RESEARCH PROPOSAL

to

MICHIGAN SEA GRANT CORE RESEARCH PROGRAM

United States Geological Survey, National Oceanic and Atmospheric Administration

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# Abstract:

Islands can serve as unique experimental units for a number of areas of research. The traditional theory of island biogeography, in terrestrial context, suggests that isolation of certain environments will lead to faunal composition that is a function of extinction and colonization rates, which themselves are a function of island size and proximity to mainland metapopulations. In the Great Lakes, this concept may apply to nearshore and coastal fish taxa in areas where archipelagos provide habitat patches of different proximities to mainland coastlines. I propose that island biogeography theory can be tested among nearshore fish fauna found at islands in the Beaver Archipelago, located in northern Lake Michigan. Marked fish will be used to determine local migration rates and demographic parameters of many fish taxa in the nearshore zones at seven islands of the Beaver Archipelago, which are isolated from mainland coastal habitat of Wisconsin and Michigan by vast pelagic zones. I hypothesize that nearshore fish community structure will be a function of an island’s length of coastline and its proximity to other islands. In addition, these coastal habitats are exposed to frequent intermediate disturbances from severe weather. As climate change threatens to alter coastal habitat through increased severity and frequency of disturbances, the resilience of coastal ecosystems and the taxa that occupy them may rely in dispersal and colonization abilities of specific taxa or taxa groups.

# Introduction

The Beaver Island Archipelago in northern Lake Michigan presents a unique research opportunity to study coastal ecosystems in the Great Lakes. The entire archipelago is comprised of some 14 islands and shoals with various embayments, shoreline types, and area of coastal habitat (Figure 1). Glacial scouring and errata formed the Beaver Archipelago, which has a rich anthropogenic history as well as ecological value. Beaver Island itself is the largest island in Lake Michigan at 145 km2, and islands in the area range from 20 km2 to 0.04 km2, providing an ideal situation to study island biogeography of nearshore fish fauna. Beaver Island is 30 km from mainland Michigan, and is home to about 700 year-round residents. Central Michigan University Biological Station is located on Beaver Island and serves as a base of operations for the CMU Institute for Great Lakes Research.

Rates of extinction and colonization are important mechanisms for assembling faunas, but can be difficult to study directly. The insular nature of islands results in habitat patches of varying sizes and proximity to other metapopulations of migratory species. Less isolated insular areas are colonized more frequently (Brown and Kodric-Brown 1977) and are accessible to a wider range of species, including those with low dispersal ability (Darlington 1957, Carlquist 1966, 1974). Mainland coastal habitat areas lack pelagic zones to isolate fish with less migratory capacity, however, an archipelago within a large pelagic zone can serve as a study system to examine the effects of island biogeography among islands within the archipelago. Fish communities may be nested, with the number of species present result from a function of the island’s isolation from other systems and total habitat area; larger patches tend to have more habitat heterogeneity and more resilience to disturbance. Local fish metapopulations of the Beaver Archipelago present a unique opportunity to study island biogeography theory applied to nearshore fish species of the Great Lakes.

# Justification

Numerous studies of nearshore habitat use by fishes exist across all the great lakes (CITE), but few exist on mid-lake archipelagos. About 80% of Great Lakes fish species use the nearshore zone (DEPTH AND CITE) in some way for spawning, feeding, or migration (CITE). Nearshore fish habitat along Great Lakes shorelines is patchy and variable, but fishes in these areas are not forced to migrate across vast expanses of pelagic zones that do not provide the same resources and refuge of the coastal zone. The theory of island biogeography has been explored in terrestrial habitats (CITE), riverine systems (Hoagstrom), and isolated lakes (CITE), however, there is a paucity of research regarding freshwater archipelagos and associated development of the nearshore fish community.

Given the variety of island sizes (and thus shoreline lengths) in the Beaver Archipelago provide a framework to test fundamental predictions of island biogeography theory. Migration of Smallmouth bass (*Micropterus dolomieu*) in the Beaver Archipelago was restricted in summer months and fish remained within 5 km of the archipelago (KAEMINGK). However, fish from other species may leave and return to the archipelago, or remain isolated to small geographic habitats. Seiches and wind-driven updwellings may cause temperature and sediment disturbances that cause a shift in fish distribution (Plattner 2006), and islands with embayments may be more resistant to disturbances, and archipelagos with more island may be more resilient to disturbances (CITE?). Therefore, this research fills multiple data gaps in existing ecological theory and could provide the framework for a long-term monitoring study of fish communities in the Beaver Archipelago.

# Hypothesis

The goal of this study is to test the fundamental predictions of island biography theory on the nearshore fish communities of the Beaver Archipelago. Islands with more proximity to island, longer shorelines, and habitats protected from disturbance are expected to harbor greater abundances and diversity of species compared to smaller, isolated islands that are exposed to more disturbance. Movement of fish taxa between islands will be tracked to quantify patterns of movement between islands in the Beaver Archipelago to test if movement rates increase as a function of decreasing distance between islands.

# Methods

This research will take place in three summer field seasons. Sampling will take place between May and August of each year, using a variety of fish sampling techniques including gill nets, fyke nets, boat electrofishing, and minnow traps. Sites may be selected from a subset of islands to improve sample efficiency, and the number of sites at each island chosen will be partitioned according to shoreline length (e.g., one site per km of shoreline) and will be stratified by habitat features (e.g., substrate type, embayment).

Captured fish will be tagged with either an individually numbered floy tag (small fish < 350 mm) or a passive integrated transponder (PIT tag, large fish > 350 mm) Telemetry of PIT tagged fish will occur at islands among the archipelago to measure rates and magnitude of fish movement; additional receiver arrays in the GLATOS system and other studies may pick up signals from tagged fish, helping clarify seasonal or transient use and permanent emigration from the archipelago. Both qualitative and quantitative measurements of shoreline habitat features will also be recorded as covariates determining fish distribution and abundance.

This study design allows for application of a number of analyses including multistate capture-mark-recapture analysis that quantify emigration rates, and occupancy modeling of cryptic taxa among various habitat types when tagging data is insufficient. Standard metrics that describe the relative abundance and biodiversity of the nearshore fish community. ADD A SENTENCE OR TWO ABOUT STANDARD ISLAND BIOGEOGRAPHY ANALYSIS.

# Anticipated Results: