Update Report
Period: 2/1/2012 - 1/31/2013

Rensel, Jack

Project: R/LME/N-6 - *Fish Aquaculture Simulation Model and GIS: Validation and Adaptation for Government Management Use*

:: STUDENTS SUPPORTED

No Students Reported This Period

:: CONFERENCES / PRESENTATIONS

Management Tools and Modeling of Fish Farm effects.

Marine Net Pen Science Forum. Presented by Northwest Fisheries Science Center (NOAA) and the Washington Department of Ecology. Lacey, WA January 10, 2013.
ftp://www.ecy.wa.gov/sea/NET%20PEN%20FORUM%20JAN%2010%202013/
, public/profession presentation, 130 attendees, 2013-01-10

:: ADDITIONAL METRICS

K-12 Students Reached:	**Acres of degraded ecosystems restored as a result of Sea Grant**
Curricula Developed:	**Resource Managers who use Ecosystem-Based Approaches to Management:**
Volunteer Hours:	**HACCP - Number of people with new certifications:**
Cumulative Clean Marina Program - certifications:	

:: PATENTS AND ECONOMIC BENEFITS

No Benefits Reported This Period

:: TOOLS, TECH, AND INFORMATION SERVICES

No Tools, Tech, or Information Services Reported This Period

:: HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

:: ADDITIONAL MEASURES

Safe and sustainable seafood

Number of stakeholders modifying practices
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

Number of fishers using new techniques
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

Sustainable Coastal Development
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

Coastal Ecosystems
Actual (2/1/2012 - 1/31/2013) :
Anticipated (2/1/2013 - 1/31/2014) :

:: PARTNERS

Partner Name: American Gold Seafoods - Icicle Seafoods Inc., type: industry, scale: regional
Partner Name: Department of Fisheries and Oceans Canada, type: government, scale: federal
Partner Name: NOAA National Ocean Service, type: government, scale: international
Partner Name: University of Washington School of Oceanography, type: academic, scale: regional

:: IMPACTS AND ACCOMPLISHMENTS

Title: **Application of Salish Sea circulation model to AquaModel aquaculture siting and effects software system.**

Type: accomplishment
Description:
Relevance: Marine biological models for aquaculture siting and impacts are dependent on physical circulation data to transport water through the modeled domains. Most aquaculture models rely on single point circulation data (current meters) or gross estimates of water movement such as flushing rate calculations. These data sources are of limited use in development of accurate models of "far-field" (widespread) aquaculture effects or carrying capacity estimates, as well as for use in aquaculture model validation studies.
Results: Using Washington Sea Grant funds and extensive in kind contributions, the AquaModel team has adapted extensive Salish Sea circulation model output provided by Professor Parker MacCready of the University of Washington School of Oceanography. The un-gridded model output was modified to run within the gridded domain field of AquaModel and is presently being tested as an alternative to current meter data sources. Agency and other potential users contacted have agreed that it would be useful to have a means for non specialist users to view and conduct basic analysis of currents in the Salish Sea that AquaModel could provide as an easy to use "viewer" software product.

Recap:
Sophisticated and powerful Salish Sea Circulation model data have been adapted to run with an easy-to-use aquaculture siting and impact measurement software tool known as AquaModel.

Comments: *none*

Related Partners: University of Washington School of Oceanography, American Gold Seafoods - Icicle Seafoods Inc.
Title: **Computer model software enhancement to validate simulation of fish farm benthic effects**

Type: accomplishment
Description:

Recap:*none*

Comments: *none*

Related Partners: Department of Fisheries and Oceans Canada, NOAA National Ocean Service

:: PUBLICATIONS

No Publications Reported This Period

:: OTHER DOCUMENTS

No Documents Reported This Period

:: LEVERAGED FUNDS

No Leveraged Funds Reported This Period

2012 Progress Report to Washington Sea Grant: 2012

Project : R/LME/N-6 - *Fish Aquaculture Simulation Model and GIS: Validation and Adaptation for Government Management Use*

Principal Investigator: Jack Rensel Ph.D. System Science Applications Inc.

