Progress to Date

Project 070804/ Significance of Whale Predation on Natural Mortality Rate of Pacific Herring in PWS

Summary: This project was approved in late fall of 2006, precluding a heavy field emphasis in year 1. No field work as initiated in Sitka Sound because of the late funding approval (none was planned), but field work was initiated in both Sawmill Bay and Lynn Canal, using small boats and local resources in both locations. Extensive charters for winter could not be set up in time to capture a full seasonal picture, but information was gained that increases the quality and likelihood of success in the 2007/2008 fall-winter. Procedures were worked out; sample collections of prey were made in two locations; whales were enumerated in two locations. Because of the time of funding this year, the transition from summer feeding patterns and numbers through fall and into winter will be captured at all three locations.

Outlined below are the first year objectives. Specific progress towards these goals is itemized in italics.

Objectives

1. Determine whale numbers and distribution in Sawmill Bay/Chenga Bay and southern Lynn Canal.
    a. Find locations where whales are foraging and identify their prey. *In Sawmill Bay, humpback whales appear to be feeding almost exclusively on herring during the fall and winter. In Lynn Canal, herring, euphausids, and other forage fish were identified by trawl and acoustic survey in the vicinity of foraging whales.*

    b. Use photo-identification methods to estimate whale abundance in these locations using twice-monthly, surveys starting in fall 2006. *Boat-based surveys were completed in PWS and Lynn Canal. Fluke photos from PWS and Lynn Canal are being cataloged. An experienced contractor has been hired to complete the fluke matching process.*

    c. Locate other feeding focal areas in PWS through cooperative boat surveys and aerial observations. *During fall/winter surveys we found no concentrations of humpback whales in PWS outside of Chenga Bay and the surrounding area. Poor survey conditions may have been a factor; we will increase our survey efforts in the FY 08.*

2. Estimate biomass of herring and euphausids in Sawmill/Chenega Bay and Lynn Canal.
    a. Estimate biomass before, during, and end of winter to determine if direct impacts of whale foraging can be detected in Lynn Canal. *Acoustic surveys were conducted in Lynn Canal; they have yet to be quantified.*

b. Identify forage species consumed by whales to determine when and if prey switching occurs in Lynn Canal and Sawmill Bay/Chenega Bay. *PWS whales appear to be predominately feeding on the over-wintering herring aggregations in Sawmill Bay. In Lynn Canal individual whales were observed switching from euphausids to herring within 24 hours at the same location.*

c. Determine size composition, and energy content of prey, using trawl surveys in Sawmill Bay and Lynn Canal. *Length, weight, and age have been determined for prey in both areas. Bio impedance analysis was performed on herring at the time of capture and proximate analysis has begun.*

3. Estimate the percentage of a humpback whale's energy requirements fulfilled by herring using bioenergetic models
   a. Energy content will be determined for each forage type, including different age classes of herring. *Energy content for herring and other prey is being determined.*

   b. Using prey switching information, estimate the energy consumed by whales. *Data on prey switching has been collected and is being analyzed.*

4. Using herring age structure models, along with whale numbers and foraging information, assess the significance of winter humpback whale predation on each population, for both years.
   a. Develop time series of whale abundance for PWS and Sitka from published reports, photo ID information, and mark-recapture methods. *To be completed in FY08.*

   b. For Lynn Canal, compare whale sightings with the Sitka and PWS catalog to determine if unique whales utilize Lynn Canal. Estimate abundance in 2007 using photo ID and mark-recapture methods. *Cataloging and comparisons have begun.*

   c. From objective 3, estimate the winter consumption by humpback whales by herring age-class and year in PWS and Sitka. *To be completed in FY08*

   d. Modify the age-structured models for PWS and Sitka to subtract winter whale consumption. Compare with results from the models without predation time series. *Terry Quinn has improved the age-structured herring model.*

   e. In Lynn Canal, determine what proportion of the herring population is consumed by humpback whales in the winter. *To be completed in FY08*

Progress Report on Project 070804/ Significance of Whale Predation on Natural Mortality Rate of Pacific Herring in PWS

to Exxon Valdez Oil Spill Trustee Council

Modeling Component

Quinn et al. (2001) and Marty et al. (2003) developed an age-structured assessment model for Pacific herring in Prince William Sound that includes disease information. The model has been used to evaluate the impact of disease on population abundance, recruitment, and survival, to assess the population status of herring, and to make harvest recommendations (S. Moffitt, ADF&G, pers. comm.).

