Update Report

Period: 2/1/2014 - 1/31/2015

Project: R/LME/N-5 - *Planning for sustainable shellfish aquaculture in complex multiple use environments: Determining social and ecological carrying capacity for south Puget Sound, Washington*

STUDENTS SUPPORTED

No Students Reported This Period

CONFERENCES / PRESENTATIONS

PCSGA/National Shellfisheries Association meeting, Vancouver, WA, public/profession presentation, 275 attendees, 2014-09-22

Salish Sea Ecosystem Conference, Seattle, WA, public/profession presentation, 100 attendees, 2014-05-01

National Shellfisheries Association meeting, Jacksonville FL, public/profession presentation, 400 attendees, 2014-04-01

Sea Grant facilitated workshop/seminar to present study findings to the general public and stakeholders,, SG-sponsored, 150 attendees, 2014-12-08

ADDITIONAL METRICS

P-12 Students Reached:	0	**P-12 Educators Trained:**	0
Participants in Informal Education Programs:	0	**Volunteer Hours:**	0
Acres of coastal habitat protected, enhanced or restored:	0	**Resource Managers who use Ecosystem-Based Approaches to Management:**	20
Annual Clean Marina Program - certifications:	0	**HACCP - Number of people with new certifications:**	0

ECONOMIC IMPACTS

Description	Patents	Market Impacts ($)	Non-Market Impacts ($)	Businesses Created	Businesses Retained	Jobs Created	Jobs Retained
• Non-market impacts --	0	0	0	0	0	0	0

assisting resource managers with decision marking regarding shellfish aquaculture

SEA GRANT PRODUCTS

Description	Developed?	Used?	ELWD?	Number of Managers	Names of Managers
Ecopath models of South Puget Sound in 2970 and 2012.	Yes	Yes	No	0	
Farm Aquaculture Resource Management (FARM) model for shellfish in Puget Sound.	Yes	Yes	No	1	Grower, Bill Dewey, Chuckanut Shellfish

HAZARD RESILIENCE IN COASTAL COMMUNITIES

Name of coastal community	County	Number of resiliency trainings / technical assistance services *provided*	Was community hazard resiliency improved (e.g., via changes in zoning ordinances) ?
		0	Yes

ADDITIONAL MEASURES

Number of stakeholders modifying practices: 0

None

Sustainable Coastal Development

# of coastal communities: 0
None

PARTNERS

Partner Name: Arcadia Point Shellfish Co., type: Industry and Business, scale: Local
Partner Name: Baywater Shellfish Farm, type: Industry and Business, scale: Local
Partner Name: Calm Cove Oyster Co., type: Industry and Business, scale: Local
Partner Name: Chelsea Farms
Partner Name: Longline Environment, LLC
Partner Name: Madrone Environmental Services
Partner Name: Nisqually Indian Tribe
Partner Name: Taylor Shellfish Farms, type: Industry and Business, scale: Regional
Partner Name: Washington Department of Ecology
Partner Name: Washington State University Social & Economic Sciences Research Center

IMPACTS AND ACCOMPLISHMENTS

Title: **Washington Sea Grant investigates social and ecological carrying capacity for shellfish aquaculture**

Type: accomplishment

Description:

Relevance: Washington is the nation's leading producer of bivalve shellfish, with harvests of about 40,000 metric tons annually, and South Puget Sound is a major growing area. The region also is experiencing rapid development, which has created conflicts between shoreline residents and shellfish growers and the need for tools and information to inform regional planning and management of sustainable shellfish culture.

Response: Funded through a national strategic initiative, Washington Sea Grant-supported researchers are conducting an evaluation of South Puget Sound's shellfish production and ecological and social carrying capacity. The research team is applying comprehensive farm- and ecosystem-scale models (e.g., FARM, EcoWin) to help shellfish farmers and harvesters, resource managers, and other interested parties identify, evaluate, and account for social and environmental considerations in shellfish aquaculture development.