Project Starting Date: October 2012 **Reporting Date:** 9 February 2013.

Because this project just began a few months prior to this report, we have only begun striving to achieve the project goals but have made progress. To recap, project goals center around formal validation of an aquaculture siting and effects simulation model that has been produced in part from federal agency support and is being shared presently with agencies such as NOAA in different regions of the U.S. Model validation is an essential and difficult component of any coupled hydrodynamic and biological model and in this case focuses on sea bottom and concurrent water column effects of aquaculture. The model may be used by non-technical users or those with advanced skills. The following summarizes progress to date:

AquaModel software produces graphic and data rich simulations of the probable effects of floating fish farms, both adverse or beneficial, and of marine sediments and water columns. The goal of this project is to validate *AquaModel*'s performance in performing these tasks using two or more sets of specialized data collected at fish farms by government or their contractors. In order to achieve this goal, it was necessary to design and build a new software sub module of the program to input the exact spatial and temporal changes in fish culture that occurred at existing fish farms where data were collected and published. Previous to these changes, the virtual fish were grown in cages in the model but were not subject to the real world operations that occur at fish farms such as transfer among pens, accounting of variable mortality, adjustment of feed rates or volumes, stocking of new fish in empty cages, and removal or harvest of fish. Now these events can be made on any time or spatial scale using a spreadsheet input system. To accompany these improvements, instructions for the system have been written to instruct user groups in the use of this new system. The system is being tested in one of our primary benthic-effects study site, in British Columbia, where appropriate data are available for model validation through cooperation with Canada Fisheries & Oceans.

During the past several months we worked closely with a Canadian Department of Fisheries and Ocean scientist to obtain, explore and begin coding extensive field data for a net pen site that was closely monitored for benthic effects in British Columbia. There is an excellent published record about this site but we needed further detailed information to be able to use the site for model validation. We now have obtained most of the data, configured and coded it for entry into *AquaModel* software for all the types of daily events that occur at fish farms as described above. A month-long acoustic Doppler current meter record from the site was also provided and configured for use in model validation. This effort should be well along by early spring 2013 and generating data such as sediment total organic carbon deposition rates to be compared with measured sediment sulfide data and predicted TOC rates from another software program known as DEPOMOD that is used without a sediment resuspension module in some cases. Our initial Sea Grant proposal contains snapshot images of what this will look like, we do not repeat those figures here.

Another aspect of this study has been to begin to utilize regional ocean circulation modeling data to provide the physical transport data for *AquaModel*. To this end, we have collaborated with Professor Parker MacCready of the University of Washington School of Oceanography. Professor MacCready has graciously provided us with a year's worth of Salish Sea Model circulation data from his regional ocean model (ROMS) efforts. We then built a software modification to use the data that converted and interpolated results from the unstructured (variable) grid of ROMS to the structured (Cartesian) grid used in *AquaModel*. The voluminous data (2TB per year) was then preprocessed using a new *AquaModel* flow field utility and testing of results in subareas of Puget Sound including Port Angeles Harbor has commenced.

Figure 1 illustrates a single time snapshot of thousands in the sequence for Port Angeles Harbor, site of an existing fish farm that has operated there for about 30 years. Figure 1 only shows currents flowing, in this case at 8 meters depth and near slack tide. The phase of the tide explains why currents are stronger inside the harbor vs. outside, where current velocity is usually stronger.

