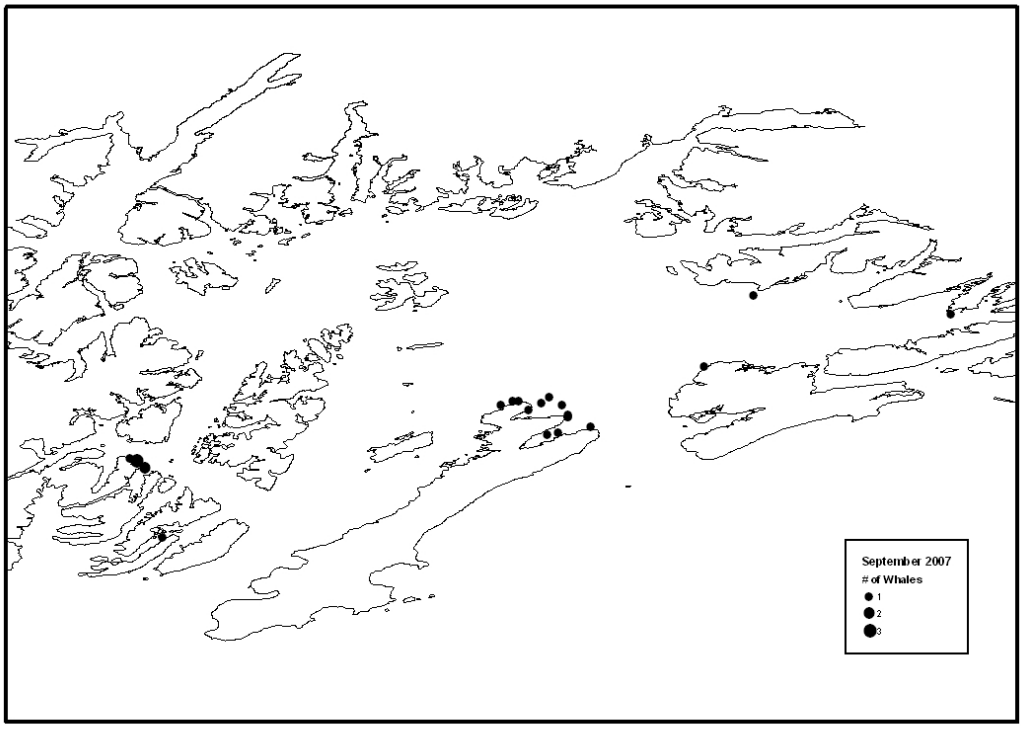
Progress Report
Project 080804/ Significance of Whale Predation on Natural Mortality Rate of Pacific Herring in PWS

Summary: Excellent survey conditions during the fall/winter of 2007/2008 allowed us to thoroughly survey Prince William Sound by boat for humpback whales. In addition to the known feeding aggregation of humpback whales in Sawmill Bay, we found whales feeding on herring in Elrington Passage, Prince of Wales Passage, and Port Gravina (Figure 1.). We did not locate whales at these sites during the fall/winter of 2006/2007 through aerial surveys, however most of our effort focused on Sawmill Bay in year 1 of this study. Counts of 25(Sept), 81(Nov) and 59(Jan) whales, combined with photographic mark-recapture models resulted in a peak estimate of 165 whales occurring in late December (Figure 2.). Based on a resting metabolic rate, the energetic requirements for these whales feeding exclusively on herring would account for 18-23% of the pre-winter herring biomass being consumed in PWS.



