**ATTACHMENT C** ***EVOSTC Annual Project Report Form***

Form Rev. 10.3.14

**1. Program Number:** *See,* Reporting Policy at III (C) (1).

12120114-128102

**2. Project Title:** *See,* Reporting Policy at III (C) (2).

Long-term Monitoring: Synthesis and Conceptual Modeling - Conceptual Ecological Modeling

**3. Principal Investigator(s) Names:** *See,* Reporting Policy at III (C) (3).

Dr. Tuula Hollmen

Suresh A Sethi (Collaborator)

Lisa Sztukowski (Research Associate)

**4. Time Period Covered by the Report:** *See,* Reporting Policy at III (C) (4).

February 1, 2015 to January 31, 2016

**5. Date of Report:** *See,* Reporting Policy at III (C) (5).

February 15, 2016

**6. Project Website (if applicable):** *See,* Reporting Policy at III (C) (6).

http://www.gulfwatchalaska.org/program-services/conceptual-modeling/

**7. Summary of Work Performed:** *See,* Reporting Policy at III (C) (7).

Conceptual ecological models synthesize information about complex systems into visual frameworks which promote understanding, communication and offer guidance to future research. Key to this process are clearly defined objectives, defined spatial and temporal boundaries, and decisions on the currency of the system (e.g. energy transfer) to ultimately produce a model structure. In the current reporting period, work has focused on four areas:

1. Publishing results from the first two years of method development and modeling, and developing manuscripts for additional papers.
2. Development of a framework and working groups for a suite of submodels to explore and represent key hypotheses relating to the components of our program: environmental drivers, pelagic, and nearshore.
3. Development of visual aids to represent ecosystem structure and monitoring efforts related to the program components.
4. Development of a framework to consider monitoring priorities and management relevance to assist long term programmatic planning efforts.

We continued to make progress on series of submodels which require the collaboration among the key program components: nearshore (Submodel 1), pelagic (Submodel 2), and environmental drivers (Submodel 4). The first manuscript based on conceptual modeling development for Gulf Watch Alaska program was published in Arctic (2015) and was based on Submodel 3. We presented a poster 'Mesoscale ecosystem processes in the Gulf of Alaska' at Alaska Marine Science Symposium on development of submodels. We are continuing to work with the pelagic group on Submodel 2, including

discussion on a conceptual spatial model and a structured framework to help integrate sampling efforts within their component. Summary of work for our suite of submodels follows:

Submodel 1: Key Trophic Linkages in Nearshore Northern Gulf of Alaska Ecosystem

The overall goals of the modeling effort are to 1) examine the impact of changes in invertebrate prey fields on consumers of interest [sea otters and Barrow's goldeneye] as measured by a suite of behavioral and demographic performance metrics, 2) provide semi-quantitative simulation models to forecast consumer population outcomes/effects on consumer performance metrics, 3) identify data gaps, and 4) prioritize research to fill data gaps. After reviewing the available methods used to create conceptual models (Bayesian Belief Networks, EcoPath models and the methods used by Sethi & Hollmen 2015) we decided to employ goal-specific Bayesian Belief Network for the nearshore submodel as it provides a suitable modeling framework that allows for the use of a combination of quantitative information and expert opinion. We have collaborated with the nearshore group to define clear objectives, decide site-specific and population-level spatio-temporal boundaries, and determined the model structure. The sea otter model framework has been built, and scenarios of interest will be run based on PI input. A similar model for Barrow's goldeneye will be constructed. Based on this work, we plan to develop a manuscript that examines the influence of changes in the invertebrate prey in Alaska nearshore systems on the response of both generalist consumers (sea otter) and specialist consumers (Barrow's goldeneye).

Submodel 2: Ecological Linchpin with Forage Fish Abundance

The conceptual submodel examines linkages among environmental indices, forage fish prey, a suite of selected forage fish species, and higher trophic species populations. Abundance and temporal distributions of forage fish such as salmon, capelin, sand lance, and herring provide a key trophic element in the Gulf of Alaska (GOA); thus forage fish can provide unique insights into food web dependencies and future management considerations. We have completed a draft model which is ready for expert input. The working group of experts has been identified.

Submodel 3: Top-down Control with Humpback Whale Predation

The pelagic team explored movements and distribution of humpback whales in Prince William Sound, represented in a conceptual model. Current understanding about the processes affecting herring-whale dynamics in the Northern GOA was explored in a submodel exercise rating properties of linkages in a zooplankton-herring-whale submodel system, including assessment of the state of knowledge, the strength of ecological impact, and the state of management or research attention devoted to a given component. This model framework has been published in Sethi & Hollmen 2015. Conceptual modeling proved to be an effective and efficient tool for synthesizing information about ecological systems and a transparent system for prioritizing components for future attention. This effort highlighted uncertainties about the mechanisms of energy movement in zooplankton-herring-whale system, and the potential importance of long-term effects of ocean acidification.