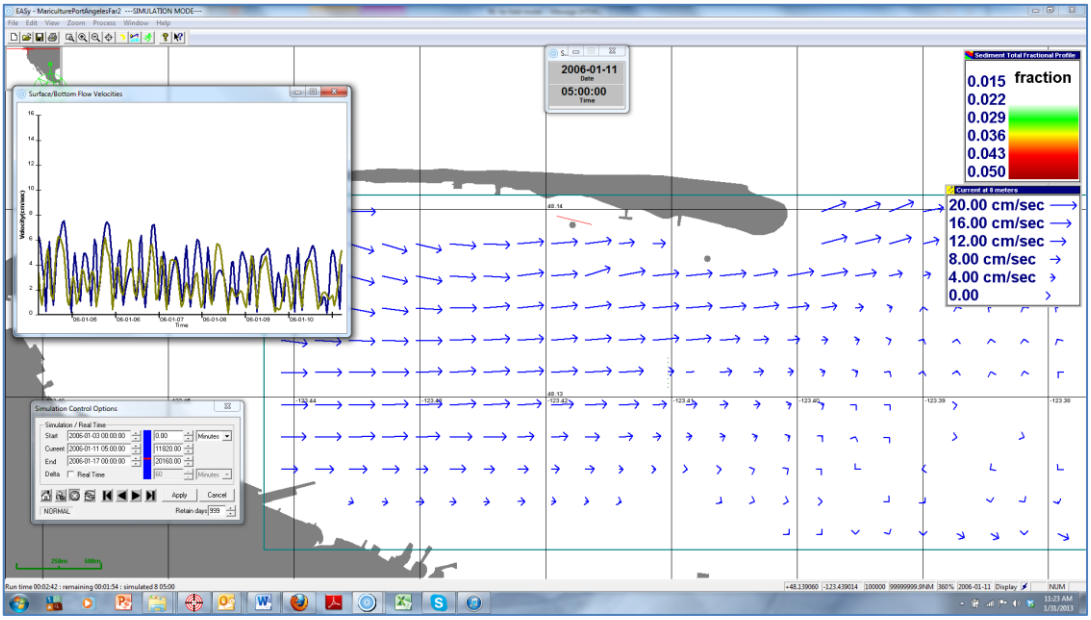

Figure 1. Screen print of one time step in a simulation of currents in Port Angeles Harbor using *AquaModel* simulation software with University of Washington Salish Sea ROMS circulation data powering the water transport. Far field circulation data has never been used before in Puget Sound aquaculture modeling in the past and promises to be a useful addition to toolbox of methods available to agencies and industry.

Figure 2 is a subset of Figure 1, but is zoomed in on the existing fish farm in the northern part of the bay near Ediz Hook as explained in the figure legend. Figure 3 is the same time step, but with most of the XY plots hidden and zoomed in further to show the waste particle trajectory on their initial pathway to the seabottom. Additional movement across the seabottom known as resuspension, is not shown here for the sake of simplicity.