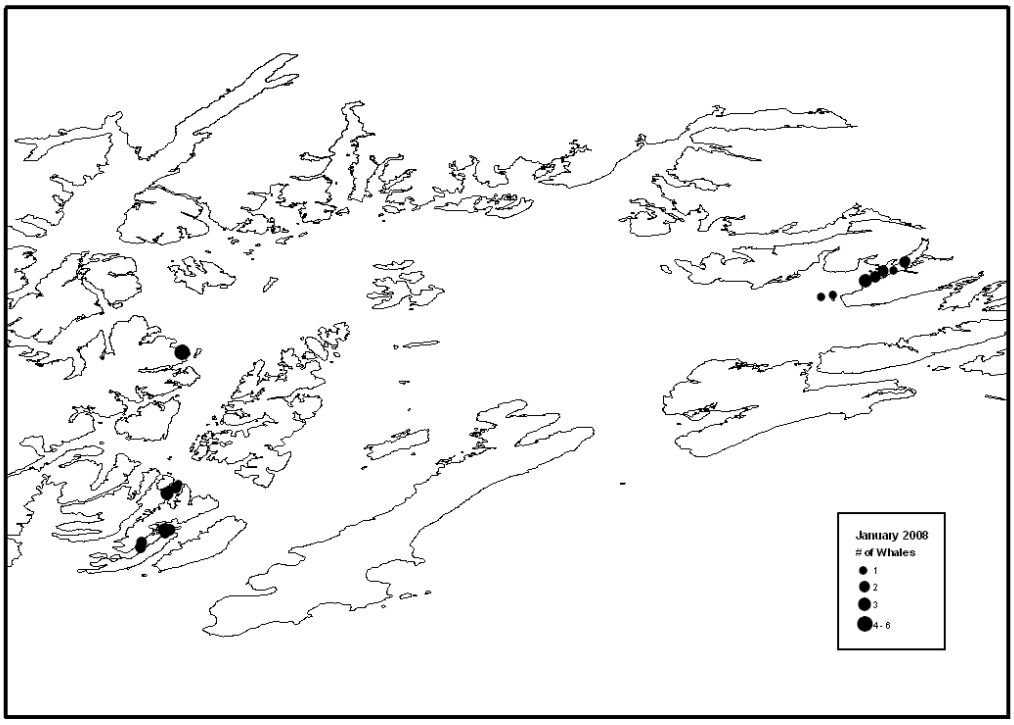


Figure 1. Distribution of humpback whales in Prince William Sound during September 2007, November 2007, and January 2008 boat-bases surveys.

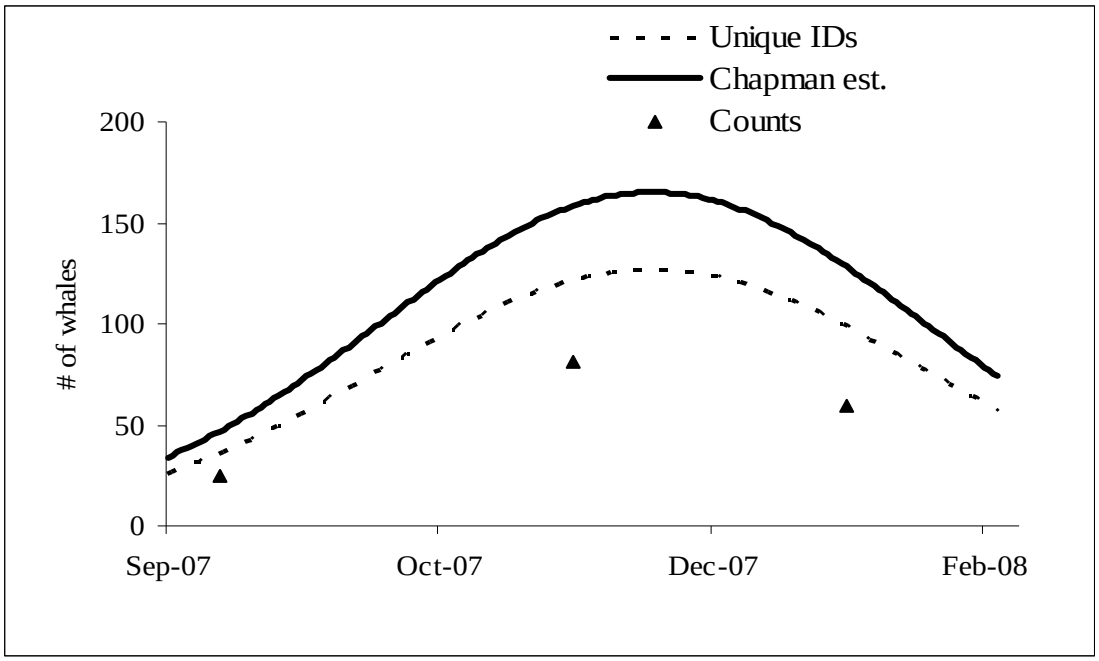


Figure 2. Estimates of humpback whale abundance in Prince William Sound from September of 2007 through February 2008. Estimates were based on counts during boat-based surveys (triangles), unique individuals from fluke photographs (dashed line), and the Chapman form of Petersen estimator (solid line).