Results: Researchers analyzed farm production records, shellfish species metrics, and aquaculture-related policies and regulations, and they completed a detailed review of regional industry constraints and incentives. They also examined nitrogen removal and natural shellfish recruitment. Information from a variety of sources has

been compiled and incorporated into the models, which also build upon and complement ongoing and recently completed efforts elsewhere in the region. Model outputs assist in simulating and predicting future biomass, nutrient, and dissolved-oxygen conditions for a wide range of farming and harvest scenarios. All findings have been presented to stakeholders as completed.
Recap:
Recap: Washington Sea Grant-supported research investigates ecosystem conditions and perspectives—including human dimensions—that determine South Puget Sound's carrying capacity for shellfish aquaculture.
Comments:
Primary Focus Area – LME (SSSS)
Secondary Focus Areas – COCC (SCD)
Associated Goals: Support conservation and sustainable use of living marine resources through effective and responsible approaches, tools, models, and information for harvesting wild and cultured stocks and preserving protected species. (SSSS Industry)
Assist coastal communities and marine-dependent businesses in planning and making decisions that provide local and regional economic benefits, increase resilience, and foster stewardship of social, economic and natural resources. (SCD Inter-relationships)
Partners:
Arcadia Point Shellfish Co.
Baywater Shellfish Farm
Calm Cove Oyster Co.
Chelsea Farms
Longline Environment, LLC
Madrone Environmental Services
Nisqually Indian Tribe
Taylor Shellfish Farms
Washington Department of Ecology
Washington State University Social & Economic Sciences Research Center
Related Partners: *none*

PUBLICATIONS

Title: **Ecopath models of South Puget Sound in 1970 and 2012.**
Type: Workshops, Proceedings, Symposia Including Highlights/Summaries of (please note: document number reflects the year the proceedin Publication Year: 2014
Uploaded File: SPS_Ecopath_Results_Ap....4.pdf
URL: *none*
Abstract:
1970 and 2012 Ecopath model will provide comparative frameworks for identifying knowledge gaps and identifying baselines, targets and limits for the ecosystem in the future.

•SPS Ecosim model will examine historic, current, and potential effects of shellfish harvest and aquaculture. 1970 is the staring point for simulations of the past as a

framework for forecasting after 2012
•SPS Ecosim will examine potential ecosystem feedbacks from different shellfish management strategies
•Forecast likely ecosystem effects arising from bottom up forcing changes due to climate and regime shifts
Citation:
Preikshot, D, Hudson B (2014) Ecopath models of South Puget Sound in 1970 and 2012. Presentation to the Salish Sea Ecosystem Conference 2014, Seattle, WA.
Copyright Restrictions + Other Notes:
Journal Title: *none*

Title: **Ecological Carrying Capacity for South Puget Sound**
Type: Workshops, Proceedings, Symposia Including Highlights/Summaries of (please note: document number reflects the year the proceedin Publication Year: 2014
Uploaded File: SG_Shellfish_Carrying_....I.pdf
URL: *none*
Abstract:
Sea Grant Funded Research From a Shellfish Farming and Fisheries Perspective
Citation:
Pacific Shellfish Institute (2014) Ecological carrying capacity for South Puget Sound. Presentation to the Shellfish & the Environment_Conference, December 8.
Copyright Restrictions + Other Notes:
Journal Title: *none*

Title: **Determining Social and Ecological Carrying Capacity for South Puget Sound**
Type: General Public and Advisory Reports, Fact Sheets, Posters Publication Year: 2014
Uploaded File: *none*
URL: *none*
Abstract:
The goal of this project is therefore to provide tools and information that assess the ecological and social capacity of south Puget Sound to support shellfish aquaculture.
Citation:
Determining social and ecological carrying capacity for south Puget Sound (2014) Pacific Shellfish Institute, 1 p.
Copyright Restrictions + Other Notes:
Journal Title: *none*

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

No Leveraged Funds Reported This Period

UPDATE NARRATIVE

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UPDATE NARRATIVE

WASHINGTON SEA GRANT PROGRESS REPORT, Year 2 -- for the period 2/1/2014 – 1/31/2015

PROJECT TITLE

NOAA Sea Grant Aquaculture Research Program: Planning for sustainable shellfish aquaculture in complex multiple use environments: Determining social and ecological carrying capacity for south Puget Sound, Washington

PARTICIPANTS AND AFFILIATIONS

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Teri King, Wash. Sea Grant Extension / (360) 432-3054 / guatemal@uw.edu

GOALS

To apply an expanded definition of carrying capacity to include interrelated and co-dependent elements of 1) physical, 2) production, 3) ecological and 4) social carrying capacities in south Puget Sound; and to provide tools and information, and develop recommendations for multi-use spatial or geographic planning for a wide range of user groups.

