Project 080806 - Are Herring Energetics in PWS a Limiting Factor?

I. PROGRESS REPORT

Outlined below are the second year objectives. Specific progress towards these goals is itemized in following remarks.

Objective 1. Field collections (Replication of year 1) - Measure overwinter energetic changes in herring to examine juvenile mortality and adult reproductive investment.

Wild herring were collected from each of the 3 study regions (PWS, Sitka, Lynn Canal) between December 2007 and May 2008. Bioelectrical impedance (BIA) measurements to estimate energy content were performed at the time of capture. In addition, samples were collected for chemical analysis. Collected samples generally fulfilled the study design (collection periods, ages…) with some low sample sizes for YOY fish which were difficult to find. In addition, no pre-winter samples were collected in Sitka Sound this past winter due to their scarcity. Usually herring arrive in Sitka Sound in December or January to form their deep, overwintering schools. This past winter, however, the herring were several months late, as were the humpback whales. In addition to our search efforts, a variety of entities verified the lack of herring in the sound, including the hydroacoustic surveys made by the whale project, ADF&G searching for roe samples, Jan Straley (UAF) searching for humpbacks (whale project), and from local contacts out on the water, including Sitka Sound Science Center, and the US Coast Guard. Thus, herring collections in Sitka were limited to immediately prior to spawning and after spawning this year.

All measurements of the wild-caught herring are complete for both collection years (n=2000). These measurements included length, wet weight, stomach content weight, age and chemical analysis. A total of 1040 were aged using scales and 940 were assessed for stomach contents. Chemical analysis of 300 wild-caught herring has been completed for both years of field collections, including lipid, protein, and energy content of fish. Mature fish were divided into soma and reproductive organs to assess the energy content of roe and milt for reproductive analyses. Analysis of these additional 160 samples is also complete. Initial analysis of voucher specimens indicates that bioelectrical impedance (BIA) measurements are highly correlated with estimates of energy content derived from proximate analysis (R^2=0.91). This suggests that our existing BIA data can be used to significantly expand the number of observations for energy content in our data set. Water temperature data obtained in CTD casts still require analysis.

Objective 2. Laboratory-based studies – Parameterize the Wisconsin bioenergetics model to weigh the evidence for or against energy limitations contributing to the PWS population decline via winter survival or reproduction.

One iteration of the lab study has been completed. After plumbing and laboratory set-up, the trials ran for 4 months. Specifically, 3 replicate tanks of YOY herring (35 per tank) were starved to approximately 50% mortality at 3 temperatures (5.5, 8.5-ambient, 12.5 ^{o}C) Resting metabolic

rates will be calculated from energy losses incurred by these fish. After the starvation period was over, the remaining fish were re-fed to examine the potential for compensatory growth to simulate the spring bloom. Concurrently, 3 replicate tanks (15 fish per tank) at each temperature contained fed herring. These fish were sampled for analyses to relate increases in herring mass and length to biochemical measures of growth including RNA/DNA and enzyme activities. In addition, maximum consumption rate and assimilation efficiency was determined from these fish. Proximate analysis and bomb calorimetry of these samples will begin soon. We have completed development of the RNA/DNA assay and those analyses are underway.

A second iteration of the YOY starvation study is underway. We opted to perform a second iteration because sample numbers were relatively small in the first trial. We were able to obtain sufficient numbers of fish earlier this summer to redo the experiment. This second iteration involves nearly twice as many fish as the first and will therefore provide more complete results. In addition, the temperatures for the second iteration will differ from those in the first, providing more observations with which we can relate metabolic rate and temperature. In addition to the YOY herring study we have initiated a starvation trial for age-2 fish.

II. INITIAL RESULTS

Our initial analysis indicates that adult herring in PWS lose energy at a higher rate than herring in southeastern Alaska. We used allometric relations between energy content and fish length to estimate the energy content of fish of a fixed length in each of our sampling strata. We calculated the energy loss rate (r) as the percentage lost per day from:

$$r = \frac{Ln(e_f) - Ln(e_0)}{t} \times 100 \qquad (1)$$

Where e_f is the estimated energy content at the end of winter and e_o is the estimated energy content at the beginning of winter and t is the number of days between e_f and e_o.
Energy loss averaged 0.42% per day for herring in PWS sampled over two winters. In contrast, energy loss was 0.36% per day for herring from Sitka in the winter of 2005-2006. In Lynn Canal loss rates averaged 0.25% per day over two winters. It is interesting to note that *Ichtyophonus* prevalence is highest in herring from PWS and lowest in herring from Lynn Canal (Paul Hershberger personal communication). Sitka has an intermediate prevalence. This suggests that disease exposure may impose a higher metabolic cost.