Initial results: Trends in seasonal humpback whale abundance and the behavior of over-wintering herring differed among PWS, Lynn Canal, and Sitka Sound. In PWS we observed an increase in whale numbers during winter months (Figure 2.). When whales were feeding on herring, schools were dispersed and found throughout the water column. In Lynn Canal, whale abundance trends were similar to what we observed in year one of this study, numbers peaked in early fall and declined through the winter (2-5 whales where present in January 2008) (Figure 3 and 4.). Lynn Canal herring differed in their behavior from PWS herring by schooling in a stable cohesive layer by mid-December 70-100m below the surface. Although whale abundance trends in Sitka Sound appeared similar to Lynn Canal, declining in the winter months (Figure 5.), over-wintering herring aggregations did not appear in Sitka Sound until late February during the winter of 2008. Typically herring return to Sitka Sound during December/January, the cause of the late herring return to over-wintering grounds is unknown at this time. We believe that whales were targeting euphausids and small schools of fish at the surface (possible herring) during the fall of 2007 in Sitka Sound.

In the fall/winter of 2008/09 we will increase our effort in PWS to 25 days at sea. This will allow us to refine the timing of whale movements in to the Sound and determine if the high numbers of whales we observed during the winter of 2007/08 were typical for PWS. Work will continue in Sitka Sound and Lynn Canal to provide a comparison for whale predation rates on herring in PWS.

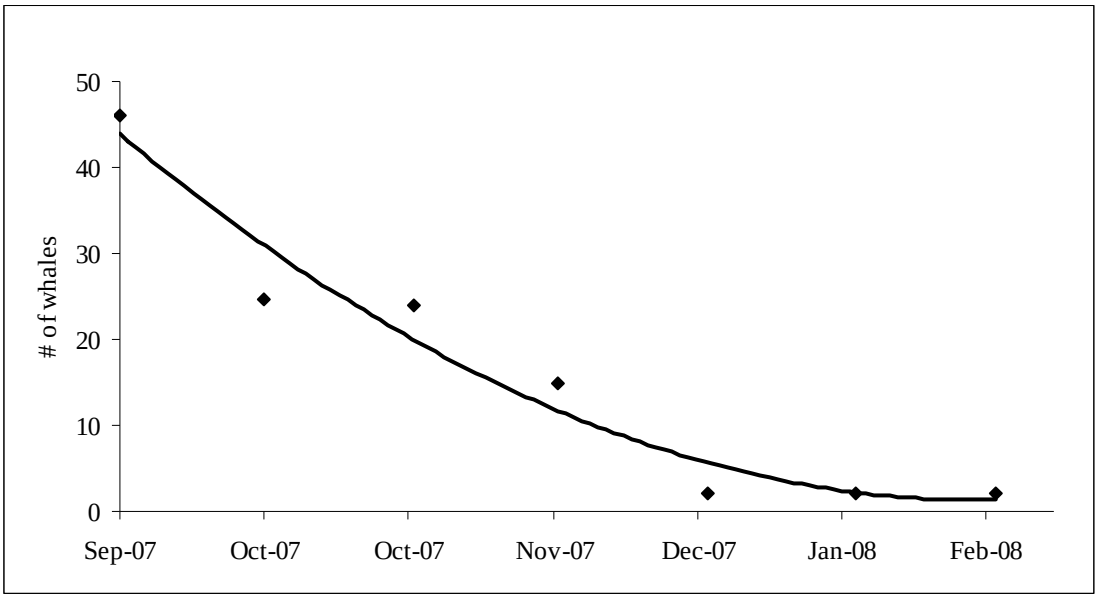


Figure 3. Estimates of humpback whale abundance in Lynn Canal from September of 2006 through February 2007, using the Chapman form of the Petersen estimator.

