Name of Organization: USGS / Great Lakes Science Center

Type of Organization: Federal Agency

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Project Title: Influence of Physical Factors and Exotics on Diporeia

Project Category: Exotic Species

Rank by Organization (if applicable): 1

Total Funding Requested ($): 38,400 **Project Duration:** 1 Years

Abstract:

In recent years, especially after the invasion of the Great Lakes region by dressinid mussels (Dreissena polymorpha and Dreissena bugensis), numbers of the amphipod Diporeia hoyi have fallen precipitously. This deepwater burrowing crustacean has historically been a key link in Great Lakes food webs. These amphipods formed a large proportion of the diet of benthivorous fish such as slimy sculpins (Cottus cognatus), lake whitefish (Coregonus clupeaformis) and other coregonines. The primary diet of Diporeia is diatoms, planktonic detritus, and bacteria, linking primary production and fish production. Competition with dressinids for food has been hypothesized to be the primary factor in the continuing amphipod decline. Evidence of no change in particle input to the Lake Michigan benthos implies that the situation is more complicated than simple food competition or interception. This study includes a focused assessment current Lake Ontario benthic communities as associated with both physical and biotic factors in areas where Diporeia is no longer present and areas where they continue to be abundant and laboratory experiments to quantify ecological interactions between key benthic organisms and interactions with physical factors. The data and analysis produced in this study will facilitate understanding the mechanisms of the change in what was a Diporeia dominated benthic community, predicting further potential trajectories of community change and the implications for higher levels in the food web. This kind of information is essential to the Lake Ontario LaMP and the ongoing native fish community restoration effort in Lake Ontario, exemplified by the proposed reintroduction of the extirpated coregonine, Coregonus hoyi. The results will be applicable to all deep cold lakes in the Great Lakes basin.

Geographic Areas Affected by the Project

States:

- ☐ Illinois
- ☐ Indiana
- ☐ Michigan
- ☐ Minnesota
- ☒ New York
- ☐ Pennsylvania
- ☐ Wisconsin
- ☐ Ohio

Lakes:

- ☐ Superior
- ☐ Huron
- ☐ Michigan
- ☐ Erie
- ☒ Ontario
- ☐ All Lakes

Geographic Initiatives:

☐ Greater Chicago ☐ NE Ohio ☐ NW Indiana ☐ SE Michigan ☐ Lake St. Clair

Primary Affected Area of Concern: Not Applicable

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area: Not Applicable

Other Affected Biodiversity Investment Areas:

Problem Statement:

Assessments of changes in the profundal benthic communities of the Great Lakes from the early 1970's to 1990's indicate that there has been a large decline in the abundance and biomass of major macroinvertebrate groups: amphipods (Diporeia hoyi), oligochaete worms, and fingernail clams. The Lake Ontario ecosystem is a dynamic system that has historically experienced many changes in its community structure. One clear illustration of this was the 1998 capture of the first deepwater sculpin in 50 years. The burrowing amphipod, Diporeia hoyi, is considered a major link in the food web in the Great Lakes. It was historically the most abundant macroinvertebrate in the profundal zone. Its diet consists of primarily of bacteria and diatoms, and is most numerous in sediments with high organic content. Diporeia is preyed upon primarily by benthic fishes like slimy sculpins (Cottus cognatus), lake whitefish (Coregonus clupeaformis) and smaller deepwater members of the coregonine family (chubs). Energy from the benthos is transferred to other tropic levels as slimy sculpins and chubs are preyed upon by lake trout.

One of the recent major changes in the Great Lakes ecosystem was the accidental introduction of the dreissenid mussels (Dreissena polymorpha and D. bugensis) from the Ukraine. Like mytilid mussels, dreissenid mussels are ecosystem engineers that radically change the physical and biological structure of the local environment. In European lakes invaded by dreissenid mussels, presence of a mussel community increased the coupling of benthic and pelagic foodwebs through facilitation of the input of energy from the pelagic zone to the benthos. This decreases pelagic food web energy residence time and increases the overall density of benthic invertebrates. Mussels provide the basis for a complex benthic community that is usually one alternative community possible in a given environment. The complex ecological relationships associated with the mussel community, including indirect effects and facultative associations, facilitate its eventual monopolization of all available habitat space.

Long term trends in the benthos of Lakes Michigan and Erie show a decline in nondreissenid macroinvertebrates. This decline in amphipods, worms, and clams was likely partly related to a general decrease in the productivity of the lakes, but researchers speculate that dreissenid mussels may be playing a major role. In Lake Ontario, Dreissena bugensis is spreading rapidly and increasing in density, particularly in the profundal zone. On a lakewide basis in Lake Ontario the macroinvertebrate trends of rapid decline, especially of Diporeia hoyi, are similar to those in other Great Lakes, but the knowledge of the current state of the composition of the benthic community in the profundal benthos of Lake Ontario is fragmented in space and time and the direct effects of the dreissenid community on the amphipod community have not been documented. A continued decline in the native amphipod community will significantly reduce the ability of Lake Ontario to support fishes (including economically valuable salmon and trout), jeopardizing management efforts to reconstruct the historic fish community through reestablishment of a self-reproducing population of lake trout, restoration of deepwater sculpin populations, and reintroduction of extirpated coregonines.

In 1999 benthic samples along the southern shore of Lake Ontario by the USGS, Diporeia was only abundant at a depth of 130m near Olcott New York. Densities at other sites and depths were near zero. The substrate at this site was much different in appearance and consistency than the other sites. We hypothesize that there are factors or a combination of factors, biological, chemical, or physical in the sediment/substrate profile that can be linked to Diporeia abundance and are allowing persistence in some areas. Delineation of these factors will allow us to predict areas (and map the extent of these areas) where burrowing amphipods may persist in all of the Great Lakes. This research will be a focused assessment current Lake Ontario benthic communities as associated with both physical and biotic factors in areas where Diporeia is no longer present and areas where they continue to be abundant and laboratory experiments to quantify ecological interactions between key benthic organisms and their interactions with physical factors.

Proposed Work Outcome:

There are two major objectives in this research project. The first is to quantify the spatial and temporal composition of the benthic macroinvertebrate community in the profundal benthos in targeted areas of Lake Ontario. We will test the hypothesis that there has been differential change in the distribution and population structure of the burrowing amphipod, Diporeia hoyi, and the nonnative dreissenid mussels (primarily Dreissena bugensis) as an interaction with physical factors (substrate characteristics, water characteristics, depth).
The second objective is to quantify through mesocosm experiments the ecological interactions (direct competition and indirect community effects) of the exotic invasive dreissenid mussels (Dreissena polymorpha and D. bugensis) with the native amphipod, Diporeia hoyi. We will test the hypothesis that properties of the benthic dreissenid mussel community, including direct competitive effects and indirect effects of associated epifauna, are allowing that community to replace the originally observed benthic community of Lake Ontario, which was dominated by Diporeia hoyi. A corollary of this hypothesis is that the interaction is modified by physical factors associated with specific locations.

Field sampling:
Field assessment of the temporal and spatial distribution and natural histories of communities are a critical part of the ecosystem ecology evaluation process. Benthic community and substrate samples will be collected on transects near Olcott and Rochester NY in areas regularly sampled for fish community changes by LOBS. Sidescan sonar will be used to characterize the lake bottom and help to initially help identify potential sampling locations. Samples will be collected twice a year, (April-May, September-October) to be representative of the reproductive cycle of the major macroinvertebrates (amphipods & mussels). Samples will be taken at several representative of depths and substrate types to provide a fine and will represent a more localized scale of sampling along physical gradients at Olcott and Rochester than has been previously attempted. Three samples will be collected at each location with a standard Ponar grab to characterize each depth/location/time combination. Ponar samples will be sieved and preserved in buffered formalin, after two days stored in 70% alcohol with glycerin, for later community composition analysis. Community interactions may be profoundly affecting the reproductive patterns of the major macroinvertebrates in the system to reproductive pattern analysis of the mussels and amphipods will be completed using standard techniques. Communities will be sorted into major functional taxonomic groups and dreissenid mussels. As needed, live animals will be retained and transported to Tunison, to set up laboratory microcosm experiments. At each site water samples will be collected near the bottom and the surface for analysis of zooplankton and phytoplankton community composition. Total chlorophyll, phosphorus, calcium, and silica will be measured using standard methods. Sediment samples will be taken using a corer. These sediment samples will be analyzed for organic carbon, particle size, water content, mineral composition, and other potentially influential factors. Graphical representations of the spatial and temporal community compositions, multivariate analysis, analysis of variance will be used to test for Diporeia and community differences between depths, sites, and physical factors.