We have also determined that YOY herring in PWS are foraging over winter. In our starvation study we observed we average mass loss rates of 0.24%, 0.25% and 0.42% per day in our cold, ambient and warm tanks, respectively. Using an approach similar to that described in equation (1) we determined that YOY herring lost 0.09% of their wet mass per day during the winter of 2006-2007 and 0.04% per day in the winter of 2007-2008. The lowest temperature in our laboratory study was 5.5° C, we will have temperature for PWS once we complete our analysis of CTD data. It is unlikely that temperature will account for the disparity in mass loss rates,

instead it appears that fish in PWS are forestalling mass loss by foraging. This was consistent with observations of prey in 60% of the stomachs we examined.

III. INTEGRATION WITH OTHER PROJECTS

Our project is tightly integrated with two other current EVOS projects, providing fundamental services to both studies. This project is a companion project with the whale project both in terms of data sharing as well as logistical support. We provide the seasonal energy content of wild herring from PWS, Sitka Sound, and Lynn Canal for the modeling component of the whale project (Project 080804) in order to estimate the number of herring required to meet the caloric demand of humpback whales throughout the winter. Additionally, both projects incur costs savings since herring collections and whale observations are often made from the same platform. Furthermore, each study is a scout for the other study, as where we find herring in the winter, we often find whales, or vice versa. For example, the acoustic surveys performed for the whale study are integral for finding herring for sample collections in southeast Alaska. Additionally, whale identification trips in Sitka carried about by Jan Straley (Sitka local) have been instrumental in saving us money and logistical effort by postponing our trips when the herring and humpbacks were late in arriving this past year.

The second current EVOS study we are tightly coupled to is the Herring Disease Program (Project 080819). During field collections, the herring energetics study provides reference samples to measure disease prevalence from Sitka Sound and Lynn Canal. The fact that the two studies are conducted during the same years has implications for both studies. Disease prevalence and energetic condition may have synergistic effects. In addition, measuring both variables in the field simultaneously eliminates any potential confounding effect from interannual variability. Project 080819, has determined that herring in PWS have a higher prevalence of *Ichthyonphonus* than in Sitka Sound and Lynn Canal. We hypothesize that our concurrent observations of increased energy loss of PWS herring results from increased metabolic demand incurred by the presence of *Ichthyophonus*. We plan to test this hypothesis in FY09 in the lab component. In addition, Hulson et al. (2008) concluded that infection of fish in low nutritional condition was responsible for the initial decline in herring abundance in 1992. This is another hypothesis we plan to test in FY09. An additional benefit of the two studies occurring simultaneously is that this has allowed for spontaneous data collections and collaboration when representatives from both studies have been aboard the same vessel (ADF&G's sampling cruises). For example, last year we began measuring bioenergetic parameters on the same individual fish that were being analyzed for disease, providing another comparison of field observations to the controlled conditions of the laboratory component.

Together, this project, the whale and disease studies provide a much more comprehensive picture of herring in PWS than any of studies could alone. Additionally, the collaboration of these three projects provides large cost savings.

Additional collaborative associations include logistical efforts with a multitude of other groups, including:

1) ADF&G Cordova – provided vessel support during their biannual herring collection trips in PWS
2) McLaughlin Environmental Services (Sawmill Bay) – have provided herring samples from Sawmill Bay
3) Prince William Sound Science Center – have provided herring samples from PWS
4) Sitka Sound Science Center – have provided herring samples from Sitka Sound and logistical support during our visits to Sitka (vessel support, in-town transportation, knowledge of herring locations…)
5) ADF&G Sitka – provided vessel support during herring collection trips in Sitka Sound
6) USCG Sitka – provided observations of humpback whales in Sitka Sound in order to find herring
7) NOAA Undersea Research Program program provided funding for us to study herring predator avoidance behavior with DIDSON sonar. This project was leveraged off of an EVOS funded survey. We were able to capture multiple videos of Steller sea lion attacks on herring in winter. From the imagery we can estimate swimming speed. Combining the swimming estimates with bioenergetic data collected under this study will allow us to estimate the cost of predator avoidance.