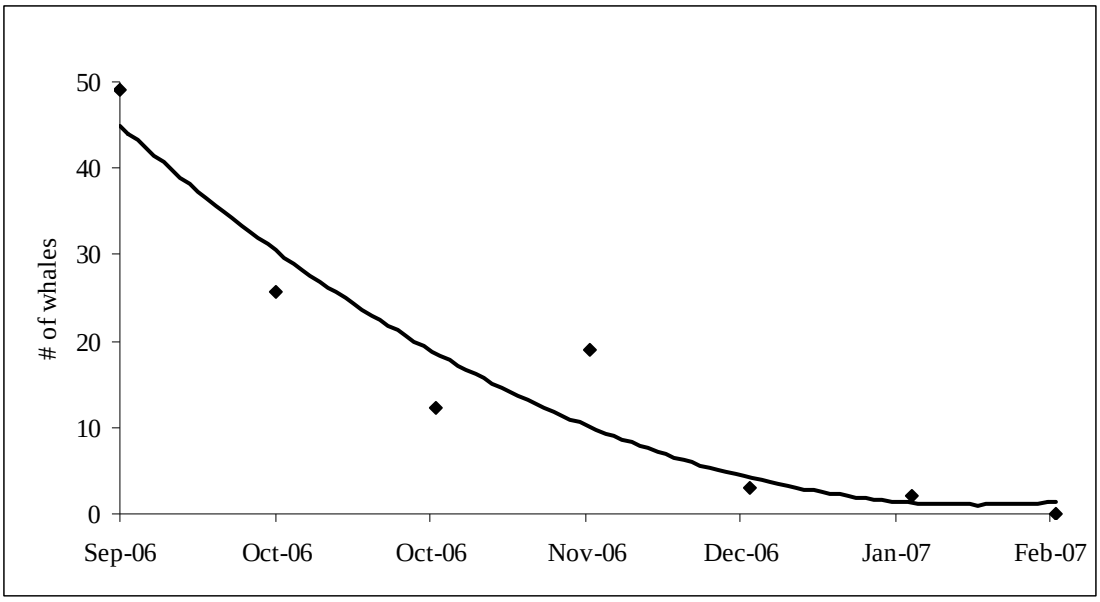


Figure 4. Estimates of humpback whale abundance in Lynn Canal from September of 2007 through February 2008, using the Chapman form of the Petersen estimator.

