Terms of Reference

ESSAS Working Group on Bioenergetics

Ecosystem Studies of Sub-Arctic Seas (ESSAS)
January 2012

Introduction

A major goal of ESSAS is to predict the potential impacts of climate variability on the sustainable use of the sub-arctic seas. ESSAS has elected to employ a comparative approach to investigate which energy pathways appear particularly vulnerable to decadal and long-term climate change in each of the sub-arctic seas. The ecosystem response to climate change can be non-linear with thresholds, have complex interactions between species, and different species impacts from similar climate fluctuations. Reducing uncertainty about the future states of ESSAS ecosystems depends on knowledge of the response of the ecosystem to changes in climate and a quantitative ability to project future climate states. The first ESSAS goal of prediction requires a fundamental understanding of climate-biological interactions.

Goal

The main goal of the working group on bioenergetics is to gain knowledge and improved understanding on how climate change will affect the structure, functioning, and interactions among and within marine species groups. A key part of this work will be to quantify how climate change will affect the bioenergetics of key commercial species such as gadoids and clupeids and compare those effects across sub-arctic seas. Our specific objectives are to 1) evaluate how ocean temperature affects prey quality and nutritional value, and 2) how those effects propagate through the food web to influence fish bioenergetics in different sub-arctic seas.

Rationale

Just as climate change is expected to alter the distribution of commercially valuable fish species, the same forces will likely change the availability and quality of their prey. Different climatic states within an ecosystem have been observed to directly influence the composition of prey fields available to commercially valuable fish. These compositional changes can also have a direct effect on the quality of food available to fish. Simultaneous shifts in phytoplankton communities lead to changes in zooplankton phenology, changes in the energy content of specific prey types and changes in the availability of essential nutrients in prey. While much research has been focused on understanding how climate related changes in ocean temperature on fish growth and metabolism, much less effort has been directed towards the importance of food quality. Still, growth depends on the ability of fish to obtain energy with the least investment. We will combine data on temperature and prey quality in bioenergetic models to predict how climate changes will influence the bioenergetics in different ESSAS ecosystems. In particular we will focus on larval and juvenile fish, as these life stages are extremely sensitive to the consequences of reduced growth. By examining herring and gadoids we will be able to determine if high lipid fish will be constrained by climate change in the same way as low lipid fish. Our working hypothesis is that species with the highest routine metabolic rates will be more sensitive to climate impacts on prey quality and temperature than those with lower metabolic rates.

We expect to develop these ideas for Atlantic cod, walleye pollock, Atlantic and Pacific herring. The bioenergetic model we propose to use is a mass (or energy) balance model that is commonly referred to as the "Wisconsin model". Most of the parameters required for this model are available for our target species. We plan to implement this bioenergetic model into a mechanistic individual-based model that allows for detailed studies of feeding and growth, which allows for a direct comparison between observations and predictions. We will rely on other working groups for information regarding future physical oceanographic conditions. We plan to engage experts in the bioenergetics of zooplankton and fish to obtain estimates of future prey composition, distribution, and quality. Modelers will be engaged to run the models and determine how growth is influenced under different climate regimes with various assumptions regarding future prey quality. Comparisons will be made across ecosystems and species groups (i.e. gadoids versus herring).

Tasks

Acquire information on climate effects on prey composition, distribution, and quality including changes in energy content, variation in quality with developmental stage, changes in nutritional composition.

Acquire parameters necessary for constructing the bioenergetic models for herring and gadoids.

Acquire information on future physical environments relevant for herring and gadoids for all ecosystems to be compared.

Develop a suite of model outputs describing how growth and condition is affected under various combinations of prey quality and thermal regimes.

Compare model output across species and ecosystems

Implementation

The Working Group on Bioenergetics shall exist for a period of three years, beginning with January 2013 and ending January 2016.

The working group will consist of eight members, four of which will be numerical modelers currently working on climate effects on larval and juvenile fishes. The remaining four will be selected from the field of nutritional ecology and will be marine scientists engaged in understanding how climate change will affect fish condition and the quality of their prey.

Much of the work will be done between workshop meetings and we envision three workshop sessions to define the datasets, refine the analysis and compare results. The objective of the first workshop will be to identify the datasets available to the modelers and develop an agreement as to the details of the modeling effort. The objective of the second workshop will be to compare model outputs with empirical data and specify scenarios to be used for regional and inter-specific comparisons. The objective for the last workshop will be to present the final comparison and reach a consensus.

Expected Results

We expect to produce a series of papers establishing the hypothesis that climate-induced effects on prey quality will have significant impacts on the productivity of commercially valuable fish species.

Included will be a series of papers describing climate effects on prey quality and the subsequent impacts on gadoid and clupeiod growth in different ESSAS areas. These papers will contribute to a synthesis that examines the viability of our hypothesis.