The model contains information about the fisheries on PWS herring, which include purse-seine, gillnet, and pound fisheries in the spring (mainly for roe), and a food and bait fishery in the summer and fall. The model provides an estimation framework to integrate the various sources of information about Pacific herring in Prince William Sound from 1980 – 2006, including age compositions from the purse-seine fishery and spawning surveys, egg production estimates, mile-days of milt from aerial surveys, and hydroacoustic biomass estimates (Quinn et al. 2001, Marty et al. 2003, Hulson et al., in review, Marty et al., in prep.). These observations are compared to comparable model quantities in a least squares setting to obtain parameter estimates of recruitment, natural mortality, abundance, and biomass.

We are refining this model as the basis of comparing the relative magnitudes of the various factors affecting PWS herring dynamics. Recruitment estimates at age 3 will be related to auxiliary variables related to disease, the environment, spawning stock, and predation. It is a simple matter to use the model as a simulation framework, in which alternative harvest and recruitment scenarios are developed. An example of a question to be addressed would be: If whales did not eat herring, would the population have rebounded more so than what really occurred?

Specifically the model will be used: (1) to determine if predation on adult PWS herring is significantly contributing to its failure to recover, (2) to compare the magnitude of this effect to other known factors such as disease and low recruitment, (3) to investigate whether low recruitment is a function of predation.

Our work this year has led to the development of two manuscripts: Hulson et al. (in review) and Marty et al. (in review). The first manuscript has been reviewed once by the ICES Journal of Marine Science and a revised manuscript has been submitted. This paper evaluates the hydroacoustic information that is collected by PWSSC and ADF&G as a useful data source in the PWS herring model. The outcome of modeling using data through 2004 is that a severe data conflict between data sources during 1988 to 1992 is revealed. Our preferred model suggests that the PWS herring population collapsed in 1992 due to a VHSV disease event. However, other researchers have undertaken an

analysis that suggests that the collapse started at the time of the oil spill. In the manuscript, we show that when the decline began is still uncertain and depends on how heavily various data sources are weighted. The abstract of this manuscript is in Appendix 1.

The second manuscript, Marty et al. (in prep.) is nearly finished and involves the further analysis of disease impacts on PWS herring. All datasets have been updated through 2006, providing two more years of data. New parameter estimates from the model support earlier work on disease impacts: VHSV has more effect on younger ages, while the fungus *Ichthyophonus hoferi* has more effect on older ages. There appear to have been three disease events since 1992. VHSV events were prominent in 1992-1993 and 1997-1998. It appears that *I. hoferi* may have contributed to higher adult mortality since 2001. Thus, it appears that disease continues to play a major role in Pacific herring recovery.

Our work in FY08 will focus on predation, specifically of humpback whales. As the whale time series are developed, they will be included in the model as a source of mortality. There have been no changes to our component's detailed project description or budget.

References

Hulson, P.-J. F., S.E. Miller, T.J. Quinn II, G.D. Marty, S.D. Moffit, and F. Funk. In review. Data conflicts in fishery models: Incorporating hydroacoustic data into the Prince William Sound Pacific herring assessment model. ICES J. Marine Science.

Marty, G.D., S.E. Miller, P.-J. F. Hulson, T.J. Quinn II, S.D. Moffit, R.A. Merizon, and T.R. Meyers. In prep. Role of *Ichthyophonus hoferi*, viral hemorrhagic septicemia virus, and cutaneous ulcers in preventing recovery of a Pacific herring (*Clupea pallasi*) population.

Appendix 1. Data conflicts in fishery models: Incorporating hydroacoustic data into the Prince William Sound Pacific herring assessment model

Peter-John F. Hulson[1], Sara E. Miller[1], Terrance J. Quinn II[1], Gary D. Marty[2], Steven D. Moffitt[3], and Frederick Funk[1]
[1]Fisheries Division, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, Alaska, 99801.
[2]Department of Anatomy, Physiology, and Cell Biology, School of Veterinary Medicine, University of California, Davis, California, 95616.
[3]Alaska Department of Fish and Game, Cordova, Alaska, 99574.

Abstract

A feature of integrated age-structured assessment (ASA) models is multiple datasets with weighting terms. We illustrate the difficulties that data conflicts present using the Pacific herring population in Prince William Sound (PWS), Alaska. After the 1989 *Exxon Valdez* oil spill in PWS, the Pacific herring (*Clupea pallasi*) ASA indicates a significant decline in the population starting in the winter of 1992. Back-calculated estimates from hydroacoustic abundance surveys that started in 1993 suggest that the ASA model overestimated herring biomass in 1990-1992 and the population decline actually began in 1989. To expose data conflicts, we incorporate the hydroacoustic survey information with all available spawning population indices directly into the age-structured model. In this way, the substantial uncertainty about population parameters from 1989 to 1992 due to data conflicts is quantified. Consequently, the magnitude of declines for that period estimated from both linear and ASA models depend on the datasets and weighting, particularly with indices of male spawners.