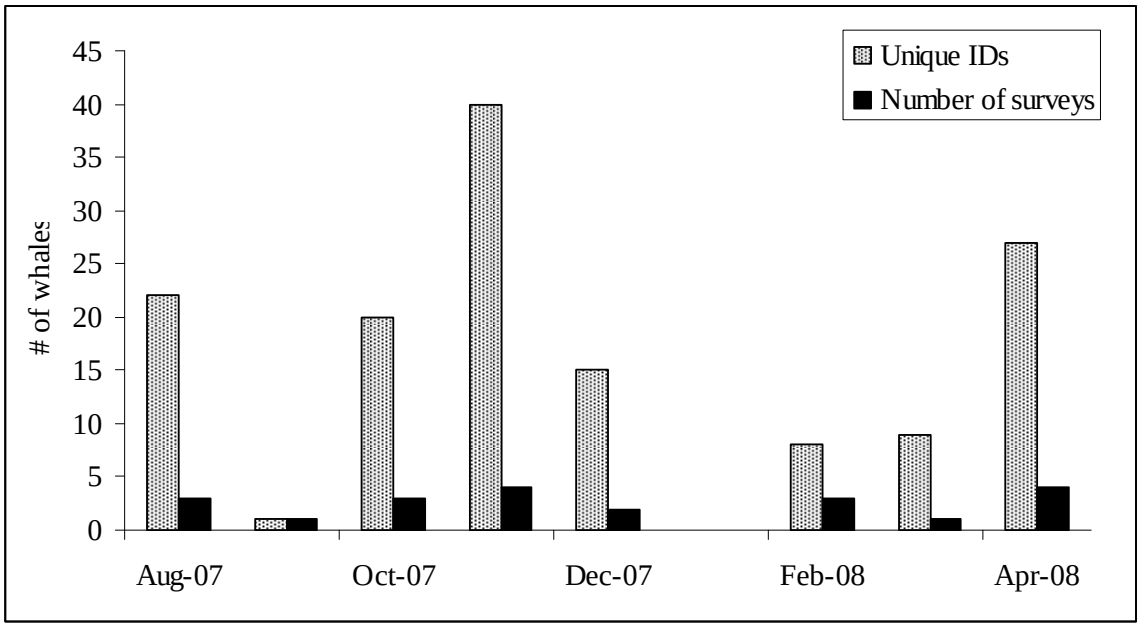


Figure 5. Estimates of humpback whale abundance in Sitka Sound from August 2007 through April 2008. Effort is displayed in number of survey days/month.

Modeling: We have pursued two research fronts for modeling work related to this project. The first is to refine the age-structured model for the herring population in Prince

William Sound. The second is to model the seasonal abundance of humpback whales during the winter using field data from 2007-2008.

EVOSTC and other agencies have funded Quinn and Marty for almost a decade to develop and refine the age-structured assessment model for Pacific herring in Prince William Sound that includes disease information (Quinn et al. 2001, Marty et al. 2003). ADF&G currently uses this model 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.). Consequently, the commercial herring fishery in PWS has not been opened since 1998 due to low abundance estimated from the model. Thus this is a management model as well as a research model that is integral to understanding the PWS herring population.

Specifically this modeling work will be used: (1) to determine if predation by humpback whales 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 recent work has included the completion of two manuscripts for publication (Hulson et al. 2008, Marty et al. 2008) and one chapter of an M.S. Thesis (Hulson 2007). One major enhancement to the PWS herring model has been the incorporation of hydroacoustic information (Hulson 2007, Hulson et al. 2008). We revealed data conflicts between various sources of information in the years following the oil spill. Therefore there is ambiguity as to which factors caused the population to crash in 1993. We proposed that the large population of herring in 1989 – 1992 was not able to find sufficient food, resulting in poor condition in 1992. That led to a VHSV epidemic, which caused 2/3 of the adult population to die in 1993 (Hulson et al. 2008). PWSSC scientists reviewed our work and presented an alternate hypothesis related to sea lion predation (Thorne and Thomas 2008).

Disease has continued to have a major impact on adult PWS herring: VHSV has more effect on younger ages, while the fungus *Ichthyophonus hoferi* has more effect on older ages (Marty et al. 2008). 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* contributed to higher adult mortality since 2001 (Marty et al. 2008). Thus, it appears that disease continues to play a major role in Pacific herring recovery.

Modeling the seasonal abundance of whales involved two components: estimation of total whale abundance and approximating the seasonal distribution. Estimation of total whale abundance was accomplished by using the Petersen mark-recapture method, using visual identification of whale flukes as the natural mark. This resulted in an estimate of about 160 whales, similar to the number of unique whales identified (127). The seasonal distribution was approximated by a quadratic function fitted to counts of whales during the three fall-winter surveys.

Bioenergetic models indicate that whales are an important herring predator in PWS. Our current bioenergetic model relates daily changes in whale numbers to the number of herring required to meet the total metabolic requirement for those whales (Klieber 1961). In PWS, whales required between 10,000 and 14,000 MJoules to meet metabolic demand between September 1, 2007 and February 28, 2008. The average mass specific energy content of a herring declined from approximately 8.9 kJ/g wet mass to 5.1 kJ/g wet mass during the same period. Thus, whales required 1600 to 2100 metric tons of herring over the winter of 2007/2008. This represents approximately 18-23% of the pre-winter biomass of herring. It is important to note that this estimate only reflects the energy required by whales to meet basic metabolic function. Energy costs associated with searching and handling prey will increase this estimate.