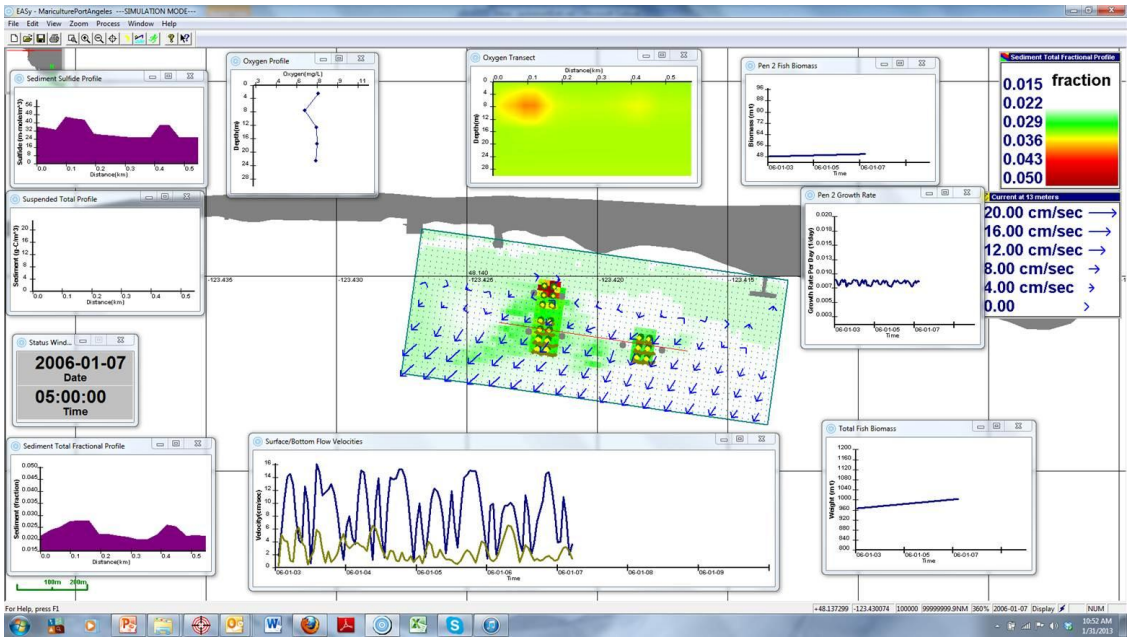

Figure 2. ***Aquamodel*** **with a portion of Port Angeles Harbor where an existing fish farm is modeled with several XY plots from top left clockwise showing sediment sulfide horizontal profile, vertical water column oxygen profile, horizontal water column oxygen profile, Pen 2 fish biomass, Pen two fish growth rate, total all pens fish biomass, surface and bottom velocity plot, sediment total organic carbon fractional profile, and suspended total organic carbon profile, all of these at one single snapshot in a continuous movie playback that the model provides.**

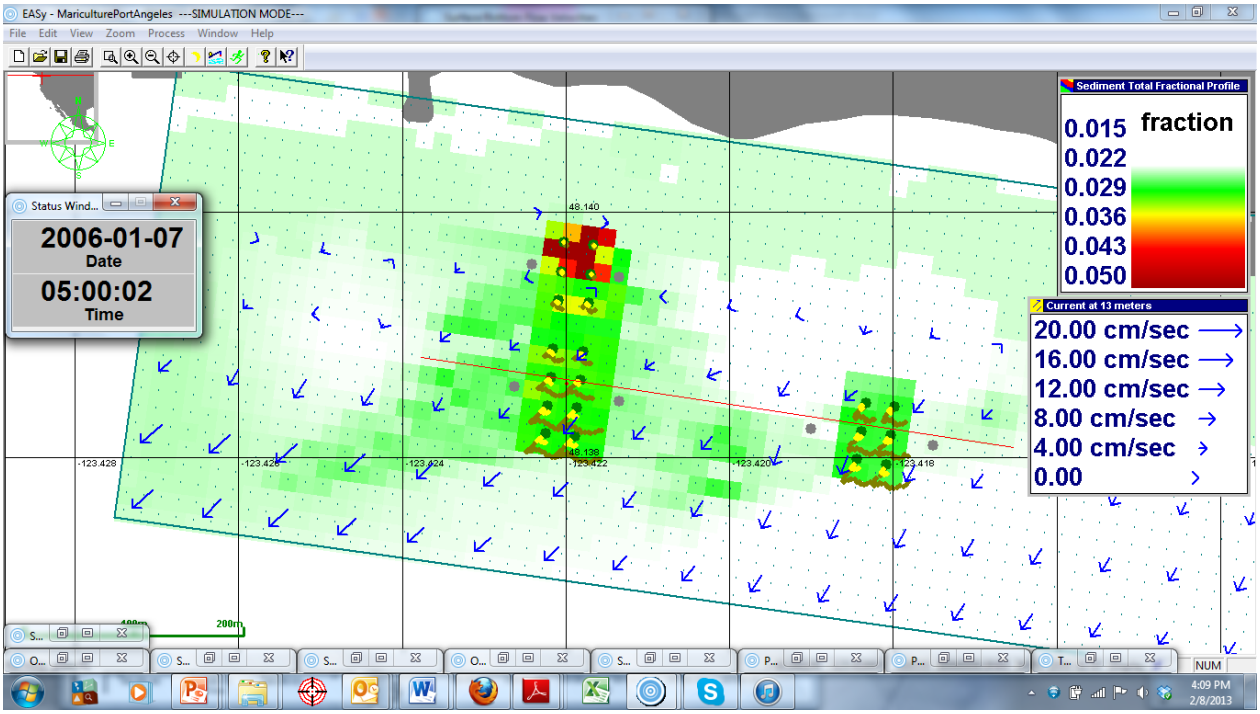

Figure 3. Close up of portion of Figure including total organic carbon fraction with background about 2% and modest enrichment around pens except in one shallow area. Current vector arrows indicate changing of the tide. Waste tracks from each of the 14 cages on the left and 6 cages on the left include fish fecal and waste feed streams, colored differently.

