EVOSTC ANNUAL PROJECT REPORT

Recipients of funds from the *Exxon Valdez* Oil Spill Trustee Council must submit an annual project report in the following format by **Sept. 1 of each fiscal year** for which project funding is received (with the exception of the final funding year in which a final report must be submitted). **Please help ensure that continued support for your project will not be delayed by submitting your report by Sept. 1. Timely receipt of your report allows more time for court notice and transfer, report review and timely release of the following year's funds.**

Satisfactory review of the annual report is necessary for continuation of multi-year projects. Failure to submit an annual report by **Sept. 1** of each year, or unsatisfactory review of an annual report, will result in withholding of additional project funds and may result in cancellation of the project or denial of funding for future projects. **PLEASE NOTE:** Significant changes in a project's objectives, methods, schedule, or budget require submittal of a new proposal that will be subject to the standard process of proposal submittal, technical review, and Trustee Council approval.

Project Number: 070810
Project Title: An Ecosystem Model of Prince William Sound Herring: A Management & Restoration Tool

PI Name: Dale A. Kiefer

Time period covered: February 15, 2007 to August 24, 2007

Date of Report: August 24, 2007

Report prepared by: Dale A. Kiefer

*Project website (if applicable): **http://smbay.usc.edu/pws/***

Project Objectives, Hypotheses and Summarized Accomplishments

The goal of this project is to produce a spatially-explicit, life-stage, compartmentalized, and ecosystem-based herring model that simulates intrinsic and extrinsic effects on herring survival and mortality. The model should provide reliable guidance to both future fishery management and ecological intervention. The data and model will be fully housed in a dynamic, web-based GIS (called EASy) that we have developed specifically for marine applications. The project is a 3-year effort that will provide at the end of each year model and data analysis products that are steps towards a full 3 dimensional simulation that will be used to assess restoration proposals.

After the first 7 months of the project, the major accomplishments are:

1) We have constructed both a prototype one-dimensional model and spatially-explicit models of herring population dynamics that will be tuned to observed observational data derived from our PWS Herring database.

2) We have collected significant portions of our PWS Herring database from a variety of sources and some of this data has already been imported into our web-based geographic information system. This data is drawn from a number of field research projects including IMS, SEA, APEX, GLOBEC, etc. Collecting and analyzing this data is the first step necessary in constructing the simulation model since we use observed model parameters (e.g. growth and survival rates) and physical/biological data (e.g. temperature and size at age) data both to derive the system of equations describe herring population dynamics and to obtain estimates of the values for coefficients within these equations.

3) We have initiated our outreach program by producing two quarterly newsletters, taught a graduate level course on modeling herring dynamics in PWS, and developed a web-based data sharing and query structure for the model and database.

The original hypotheses developed centering on limitations to herring recovery were:

1) A climate shift has impacted regional production by changing circulation patterns and temperature that directly affects larval drift and prey resources for herring;
2) Hemorrhagic Septicemia virus (VHSV) continues to limit growth rate and increase mortality rates of adult fish;
3) A change in community structure has created a "predator" that has caught herring in a low-density state, that acts to limit herring recovery (interaction of predation, prey, competition in relation to abundance of the species involved);
4) Contamination from EVOS continues to limit the herring's habitat.

During the course of the first year's work and drawing from the discussions and summaries provided by the EVOSTC Herring Planning Committee, we refined hypothesis testing to two prioritized theories that we conclude should be examined first and that can be tested using existing, compiled data:

1) The spatial structure of the PWS herring stock that functions to maintain recruitment to the adult population has been compromised; spatial diversity has been decreased resulting in a negative impact on stock building. This hypothesis has been termed the "broken stock" theory.

2) Same as 3) above and now termed the "predator pit" theory.

In reformulated and prioritizing the key hypotheses tested, we did not intend to discount three of the original hypotheses (1, 2 or 4). However, we need additional data, expert input, and model structure to test these and have therefore focused our first year efforts on the two hypotheses listed above.

Work Performed:

A generic spatial modeling framework for the herring has been developed and implemented as a Visual Basic module extension to EASy-GIS via the software's application programming interface. A more complete description of the model is available via the following link (http://smbay.usc.edu/pws/media/WorkingDoc01_Model+Framework.pdf), but in a nutshell two simulation programs are being developed to model Herring population dynamics in the Alaska Prince William Sound: a 1-D model and a 4-D model. Both models operate as plug-ins to the Environmental Analysis System (EASy), and are designed to address questions about possible stock improvement strategies.

The one-dimensional model describes the population dynamics of all herring within the Sound. We have worked on both the growth equations of herring and on the equations describing the predation of juveniles by larger fish (assumed to be largely Pollock). Both sets of equations are nearly finished, and should be completed by the end of September. The growth model is based upon Dr. Kiefer's salmon model and is similar to the model that has been developed by Megrey and his collaborators. With regard to the juvenile predation model, we are most excited by the fact that the system of equations produces 4 year cycles in year class strength that are similar to the oscillations that occurred prior to the 1989 oil spill. We do not yet know if these cycles disappear when the herring population is trapped in a low-density condition. We have pasted a schematic of the growth and survival model below (left hand panel).