IMPACTS AND ACCOMPLISHMENTS

This section summarizes the status of project tasks for the reporting period, and required elements to be completed at the conclusion of the project. A project timeline is provided in Table 1.

Title: Objective 1 -- Model the effects of shellfish production on key ecological variables, and estimate the value of nitrogen removal

Type: accomplishment

Description: Substantial developments were made both in the Farm Aquaculture Resource Management (FARM) and EcoWin models (see Objective 2). A brief synthesis is given below.

Individual FARM models are now available using the AquaShell approach for Manila clam (*Venerupis philippinarum*), Pacific oyster (*Crassostrea gigas*), and Mediterranean mussel (*Mytilus galloprovincialis*). Work on the development of an equivalent model for geoduck (*Panopea generosa*) is underway, and will be supported by feeding and clearance rate experiments. See Table 3 in the project proposal for other data types being gathered to be employed in model development. Also, available to date are parallel model runs for Manila clams from a recently completed SK funded Samish Bay project. Figures 1 and 2 show example outputs of the individual models for Manila clams and Pacific oysters.

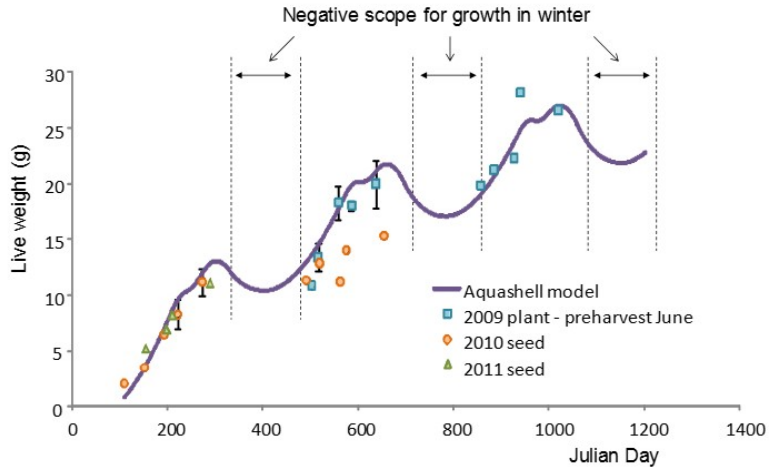

Figure 1. Manila clam simulation, validated for Puget Sound. The model simulates animal length, live weight, and the environmental effects of culture.

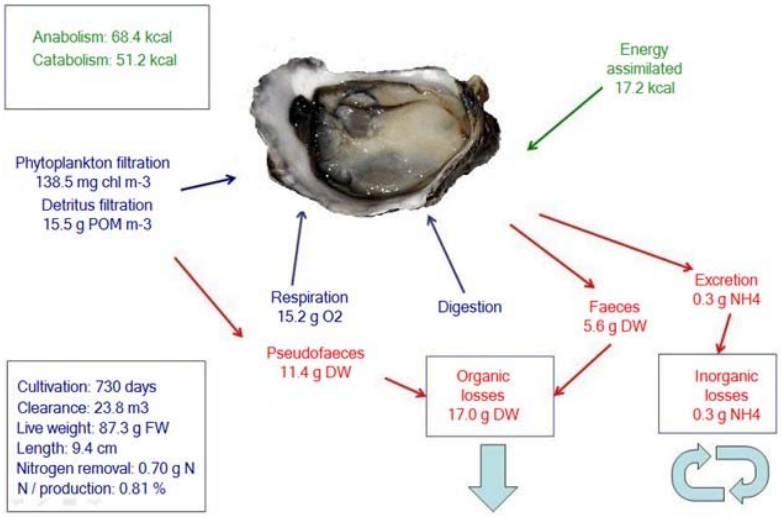

Figure 2. Pacific oyster simulation, showing the mass balance at the end of a two-year cultivation period. The model performs a full analysis of growth based on net energy balance, and allows for the quantification of nitrogen removal.

