degree of fine-scale temporal and spatial overlap between and among fin and humpback whales from Kodiak and Shumagin Islands

During the report period, 37 humpback and one fin whale samples were analyzed for stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes (Table 1). These results have been added to the growing database of stable isotope ratios and will contribute to the analysis of fine-scale temporal and spatial within and between species. In addition, 122 weathervane scallops were analyzed for their stable isotope signatures. Weathervane scallops are used to establish baseline values for regional carbon and nitrogen isotopes and will aid in determining if observed differences in whale stable isotope ratios reflect different foraging strategies or are the result of changes in regional baselines.

Also during the report period, graduate student Dana Wright made significant additional progress on her thesis research exploring fine scale temporal and spatial patterns for Kodiak humpback whales using $\delta^{13}C$ and $\delta^{15}N$. Based on observations of humpback whales feeding on different prey types in the northern and southern regions of Kodiak, discriminant function analysis (DFA) with jacknifed predictions and $\chi^2$ goodness of fit tests were used to assess a North and South regional assignment of whales (Figure 1).

The two-region linear DFA misclassified three animals to the North region (observed (DFA)/actual assignment: 63/66 for North and 52/55 for South), and observed regional assignments were not significantly different from actual assignments $\chi^2$, $(2, N = 118) = 0.30, P = 0.60$. Thus, two humpback whale feeding aggregations in the Kodiak Archipelago have been identified.

To determine the plausibility of using weathervane scallop as basal $\delta^{15}N$ in TL estimation of Kodiak humpback whales, scallop $\delta^{15}N$ were tested for differences by year (2009 or 2012), day of year (DOY), water depth (m), and region (North or South). A student’s t-test was conducted to test
for differences in basal $\delta^{15}$N between years. Differences in $\delta^{15}$N were not significant ($t_{179} = -1.625; P = 0.106$), thus data were pooled across years. To test for potential $\delta^{15}$N remineralization biases with depth or DOY, local polynomial regression fitting (LOESS) trend-lines were fit to scallop data; no prominent trends in the data were found (Figure 2a,b). Therefore, regional mean scallop $\delta^{15}$N were used to estimate TL of humpback whales in Kodiak waters across years using the following equation:

$$\delta^{15}X = 2 + \left( \delta^{15}N_{\text{humpback whale}} - \delta^{15}N_{\text{scallop}} \right)/2.8$$

where 2 is the TL of the primary consumer (scallop) and 2.8 is the isotopic discrimination between euphausiids and fin whale skin. Overall TL was significantly higher in the North ($t_{116} = 4.0, P < 0.001$), indicating higher consumption of higher TL prey (e.g. forage fish) in the North compared to the South. Visual inspection of the data supports higher TL foraging in the North across all years (Figure 3). The North TL was 3.4±0.34, South was 3.1±0.34 and overall mean TL was 3.2±0.36.

b. Synthesize humpback whale sighting histories and association data

During the reporting period, efforts continued to upgrade the existing humpback whale database, which includes daily effort, sighting histories and features unique to individuals (i.e. sex, haplotype, migration destination), into a more comprehensive, streamlined and user-friendly interface called Discovery (http://www.biosch.hku.hk/ecology/staffhp/lk/Discovery/index.html). Once complete, the new database will greatly assist in conducting analyses on long term sighting histories and association data for humpback whales around Kodiak Island and the Shumagin Islands.

Advancements in the abundance estimation of Kodiak humpback whales have not occurred during this reporting period. To date, the model is producing biologically implausible estimations of Kodiak humpback whale abundance, and therefore, modifications to the model parameters need to occur. A conversation with mark-recapture analysis expert Dr. Terrance Quinn II is planned for the next report period.

c. Synthesize dive data from foraging fin and humpback whales

No specific tasks with respect to this objective were scheduled for this report period.

d. Synthesize pinniped diet data

i. Examine seasonal and regional prey overlap between Steller sea lions and harbor seals in waters around the Kodiak Archipelago.

