# Project proposal for 2008/2011

***(Three pages only- additional information will not be considered by the Committee)***

**Project Title: Impacts and Vulnerabilities - Climate Impacts on Ecosystems**

**Proponents names: Dave Gillis and Georgine Pastershank**

**Affiliation: Department of Fisheries and Oceans**

**E-mail address:**
**Dave. Gillis@dfo-mpo.gc.ca**
**Georgine.Pastershank@dfo-mpo.gc.ca**

**Phone: 613 949-6829**
**Fax: 613 954-0807**

**Amount requested: $ 50K/yr for three years, 2008-2011**

**Project Location: Ottawa**

**1. Context:**

Under the Climate Change Science Initiative (CCSI), $50K/yr for three years (2008-2011) has been allocated to pilot a project with one ERI that investigates the potential impacts of climate change on ecosystems – by linking ecosystem and ocean models.

There are six ecosystem research initiatives underway (second year of three year funding). One of the goals of these initiatives is to develop tools for managing ocean regions based on an understanding of whole ecosystems. Some ERIs are already working towards developing ecosystem models with sufficient complexity, for example, to test the impacts on higher trophic levels if a major prey species were harvested. Linking these ecosystem models with existing ocean models has the potential to assess the impacts of climate change on ecosystems.

**2. Overview and approach:**

Currently some of the ERI leads are working towards integrating their ecosystem model(s) with ocean model(s). In fact, for the Georgia Strait ERI, the ERI's co-lead (Ian Perry) is an ocean modeler (Diane Masson). In addition, there is some work underway to link the Gulf of St. Lawrence ERI model with some of the ocean-atmospheric models being developed in the Atlantic Region.

It's foreseeable to do some forecasting with the ocean models to reflect different climate scenarios to determine their impacts on the ecosystems as determined by the ecosystem models. Also, the knowledge available on atmospheric forcing will be used to create credible climate scenarios to drive the ocean models.

**Approach:**

Due to limited resources, $50K/yr for three years, we recommend that we pilot this CCSI research project with the work underway with the Georgia Strait ERI. The work underway with the Georgia Strait is well suited for expansion in order to achieve our goal of addressing impacts of climate change and to investigate ecosystem vulnerabilities. A brief description of the modeling work underway in Pacific Region is attached in Appendix 1.

***Proposed Work Plan Elements***:

- 2008-09:
    1. Host a joint workshop with ECONET (DFO's expert ecosystem modeling advisory group) in early winter 2009. Participants of the workshop will include ERI leads, coordinators and modelers, and modeling experts from ECONET and Ocean Science. The workshop will provide an opportunity to exchange information on the ERIs and ecosystem and ocean modeling initiatives underway, and allow a discussion on linking ecosystem and ocean models;
    2. Expand the Strait of Georgia ocean model to include the flow conditions of the Fraser River. This will permit the associated climate change impacts to be modeled into the Strait of Georgia ocean model (Foreman);
    3. Create a zooplankton data base for the Strait of Georgia that will be used to validate the NPZD model (Pena); and
    4. Hire a co-op student to extract and analyze current meter data that will be used to validate the circulation model (Masson).

- 2009-2010: $50K for further model development, refining climate scenarios, and to conduct the forecasting of climate impacts on ecosystems.

- 2010-2011: Finish modeling project , host a workshop to demonstrate the impacts of climate on ecosystems for the ERI leads and the ocean modelers, and publish a final report on the results of this initiative.

Detail work plans will be submitted to the project proponents by the Ian Perry and Diane Masson at the beginning of the fiscal year 2009-2010 and 2010-2011.

**3. Objectives:** To determine the impacts of climate on ecosystems using ecosystems model(s) (development underway) and regional oceanic model(s).

**4. Correspondence with CCSI priorities:** This work addresses the following:

- <u>DFO research priorities identified by the Science Management Board</u>: A science program should support ecosystem-based management

- Four priorities identified in the five year research plan**:**
    - Fish Population and Community Productivity – understanding factors controlling populations and **how climate may affect carrying capacity**
    - Habitat and Population Linkages – quantifying effects of human-induced and **natural changes to habitats** and the aquatic resources they support
    - Climate Change / Variability – **understand and forecast changes**, **provide scientific information** for developing adaptation strategies
    - Ecosystem Assessment and Management Strategies – undertaking **ecosystem modeling** to support evaluation of management strategies; developing ecosystem status reports to meet the needs of diverse clients
- CCIS central theme: Assessing impacts of climate change on ecosystem composition, structure and function.

**5. Deliverables (relate to *Key Products*):** Two workshop summary reports, and one final report on the impacts of climate on ecosystems – a pilot project with the Georgia Strait ERI. *See #2 above*.