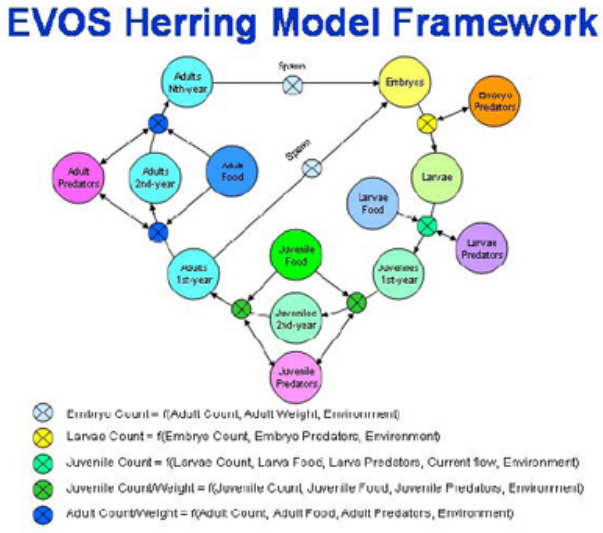
The 4-D model, which is a metapopulation model, now provides a home for:

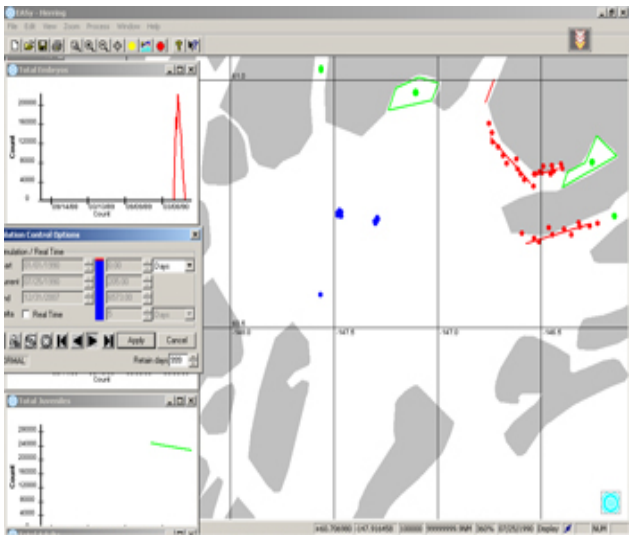
- the growth of year classes of herring as a function of temperature and food availability
- the survivorship of these year classes as determined by predation upon juvenile and adult fish; predation rates (including fishing mortality will vary spatially)
- the movement of schools of adult herring to over-wintering sites within the Sound; the decision to move to a given site is determined by a majority "vote" of individuals

within the school. The voting of individuals within the school is a function of their memory of where they spent the previous winter.

- the movement of schools of adult herring from the over-wintering site to the spring spawning grounds
- the joining of juveniles with adult schools is determined by the location of the bay and the location of the feeding grounds of adult schools

No further work will be done on the spatial model until the one-dimensional model is fully operative. A screen shot of this model is shown in the right hand panel below. An early prototype of this simulation model was demonstrated using EASy at a project briefing at the recent The Alaska Marine Science Symposium. No further work will be done on the spatial model until the one-dimensional model is fully operative.





Future Work:
During the next 2 quarters we will complete the prototype one-dimensional herring model, and tune our 1D-herring model to our database, which will continue to be collected and imported into our geographic information system. Any suggestions that we receive during our workshop in Cordova will be evaluated and if appropriate entered into the model. We will then proceed as planned and as described in our proposal to complete development of the 3-D (spatial) model

Coordination/Collaboration:
We held a workshop from May 28 through May 30 at the University of Southern California with our consultant, Evelyn Brown, and Herring Restoration participants Michael Schlei and Rob Bochenek. This workshop focused on co-coordinating our efforts in EVOS PWS herring database, and identifying how this database can support development of the herring model. In addition we have:

1. established a FTP-site at USC for the posting of datasets by collaborators (ftp://128.125.173.225). In parallel, Web access to SEA project data archives recently transferred to EVOS was set up by Michael Schlei (http://www.evostc.state.ak.us/herringdata).
2. contacted several holders of relevant herring and oceanographic survey data:
3.
    - Evelyn Brown, for a definition of portions of the SEA dataset and pointers to other survey databases of importance.
    - Shelton Gay, for additional SEA broadscale and nearshore survey datasets.

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- Steve Moffit & Rob Bochenek for the ADFG herring survey data.
- Richard Thorne (PWSSC), for the herring adult and juvenile acoustic survey data.

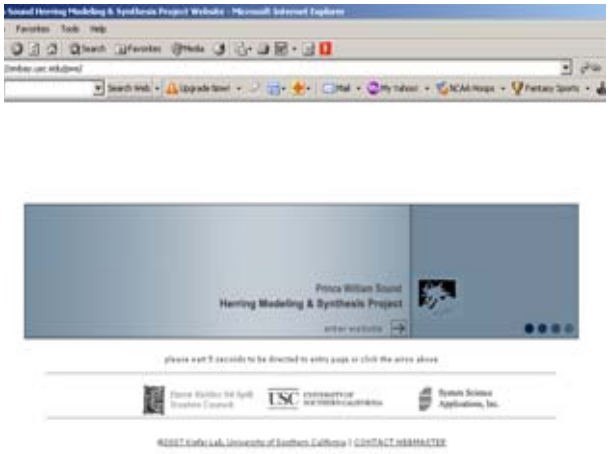
All datasets provided (i.e. mainly SEA data but also summaries of acoustic survey data from Thorne) have been downloaded, and carefully inspected. These data invariably take the form of diversely structured flat files, generally lacking metadata to assist with interpretation of data fields. Where necessary, data providers have been approached for further clarifications. On the recommendation of Brown, oceanographic data from the IMS/UAF online archive (http://www.ims.uaf.edu/ims-research/dataarchives.html) have also been acquired.

4. Compilation of ancillary data layers for Prince William Sound and adjoining region:
   - Acquisition and processing of bathymetric soundings data for PWS from NOAA-NOS (http://oceanservice.noaa.gov/dataexplorer/welcome.html) into a synoptic bathymetric vector file for use with GIS.
   - Acquisition of a series of SST satellite imagery data from NASA PoDAAC (http://poet.jpl.nasa.gov).
   - Acquisition of NOAA nautical charts for the region in both raster (BSB) and vector (ENC) formats.
   - Sequence of shapefiles provided by Brown showing the location and extent of herring spawn.

Data-related work for this project in the next quarter will include:
- Acquisition of outstanding datasets from remaining data providers (ADFG, PWSSC).
- Organization and assimilation of datasets into a relational database management system. This task will involve some considerable effort given the number of data files involved their diverse format and the general lack of interpretative metadata.

Community Involvement/TEK & Resource Management Applications:
During either October or November, 2007, Dr. Kiefer and consultant Vince Patrick will present our initial results of data collection and model development to the fishery and scientific community in Cordova. We will also invite marine scientists who are not living in Cordova to this meeting once we determine the date.

Information Transfer:
Our herring modeling project Website is now complete. The figures below illustrate the appearance and basic layout of the site, which can be accessed via the following link http://smbay.usc.edu/pws/ .



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The *Overview* and *Approach* sections provide descriptive information about the project, a statement of the problem of herring in PWS and the rationale behind and concept for the data synthesis and modeling work central to this project. The *Partners* and *Contacts* pages provide a description of the various collaborators, their specific roles in the project, and their contact information. The *News* and *Activities* sections summarize the status of ongoing work and upcoming activities. The *Outputs* section is a key area of the site, providing access to developed GIS applications, model outputs and other data products developed by the project. From here one can also access project presentations, publications, reports and other relevant documentation. The *Links* and *Feedback* pages provide pointers to other relevant information on the Internet and a means of communicating directly with us.

We have also produced quarterly electronic newsletters that will be circulated to groups and individuals interested in the PWS restoration work. Our distribution list is limited to Herring Project participants, but we will gladly expand it if the EVOS Trustee Council wishes. The basic design of the newsletter is depicted below: In addition Dr. Kiefer that a graduate course on the modeling of herring dynamics within the Department of Biological Sciences at USC. During this semester course, students collaboratively develop, analyze and explore modeling approaches using the PWS Herring as a case study. Six research papers and associated models have been submitted by the students. Drs. Kiefer and Patrick will gladly teach a similar course to PWS stakeholders in Alaska and Washington states.

Finally, Dr. Tsontos and consultant Dr. Evelyn Brown (Flying Fish Ltd.) attended The Alaska Marine Science Symposium held in Anchorage from the 20-24 January.

1. Tsontos presented a paper during the conference poster session of work completed under our previously funded by EVOSTC project "Alaskan Groundfish Feeding Ecology: An OBIS Information System" project (FY04: 040710).
2. Both attended and Dr. Brown was involved in the Herring Steering Committee meeting held on 1/23. This was followed by a briefing session on the herring modeling project for EVOS committee members and other PIs held later that afternoon. Presentations were made by both Tsontos and

Brown, the intent being to provide an overview of project objectives and approach with a view to informing, soliciting inputs and fostering collaboration with other those involved in PWS herring conservation and research efforts. The briefing concluded with a brief demo of a prototype spatial simulation model of herring life history dynamics within PWS implemented within EASy-GIS.

3. During the course of the conference, every opportunity was taken to meet with individual herring PIs to discuss their work and explore possible collaboration between projects. Particular emphasis was placed on talking to potential providers of survey data most relevant to the modeling activities, understanding the scope of their datasets and making appropriate arrangements for data access. In discussing with the EVOSTC Systems Administrator, Mike Schlei, it was also agreed to collaborate wherever possible on herring data assimilation activities.

Budget: There is no need to change our budget.

Please submit reports electronically in ProjectView or by email to mandy.migura@alaska.gov. Also, please be sure to post your annual report on your own website, if you have one.

We appreciate your prompt submission of your annual report and thank you for your participation.