Details of how you have integrated with other projects:

Data sharing and vessel time

The Auke Bay Laboratories are working with the University of Alaska Southeast (Jan Straley), University of Alaska Fairbanks (Terry Quinn), both are co PIs on this project. We have shared vessel time, sample collection, chemical analysis, and labor with EVOSTC project 080806 (Are Herring Energetics in PWS a Limiting Factor?).Our cruises in Prince William Sound have served as platforms for seabird observations by the Prince William Sound Science Center (Mary Anne Bishop and Neil Dawson, EVOSTC project 080814). Kate and Andy McLaughlin of Chenega Bay are providing us with whale observations from Sawmill Bay. The Department of Fish and Game (Steve Moffit and Lauri Jemison) are providing us with whale and herring observations from their PWS cruises. Craig Matkin is provided with killer whale observational data and photographs from PWS. Mandy Lindeberg (ABL, EVOSTC project 070805) provided whale location.

In Lynn Canal we are sharing whale data with the NMFS Alaska Regional Office (Aleria Jensen), Alaska Stranding Network, and Whale Trust (Flip Nicklin). Fluke and dorsal photos from humpback whales will be made available to the National Marine Mammal Laboratory. USFWS Migratory Bird Management (Rob Mac Donald) provided humpback whale data. We assisted the University of Hawaii (Alison Stimpert) with tagging humpback whales foraging on herring.

Community involvement

Author Charles Wohlforth and Amy Bracken of KCHU public radio participated have on PWS cruises.

Interviews regarding this project have been made with Amanda Fehd and Kate Golden of the Juneau Empire, Pete Carran KINY, KTOO in Juneau and Amy Bracken of KCHU Valdez

The Lynn Canal portion of the humpback whale catalog has been made available to the public at http://www.afsc.noaa.gov/ABL/Humpback/JuneauCatalog.htm.

Presentations to the public include**:**

Moran, J.R., S.D. Rice and S.F. Teerlink. Humpback whale predation on Pacific herring southern Lynn Canal and northern Stephens Passage: Testing a top-down hypothesis. Abstract presented at the Alaska Marine Science Symposium. January 20-23, 2008, Anchorage, Alaska.

McLaughlin, K.A., A.T. McLaughlin, J.R. Moran, and S.D. Rice. Humpback whale (*Megaptera novaegliae)* predation on winter aggregations of Pacific herring (*Clupea pallasii*) in Sawmill Bay, Alaska: Is it a problem for the herring? Abstract presented at the Alaska Marine Science Symposium. January 20-23, 2008, Anchorage, Alaska.

Moran, J., S. Rice, J.Straley, T. Quinn, R. Heintz, and S. Teerlink. Humpback whale predation on Pacific herring in Prince William Sound, southern Lynn Canal, and Sitka, Alaska. Naturalist Training, 29 April 2008, Alaska Fisheries Science Center, Ted Stevens Marine Research Institute. Juneau, Alaska

References

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Hulson, P. J.F., Miller, S.E., Quinn, T.J., II, Marty, G.D., Moffitt, S.D., and Funk, F. 2008. Data conflicts in fishery models: incorporating hydroacoustic data into the Prince William Sound Pacific herring assessment model. ICES J. Marine Science 65: 25-43.

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Marty, G.D., Quinn, T.J., II, Carpenter, G., Meyers, T.R., and Willits, N.H. 2003. Role of disease in abundance of a Pacific herring population. Can. J. Fish. Aquat. Sci. 60: 1258-1265.

Marty, G.D., Hulson, P.-J. F., Miller, S.E., Quinn, T.J., II, Moffit, S.D., Merizon, R.A., and Meyers, T.R. 2008. Failure of population recovery in relation to disease in Pacific herring. Will be submitted to Science, September 2008.

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Seber, G.A.F. 1982. Estimation of Animal Abundance and Related Parameters, 2nd edition. Wiley, New York.

Thorne, R.E., and Thomas, G.L. 2008. Herring and the "Exxon Valdez" oil spill: an investigation into historical data conflicts. ICES Journal of Marine Science, 65: 44–50.