**6. Partnerships / leveraging / A-base commitment:**

**A-base commitment:** Existing modeling work underway with the Georgia Strait ERI and Ocean Science groups (see Appendix 1).

In additional, the workshop that will be held in early winter 2009 is strategically linked to the one being hosted by ECONET in order to enhance networking opportunities between ERI leads, coordinators, and modelers, and modeling experts from ECONET and Ocean Science.

**7. Timeline:**

- Start of project – upon receipt of monies (estimated timeline is Sept 2008)
- first workshop – early winter 2009
- second workshop – winter 2011
- final report – March 31st, 2011

**8. Budget Justification:** A total budget of $50K/yr for three years would enable us to work collaboratively with work underway with the Georgia Strait ERI. As the Georgia Strait ERI is already working towards developing their ERI models and establishing links with their Ocean models, it is possible with limited funds (Option 1) to expand their research project to assess the impacts of climate change on aquatic ecosystems.

## APPENDIX 1: *Strait of Georgia Ecosystem Research Initiative – Modeling Components*

Ecosystem-based assessment and management requires new tools which take a whole-ecosystem approach rather than focus on single species. One of these tools being developed to better understand the Strait of Georgia ecosystem is an end-to-end model representing all ecosystem components from primary producers to top predators, linked through trophic interactions and affected by the physical abiotic environment. This system comprises a physical circulation model (ROMS) coupled to a lower trophic level model (NPDZ) which then feeds into an upper trophic level model (OSMOSE). In addition, a whole-ecosystem model (ECOPATH) is also being applied to the Strait of Georgia, which uses a different modeling framework from the previous three models.

The Regional Ocean Modeling System, or ROMS, is a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications. The ROMS model (D. Masson, IOS) is now being developed to provide the underlying circulation and water properties (temperature and salinity) for the Straits of Georgia and Juan Fuca over a typical seasonal cycle. The model is forced by freshwater inflow from major rivers, tidal forcing at the open boundaries, as well as wind stress and heat flux at the surface. The output from the physical model will be used to drive the lower trophic level (NPZD) model.

To address the climate change issue (M. Foreman, IOS), potential initial conditions and boundary forcing for simulations with ROMS of future conditions will be computed from two sources: i) results from a 15km resolution regional climate model for the Pacific Northwest, and ii) downscaled results from an ensemble of global climate models that were used for the recent IPCC assessment reports. Though we expect that the regional climate model values will be more accurate and thus the ones actually used in the simulations, that expectation will be confirmed (or refuted) through model comparisons against oceanic and atmospheric observations taken over the 1980-2005 period. Work will also be done into examining the impact of the predicted changes in the Fraser River watershed and resulting river flows (J. Morrison, IOS) on the Strait of Georgia oceanic conditions.

A lower trophic level ecosystem model (NPZD – Nitrate, Phytoplankton, Zooplankton and Detritus) is being developed (A. Pena, IOS) and coupled to the ROMS circulation model for the Strait of Georgia to study the dynamics of the planktonic ecosystem and to identify and understand key factors responsible for temporal and geographical changes in productivity and biogeochemical cycles. At present, a copepod compartment is being added to the model and biological parameter values are being constrained by using available field observations. Initial tests of the model will be done by simulating summer average conditions and evaluating the model output with available observations.

The coupled physical – lower trophic model will then be coupled with the OSMOSE upper trophic level of the Strait of Georgia, under development (C. Fu, I. Perry, PBS). OSMOSE (Object-oriented Simulator of Marine Ecosystems Exploitation) is an individual-based multi-species model that has a flexible structure and allows for the

study of the spatial dynamics, structured in age and size, and of a great number of species that interact. The present development of the Strait of Georgia implementation of the model includes the addition of modules for marine mammals and benthic invertebrates in the SoG ecosystem, the determination of spatio-temporal scales and parameters, and forcing with ROMS-NPZD, as well as the calibration of the model to a climatological year.

In parallel to the modeling system described above, work is also done towards the development of the ECOPATH model in order to link changing climate and ocean conditions within the Strait of Georgia to the shifting dominance of upper trophic level species. The ECOPATH approach creates a static mass-balanced snapshot of the resources in an ecosystem and their interactions, represented by trophically linked biomass 'pools'. The updated ECOPATH model package (ECOPATH with ECOSIM, EWE) includes a dynamic simulator which permits the inclusion of temporal (inter-annual) variability in time series. The EwE model for the Strait of Georgia (R. Beamish, PBS) will be extended in an attempt to directly link historical trends in species abundance with trophic relationships and environmental changes. It serves as an alternative or competing model for comparisons with the ROMS-NPZD-OSMOSE model approach.