Submodel 4: Bottom-up Control with Environmental Forcing on Plankton Populations

Since winter of 2013, several large masses of warm, nutrient poor water have formed off the Western coast of the United States and Canada, including in the GOA. Nicknamed "the Blob", this warm water has coincided with changes in environmental forcing and plankton communities and abundance which

are critical to the survival of many larger predators. Understanding mechanisms of these bottom-up processes are key to predicting ecosystem changes. Thus we have combined the original intent of this submodel with the most current issues in the GOA. The bottom-up conceptual model continues to focus on plankton production and the various environmental conditions that are thought to act as drivers of primary and secondary production in the northern GOA, but will also explore potential effects of warmer ocean temperatures and associated environmental changes on primary production. The properties of system components, such as strength of interactions, spatio-temporal linkages, variability, and uncertainty will be quantitatively rated. We have produced draft models which are ready for expert evaluation.

In the first year of the program, we developed a parsimonious general conceptual model for the Northern GOA which visually linked components based on the knowledge and program PI expert opinion at that time. Visualizations categorized model elements into forcing factors, biophysical processes, and biophysical components. The spatial arrangement of elements indicated the spatial scale at which the model components operated, and linkages represented interactions in the conceptual model. Using expert input, we will re-evaluate and update the general model to demonstrate learning and highlight contributions by the Gulf Watch program during the first five years of the long-term monitoring program. The updated model will illustrate changes in the framework and strength of interactions within the ecosystem.

| Deliverable/Milestone | Status |
|---|---|
| **Objective 1.** Continue development of conceptual models. *To be met by January 2016* | In Progress: We continue development of submodels in collaboration with GulfWatch PI groups. |
| **Objective 2**. Continue development of interactive/data visualization tools. *To be met by January 2016* | In Progress: We continue development of interactive/data visualization tools and plan to use the nearshore submodel as the template. |
| **Objectives 3.** Attend annual PI meetings and Alaska Marine Science Symposium. *To be met by November 2015 and January 2016* | Completed: Tuula Hollmen and Lisa Sztukowski attended both the PI meeting and Alaska Marine Science Symposium (AMSS). A poster focusing on development of submodels was presented at AMSS. |
| **Objective 4:** Prepare modeling progress update for annual report. *To be met by February 2016* | Enclosed. Please see text section above. |

**8. Coordination/Collaboration:** *See,* Reporting Policy at III (C) (8).

A.

- The process of developing component submodels involves close internal coordination and collaboration within and among Gulf Watch program components nearshore (Sub-model 1), pelagic (Sub-models 2, 3), and environmental drivers (Sub-model 4).
- Submodels 2 and 3 focused on collaboration within Gulf Watch Alaska program and between Gulf Watch Alaska and Herring Research Program.

B. N/A
C. N/A

**9. Information and Data Transfer:** *See,* Reporting Policy at III (C) (9).

- Publication: Sethi, SA and Hollmen, TE. 2015. Conceptual Models for Marine and Freshwater Systems in Alaska: Flexible Tools for Research Planning, Prioritization and Communication + Supplementary Appendices (See Article Tools). Arctic 68(4): 422–434.
- Conference poster: Sztukowski, LA, Sethi, SA and Hollmen, TE. Mesoscale ecosystem processes in the Gulf of Alaska. Alaska Marine Science Symposium, Anchorage, Alaska January 2016

**10. Response to EVOSTC Review, Recommendations and Comments:** *See,* Reporting Policy at III (C) (10).

N/A.

**11. Budget:** *See,* Reporting Policy at III (C) (11).

Report attached. Report does not reflect all expenses incurred on the project; due to timing of invoicing with contracts which are in progress. The project start date was initially delayed due to delays in funding allocation.

**12. Research highlights**

- Published a novel framework for evaluating zooplankton-herring-whale trophic dynamics (Sethi & Hollmen 2015). Presented a poster describing mesoscale submodels at the Alaska Marine Science Symposium (Sztukowski, Sethi and Hollmen 2016).
- Constructed a Bayesian Belief Network model to explore scenarios of changes in nearshore prey base and impacts on higher tropic level consumers. This model framework is suitable for consideration of management approaches under different ecological conditions in the Gulf nearshore system.
- In response to emerging environmental conditions in the GOA ecosystem, incorporating current events and issues into structured models to forecast potential outcomes resulting from warmer ocean temperatures.