The integration of individual models into the FARM framework has been completed, and results for one farm in Puget Sound show good agreement with field data. We are currently working to identify specific farms in the study area for testing the application of these growth models. We have also been developing a model for the growth of sea lettuce (Ulva sp.) to simulate fouling and seaweed export from farms (Figure 3).

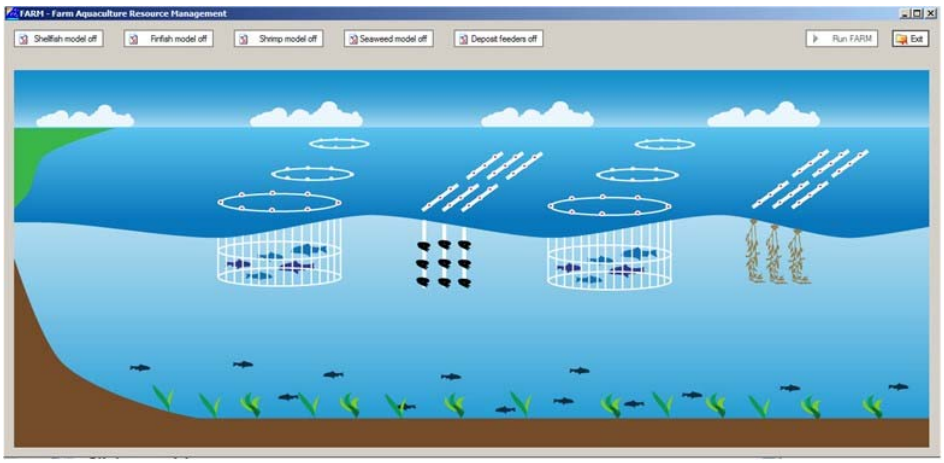

Figure 3. Screenshot of the FARM model (IMTA version for open water). Both the shellfish and seaweed components will be applied to South Puget Sound.

The FARM model now performs a full fractioning of settleable and suspended particles from shellfish culture, and allows a better understanding of the components that may be re-used in the water column, i.e. detrital particulate organic matter (POM) available for feeding of shellfish and other animals downstream of the cultivation area, and the biodeposits that organically enrich the sediment. In addition, research related to nitrogen removal and focusing on natural recruitment of shellfish was completed at sites in Budd Inlet in 2014. That work was expanded and enhanced with additional funding (WDOE) and continue through the end of the project.

Recap: FARM model runs were tested and reviewed by the project team.

Title: Objective 2, Task 1 -- Evaluate ecological carrying capacity at the ecosystem scale: model the effects of shellfish production on key ecological variables.

Type: accomplishment

Description: Continue EcoWin modeling and integrate FARM model outputs with available SPS modeling and WQ data. Considerable effort was expended over the last 12 months to obtain input from stakeholders on the locations of model box division boundaries, and to integrate WDOE modeling platforms with EcoWin. The proposal emphasized a user accessible modeling tool to forecast within a 10-yr window, shellfish production for south Puget Sound individual embayments, for varying cultivation densities and environmental effects. This work is integrated with Task 3, with a May to June 2015 completion date; and production of a guidance document as part of Objective 4.

The final box division layout currently being processed by WDOE is shown below (Figure 4).

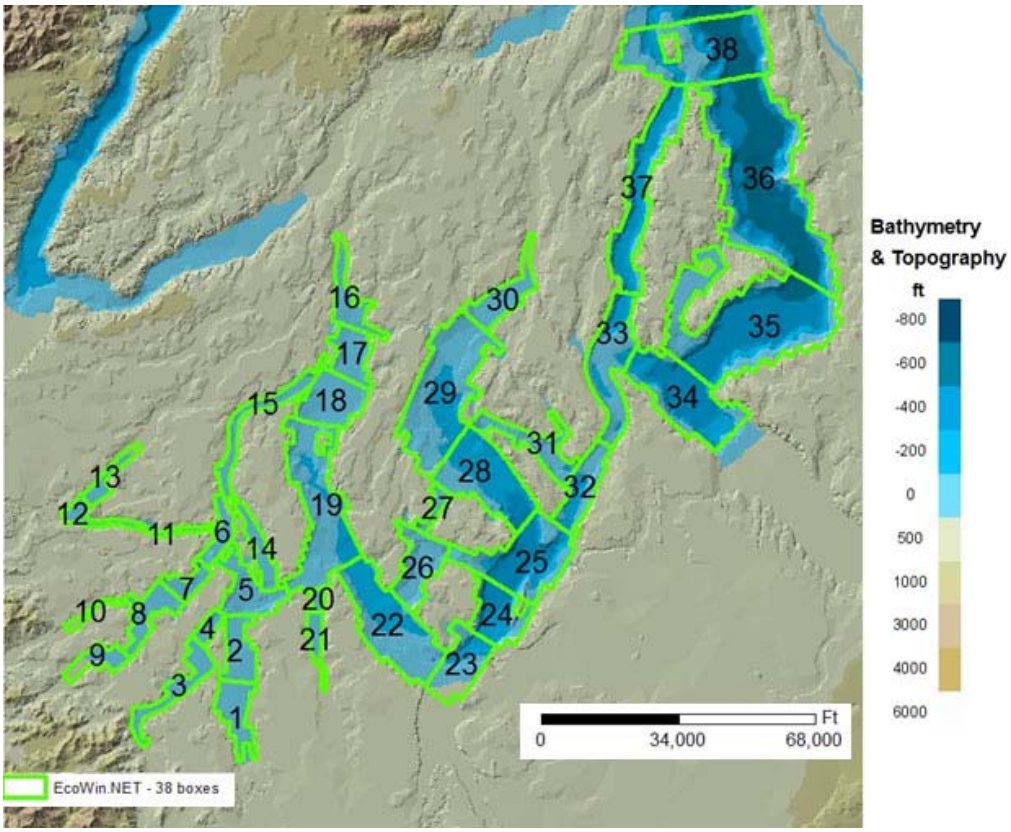

Figure 4. EcoWin model boxes (38 in total) defined for South Puget Sound.

This layout was defined through an initial review and data collection process based on the following:

1) Administrative region. The area of interest, SPS, has as administrative regions the counties of Kitsap, Thurston, Mason and Pierce, near the cities of Olympia and Tacoma. The WDFW basins were also included in the analysis.
2) Physical data. The South Puget Sound morphology, bathymetry and temperature were analyzed. Currents were considered based on the SPS hydrodynamic model, upon which the EcoWin model boxes were overlaid. Vertical stratification for the EcoWin model boxes will be evaluated by comparing surface and bottom temperature, salinity, and dissolved oxygen.
3) Aquaculture sites. The aquaculture sites together with the commercial shellfish growing areas were analyzed for the purpose of potential spatial aggregation.
4) Water Quality and Constraints. The water quality parameters used came from the literature, e.g. dissolved oxygen, and dissolved nutrients (forms of nitrogen, also integrated as dissolved inorganic nitrogen - DIN, and phosphorus). Other constraints such as watersheds for fresh water inflows, critical habitats, marine protected areas, wave exposure were used to delimit and verify the homogeneity of the boxes.

The analysis was executed in GIS, and the intermediate mapping and final draft proposal were circulated to local stakeholders. Replies, in some cases with substantial detail, were received from ten organizations.

The boxes shown in Figure 4 are expected to be further expanded into two vertical layers, to resolve water column stratification in the model. The water exchanges obtained through the application of the hydrodynamic model available at WDOE will be used to generate the physics needed to drive the system-scale modeling for aquaculture.

The EcoWin modeling framework has been extensively developed, and the full package will be made available to stakeholders as a Windows application for both 32 bit and 64 bit operating systems, fully compatible with the upcoming 2015 release of Windows 10. A screenshot of the model, in an application to Long Island Sound, is shown in Figure 5. Several feature enhancements are currently being implemented, including some GIS representations for an improved experience with respect to geographical model outputs.

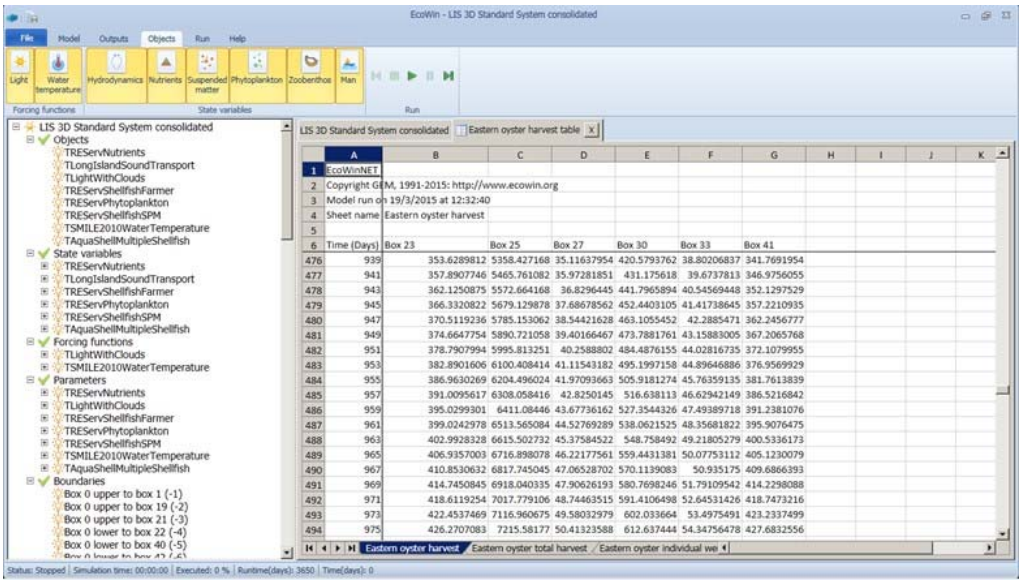

Figure 5. EcoWin.NET model screen showing example outputs from Long Island Sound (REServ project) after three years. The ribbon at the top shows the objects that are active in the model.

Recap: EcoWin model parametrization is in progress with full model runs pending.

Title: Objective 2, Task 2 -- Evaluate ecological carrying capacity at the ecosystem scale: integrate the results of ecosystem models with available water circulation and nutrient data/models for eutrophication management.

Type: accomplishment

Description: Susanne Bricker will take the lead and apply the output from Task 1 to complete the ASSETS assessment. The proposed approach was the development of a dynamic and forward looking predictive tool to assess different aquaculture scenarios. The proposal indicated ASSETS software could be applied by users to predict and/or compare water quality changes over time, with easily interpreted outputs. More work is needed to flesh out the nature of the final product. This task should be completed by mid-summer 2015.

Recap: Eutrophication analyses for SPS remains under development.

Title: Objective 2, Task 3 -- Evaluate ecological carrying capacity at the ecosystem scale: utilize the developed models to simulate the effects of shellfish production on other marine organisms.

Type: accomplishment

Description: Ecopath with EcoSim (EwE) modeling. Ecopath model parameterization is complete, and the model is operational for south Puget Sound biota based on 1970 and 2012 biomass and mortality characteristics. Results of the south Puget Sound Ecopath model were presented at the 2014 Salish Sea Ecosystem Conference in Seattle, WA (a pdf file of the presentation is available from PSI). To date, preliminary EcoSim runs forecasts of biomass changes for modelled species groups are available for a set of scenarios selected during stakeholders meetings and conversations. These scenarios include expansion of bivalve aquaculture by species farmed, examining the effects of a potential control fishery on 'nuisance' species and mandated increases to important habitat forming species groups like kelp and eelgrass. In addition, the project team has been collaborating with NOAA and the UW in central Puget Sound EwE modeling. Model outputs to date include several large scale graphics depicting biomass changes between 1970 and 2012 (Figure 6); future biomass condition simulations or scenarios for key ecosystem elements (eelgrass, kelp, phytoplankton); and model parameterization inputs.

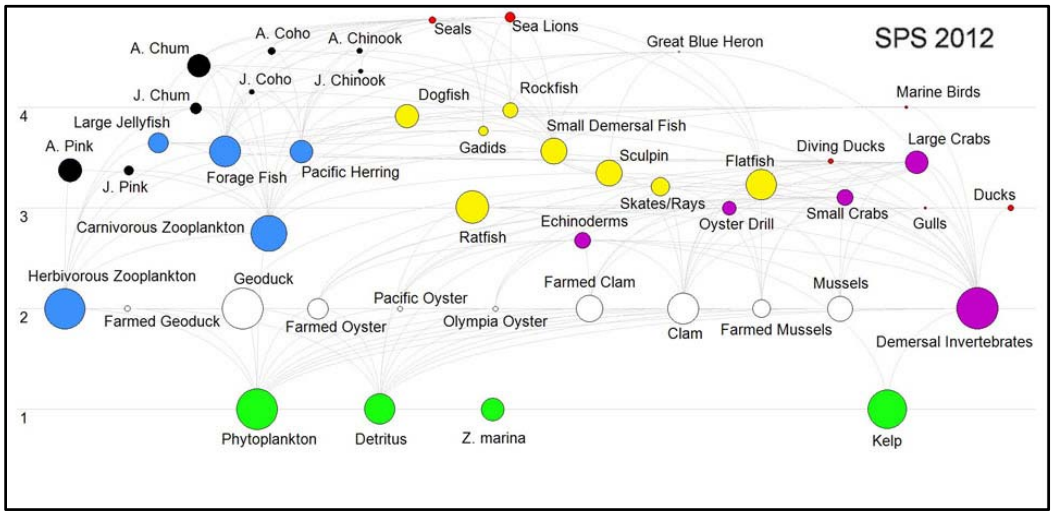

Figure 6. Graphic generated from Ecopath modeling software. Numbers on the left are trophic level. Lines indicate biomass flowing from prey to predators.

Detailed simulations were prepared and submitted in early March 2015. The results of this research will be described in a report that will be submitted to the PSI. It is also expected that two publications suitable for peer reviewed journals will be written soon after the end of the project. Still required are analyses and a narrative report describing refined simulations addressing future water quality and biological conditions for the scenarios selected last year, and other possible variations on those scenarios, and linking the EwE modeling with EcoWin. This work should be completed by early to mid-June 2015. A key output for this task will be production of a guidance manual for use of the models (see Objective 4).

Recap: Development and application of Ecopath and EcoSim models for South Puget Sound and presentation to stakeholders

Title: Objective 3, Tasks 1 to 3 - Review local priorities, planning documents, and policies and regulations; engage stakeholders from the SPS area in ecological carrying capacity modeling; and survey public values, attitudes, beliefs and behavior in relation to shellfish.

Type: accomplishment

Description: The bulk of this work was completed during the first two years of the project and described in the Year 2 progress report. Two of three stakeholder meetings focusing on EWE modeling were held in the second year, and a third meeting will be held late spring 2015. Additional survey information was also gathered from growers and others knowledgeable of SPS water conditions to refine the EcoWin model runs. Survey findings were presented at conferences listed in the previous section.

Recap: Presentation of survey findings to stakeholders and surveys of coastal communities

Title: Objective 4 -- Develop a methodology to use these models, regulatory and social data for multi-use spatial planning that includes shellfish aquaculture

Type: accomplishment

Description: Described in the attached proposal narrative. This work will be completed no later than August 2015.

Recap: Guidance manual and other deliverables remain to be completed.

Table 1. Revised Milestone Chart (March through August 2015)

Activity	M	A	M	J	J	A
FARM completion	X	X	X	X		
Geoduck feeding analyses		X	X			
EcoWin completion		X	X	X		
ASSETS modeling			X	X		
EwE completion	X	X	X			
Workshop presenting EWE results				X		
Review WSU survey findings	X					
Develop user guidance document				X	X	X
Progress report / Final report	X					X