Laboratory microcosm experiments:
Microcosms are simplified models of communities. These systems are powerful tools for clarification of complex ecological relationships by breaking them down into quantifiable components and have been used in several freshwater systems including the effects of zebra mussels on phytoplankton. Multispecies, multifactorial experiments with rigorous statistical analysis are a well-established part of the science of ecology. Amphipods and mussels collected in the field will be brought to Tunison Laboratory of Aquatic Science. Several standardized replicate microcosms will be constructed and initiated. First, direct competition between amphipods and mussels for a standard cultured algae will be tested. In that experiment amphipod growth and survival will be measured with and without dreissenid mussels. Based on the results of the initial experiments, further aspects and complexities of the interactions of the amphipod community, the dreissenid mussel community, and physical factors will be identified, hypotheses formulated, and those hypotheses tested. The results of these experiments will be analyzed using analysis of variance and a structured multifactorial analysis of variance. Many community interaction and food web models applicable to the analysis of Lake Ontario food webs have been

developed. The data obtained in the field and laboratory microcosm experiments will be entered into one of these models and an analysis of the current community connections and trajectories will be completed.

The information produced during this research will be used to evaluate the inputs of these benthic communities into the Lake Ontario food web and help to clarify the impact on and ecological relationships of dreissenid mussels in the benthic food web of Lake Ontario. These results and analyses will facilitate understanding the mechanisms of ongoing community change in the deepwater benthos. They will enhance researchers ability to predict potential trajectories of further change, and increase the knowledge base essential for managing ecosystem health. This kind of information is fundamental to the efforts to successfully restore the native fish community of Lake Ontario and the Great Lakes basin. The presence of nonnative species and reduction in productivity associated with decreased phosphorus loading of the Great Lakes is reverberating through the whole foodweb from diatoms to Diporeia to native forage fish to the top salmonid predators. Management agencies need information about the status, interactions, and trends of the benthic communities of Lake Ontario to more clearly understand the current impairments to the Great Lakes System and to facilitate restoration and rehabilitation efforts. Comparison of observed community changes in Lake Ontario with other Great Lakes and cold deepwater lakes will help provide insight into the complex dynamics of the Great Lakes ecosystem.

Project Milestones:	**Dates:**
Project Start	06/2001
Spring Sediment & Community Sampling	06/2001
Fall Sediment & Community Sampling	09/2001
Sample Analysis & Mesocosm Experiments	11/2001
Finish Experiments & Analysis	04/2002
Physical & Biotic Interaction Paper	06/2002
End Project	06/2002
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☐ Project Addresses Environmental Justice

If So, Description of How:

☒ Project Addresses Education/Outreach

If So, Description of How:

Students from Hobart and William Smith Colleges of Geneva NY will be involved in data collection and analysis as part of independent study projects for their environmental studies concentration.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	5,500	25,500
Fringe:	0	0
Travel:	2,000	1,000
Equipment:	2,500	500
Supplies:	2,000	500
Contracts:	0	0
Construction:	0	0
Other:	18,000	0
Total Direct Costs:	30,000	27,500
Indirect Costs:	8,400	0
Total:	38,400	27,500
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

Description of Collaboration/Community Based Support:

This project will involve collaboration between the USGS Tunison Laboratory of Aquatic Science, the USGS Lake Ontario Biological Station, and the Environmental Studies Program at Hobart and William Smith Colleges in Geneva NY.

Dr. John Halfman of Hobart and William Smith, Department of Geoscience will provide equipment (sidescan sonar, sediment corer) and expertise in sediment analysis. An environmental studies student from Hobart or William Smith will complete the sediment analysis as part of a senior project. Additional students may be involved in water or community analysis.

Randall Owens, Research Fisheries Biologist, of the USGS-LOBS will provide coordination of use of the R/V Kaho for sampling and expertise in Lake Ontario food webs and the ongoing changes in those food webs.

Dr. Dawn Dittman, Ecologist, of the USGS-TLAS will coordinate the overall project and specifically the mesocosm experiments and the analysis of Diporeia and benthic community compositions. Mesocosm experiments will be conducted at TLAS.