During the report period, the taxonomies of identified prey from Steller sea lions and harbor seals scat samples were standardized in order to facilitate comparison. Originally, a large number of the lowest identifiable taxonomic levels are potentially inclusive (e.g. walleye pollock and unidentified Gadids), which biased further analyses. The currently standardized taxonomies include 30 fish families, two orders (Pleuronectiformes and Cephalopoda), one class (Polycaeta), one superclass (Pisces or unidentified fish spp.), and one subphylum (Crustacea).

We completed a thorough inspection of Steller sea lion scat data and fixed over 200 mistakes related to sample ID, prey taxa, and prey number.
Data were re-organized based on the new clusters of scat collection dates, detailed below in section 3) d. *Pinniped diets*.

ii. **Compare prey distribution patterns to the diet of Kodiak’s Steller sea lions.**

During the report period, data related to prey distribution, biomass, and abundance were re-organized based on the new clusters of scat collection dates, detailed in section 3) d. *Pinniped diets*.

e. **Synthesize prey quality data**

In the last interim report (September 2013), we reported that a small number of fatty acids (20:1n-11, 22:1n-11, 20:5n-3, 20:6n-3, and 18:1n-9) in combination accounted for a large proportion of the differences in fatty acid composition when significant fine-scale intra-species differences were detected. Following those results, during this report period we focused on ontogenetic variations in the five fatty acids. Results showed that there is no consistent ontogenetic variation in any of the five fatty acids, indicating that differences in these fatty acids are results from dietary input rather than physiological change in relation to ontogeny.

2) **Data Collection & Analysis**

a. **Collect Steller sea lion scats**

During the report period, Steller sea lion scats were collected from all haulout sites (Cape Ugat (CU), Sea Otter (SO) and Long Island (LI)) on 1 October 2013. A second scat collection occurred at the LI site on 11 December 2013. Persistent inclement weather through December and into January prevented CU and SO from being sampled (Table 2).

b. **Analyze stable isotopes**

See section I.a.ii above for information regarding this objective.

c. **Analyze whale dive data**

No whales were tagged during the report period and, therefore, there is no dive analysis to report on.

d. **Maintain and monitor long-term indices of cetacean and pinniped diets and distribution**

i. **Whale distribution**

No specific tasks with respect to this objective were scheduled for this report period.

ii. **Whale foraging**

No specific tasks with respect to this objective were scheduled for this report period.

iii. **Steller sea lion diet**

See section 2.a above for information regarding this objective.

3) **Prepare manuscripts of GAP results for publication in peer-reviewed journals**

a. **Whale stable isotopes**
A manuscript addressing fine-scale temporal and spatial variability in humpback whale foraging using $\delta^{13}C$ and $\delta^{15}N$ is currently being written. We estimate the paper will be ready for submission for peer review in May 2014.

b. Whale sightings

During the report period, we began in-depth analysis of cetacean sightings collected during aerial surveys conducted between 1997 and 2013. The analysis is complicated by effort variability across years and surveys, thus the first step in the analysis is to quantify effort by survey. To do this, we created a grid consisting of 5 x 5 km cells and are currently determining the amount of effort (in km) in each cell for each survey (Figure 4). Following effort estimation, we will incorporate environmental data, such as sea surface temperature (SST) and bathymetry, into each cell for each survey. Ultimately, we will use generalized additive models (GAMs) to describe habitat preferences for humpback, fin and gray whales. In addition, we will explore sightings for spatial and temporal trends by species. These analyses will continue in the next reporting period and we will begin drafting a manuscript at end of the next reporting period.

c. Whale foraging behavior

A manuscript entitled "Using dive behavior and active acoustics to assess prey use and partitioning by fin and humpback whales near Kodiak Island, Alaska" was submitted for peer review to the journal Marine Mammal Science in January 2014.

d. Pinniped diets

During the report period, efforts with respect to a manuscript describing pinnipeds diet and diet overlap were focused on seasonal variations in identifiable prey based on frequency of occurrence found in Steller sea lion scat samples. Analyses were made to examine the assumptions underlying the temporal grouping of scat collections. Results showed that few of the previous assumptions were valid. For example, April and May were previously grouped together while June and July together. However, multivariate analyses showed that these groupings were not supported by scat data (Figure 5). Instead, April and May should be separated as was June and July. Using Julian days, the 116 scat collections can be grouped into four periods (Figure 6). These four periods will be used for further analyses and results will be the focus of the publication. We anticipate having a draft of this publication submitted within the next reporting period.

e. Prey quality

No specific tasks with respect to this objective were scheduled for this report period.