Other activities:

Coordination and planning for work to be done using the Gulf of Maine *AquaModel* studies of the University of New Hampshire open ocean aquaculture study site data. Professor David Fredriksson of the U.S. Naval Academy has installed new *AquaModel* software and is configuring it to address aspects of the project discussed in our initial Sea Grant proposal.

Data to be used in validation of the water column effects module of is also being assembled from prior Washington Dept. of Ecology NPDES monitoring work. The data is being inspected and tested for quality assurance and the cages to be simulated configured within *AquaModel*. Bathymetry, site specific tidal current information and fish stocking/feed rate data has been assembled to allow testing of the model's ability to simulate dissolved oxygen use by the fish, as well as the resulting plume of dissolved inorganic nitrogen.

Difficulties encountered, anticipated solutions:

One component of the project proposal and plan not yet initiated is the collaborative testing of the *AquaModel* benthic module with Eastern Canadian data as described in our proposal. The collaborators have not been available yet, but we are making arrangements for alternative sites, should the work in that area prove not be feasible. Another component involving *AquaModel* benthic application to the NE U.S. in the Gulf of Maine has been reconfigured to address water column aspects instead of sea bottom effects as the available sediment organic content data was not as robust as a collaborator thought and fish feed data and fish biomass data are not yet available. We may continue to pursue this portion of the study or elect to shift focus to the performance of *AquaModel*'s NPZ (nitrogen – phytoplankton – zooplankton) module over an entire year. Team member Professor Dale Kiefer's initial analysis of the performance is very good (Figure 4) but this was done with the excellent data powering *AquaModel* for the Gulf of Maine (provided by team member David Fredriksson and colleagues) and with a software modeling package known as *Mathmatica* that is used to create and link formulae for *AquaModel* code writing. Good performance here in the Gulf of Maine is remarkable as conditions vary widely over the seasons vs. other locations where the model is being applied in the tropics where conditions are relatively static. The NPZ submodel remains to be tuned in more detail to correct the amplitude of effects.

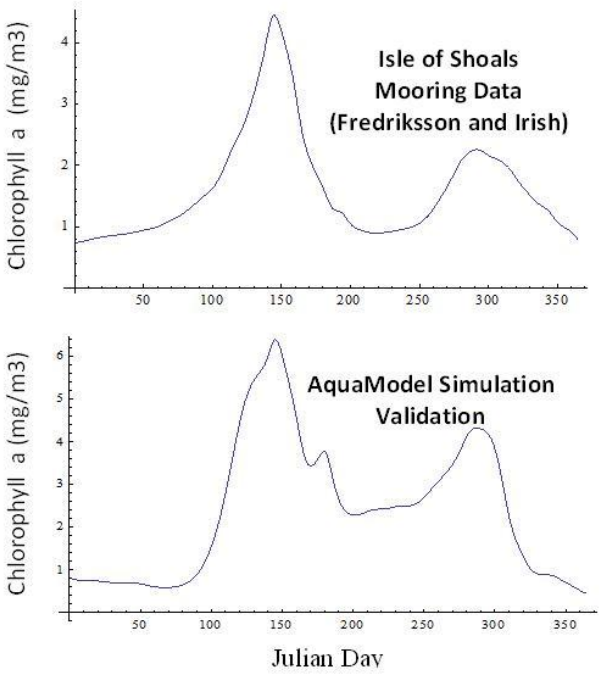

Figure 4. Phytoplankton measured vs. modeled NPZ submodel results.