4) Develop and index of foraging fish distribution and biomass in waters of the Kodiak Archipelago

No specific tasks with respect to this objective were scheduled for this report period.

Problems

There have been no unexplained expenditures or significant differences between budgeted and actual expenditures.
Table 1: Summary of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) ratios (±SD) analyzed for fin and humpback whales, as well as weathervane scallops during the report period.

<table>
<thead>
<tr>
<th></th>
<th>Kodiak 2012</th>
<th></th>
<th></th>
<th>Kodiak 2013</th>
<th></th>
<th></th>
<th>Shumagin Islands 2012</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n $\delta^{13}C$</td>
<td>$\delta^{15}N$</td>
<td></td>
<td>n $\delta^{13}C$</td>
<td>$\delta^{15}N$</td>
<td></td>
<td>n $\delta^{13}C$</td>
<td>$\delta^{15}N$</td>
<td></td>
</tr>
<tr>
<td>Fin</td>
<td>1</td>
<td>-17.9</td>
<td>12.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-18.6 ± .44</td>
<td>13.0 ± .72</td>
</tr>
<tr>
<td>Humpback</td>
<td>11</td>
<td>-18.4 ± .42</td>
<td>13.3 ± .68</td>
<td>12</td>
<td>-17.9 ± .67</td>
<td>13.8 ± .83</td>
<td>13</td>
<td>-18.6 ± .44</td>
<td>13.0 ± .72</td>
</tr>
<tr>
<td>Scallops</td>
<td>91</td>
<td>-16.9 ± .88</td>
<td>10.6 ± 1.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>31</td>
<td>-16.7 ± .43</td>
<td>10.1 ± .39</td>
</tr>
</tbody>
</table>
Table 2: Number of Steller sea lion scats collected at each of three haulout locations near Kodiak Island. CU = Cape Ugat, SO = Sea Otter Rocks, and LI B = Long Island.

<table>
<thead>
<tr>
<th>Site</th>
<th>10/1/13</th>
<th>12/11/13</th>
</tr>
</thead>
<tbody>
<tr>
<td>CU</td>
<td>53</td>
<td>-</td>
</tr>
<tr>
<td>SO</td>
<td>54</td>
<td>-</td>
</tr>
<tr>
<td>LI</td>
<td>76</td>
<td>78</td>
</tr>
<tr>
<td>Total</td>
<td>183</td>
<td>78</td>
</tr>
</tbody>
</table>
Figure 1. Map of skin samples collected from free-ranging humpback whales within Kodiak Archipelago waters from 2004-2013 (color) by region (North, South). Also shown are locations of weathervane scallop samples for 2009 (X) and 2012 (+).
Figure 2. Weathervane scallop $\delta^5$N by water depth (a) and day of year (b) for samples collected in 2009 (X) and 2012 (+). Solid black lines represent LOESS predictions with span = 0.75 and 95% confidence intervals (dashed).
Figure 3. Mean (± SD) Kodiak humpback whale trophic level (TL) from 2004 – 2013 by region (North rectangle, South triangle). Black lines indicate mean TLs for North (dashed) and South region (dotted) and overall mean TL (solid). Shaded regions represent TLs for strictly fish-eating (piscivorous) and plankton-eating (planktivorous) marine mammals.
Figure 4: Map of the Kodiak Archipelago with 5 x 5 km grid overlay to be used for analysis of aerial survey sightings. Also shown are sightings of all cetaceans during aerial surveys (black circles).
Figure 5. Multi-dimensional scaling of Steller sea lion scat collection (n = 116) in Kodiak area based on prey frequency of occurrence. Each scat collection is defined as the total samples from a given haulout or rookery in a given month; the number of scats with identifiable prey in each collection is between 2 and 84.
Figure 6. Multi-dimensional scaling of Steller sea lion scat collection (n = 116) in Kodiak area based on prey frequency of occurrence. The four periods are based on Julian days, which mostly coincide with the divides among months. P1 includes late October to April; P2 includes May and June; P3 includes July and August; P4 includes September and late October.