Development of a Coastal Habitat Framework for Near-Shore Coastal Systems

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The coastal zone of the Great Lakes basin is an important buffer and link between the open water and inland ecosystems. This zone has a variety of habitats and is home to over 120 native or established fish species, which use this area as spawning and nursing grounds. However, development and other human activities have greatly reduced the habitat available to support common aquatic species (Whillans 1987, 1990; National Research Council 1992). Only by conserving the coastal habitats of the Great Lakes can we preserve the diversity of aquatic species that rely on them. Coastal GAP is intended to identify these habitats and extend the analysis of Great Lakes Regional Aquatic GAP developed for riverine habitats to the nearshore zone of the Great Lakes coast. Two of the basic needs of Great Lakes Regional Aquatic GAP are the acquisition of data and the development of a classification framework for habitats based on enduring features.

The methodology for conducting a coastal gap analysis was developed and tested initially on selected pilot study sites in the Great Lakes basin. Pilot sites were chosen based on the availability, extent, and quality of databases containing the required abiotic and biotic data. Initial pilot studies began in Eastern Lake Ontario and Western Lake Erie. Other sites may include the Les Cheneaux Islands, Saginaw Bay, and Central Lake Erie as data become available. Many of the habitat characteristics we initially propose to use for classifying coastal habitats are derived from other data. These data, from which the derived values come, must be available at the scale and resolution necessary for the project. Preliminary investigation indicates that most of the necessary data are available for each of the pilot coastal areas. In some cases, a small amount of field effort was required to collect data that filled in some of the data gaps and was also used to ground-truth other aspects of the data.

Framework

The aquatic gap analysis modeling approach used in this coastal pilot project establishes a relationship between the location of species and the characteristics of the habitat at that location before grouping similar habitat types. Unlike the traditional approach (Figure 1) of classifying habitats and relating species information to these classifications, the modified approach (Figure 2) allows the species information to define the natural breaks in the habitat.

This conceptual design will be tested as appropriate to determine its efficacy. The resulting framework will be described in such a way that appropriate data may be applied to it through a database management system compatible with that used by the larger Great Lakes Regional Aquatic GAP.

Although there are many influences on the habitat characteristics of the coastal zone, coastal GAP will be focusing on the enduring features of the Great Lakes basin. Influences such as anthropogenic modifications, invasive species, and water chemistry, though very important to species distributions, are not easily analyzed on a landscape level such as Great Lakes coastal GAP activities. With this in mind, the enduring habitat features will be used within this modified framework developed for this project.

Habitat Characterization

Coastal GAP has begun the process of identifying candidate variables that best characterize and distinguish the coastal habitat types. These variables represent conditions in a hierarchy of spatial scales and are presumed to have significant influence on the fish assemblages found in a particular habitat. At the top of the hierarchy are the individual basins of Lake Ontario, Lake Erie, Lake Huron, Lake Michigan, and Lake Superior. The division by basin allows for an ecologically significant distribution of the habitat characteristics and the standardization of processing units for subsequent data.

The coastal zone has been defined using thermal regime or depth of water as the boundary between nearshore and open water. With the limited amount of temperature data available and the varying characteristics of each basin, this project defined the coastal zone based on the effect of energy on the coastal sediment. Energy in these systems is generally provided by wind and waves, as opposed to the influence of gravity, and water movement is not confined to the limits of a streambed. While there is a longshore drift of water and sediment, exposure to (or protection from) wave and wind energy is what most strongly influences coastal habitats. Orientation to and fetch size of prevailing winds and the resulting waves determine whether a particular habitat type is in a high- or low-energy zone. For this

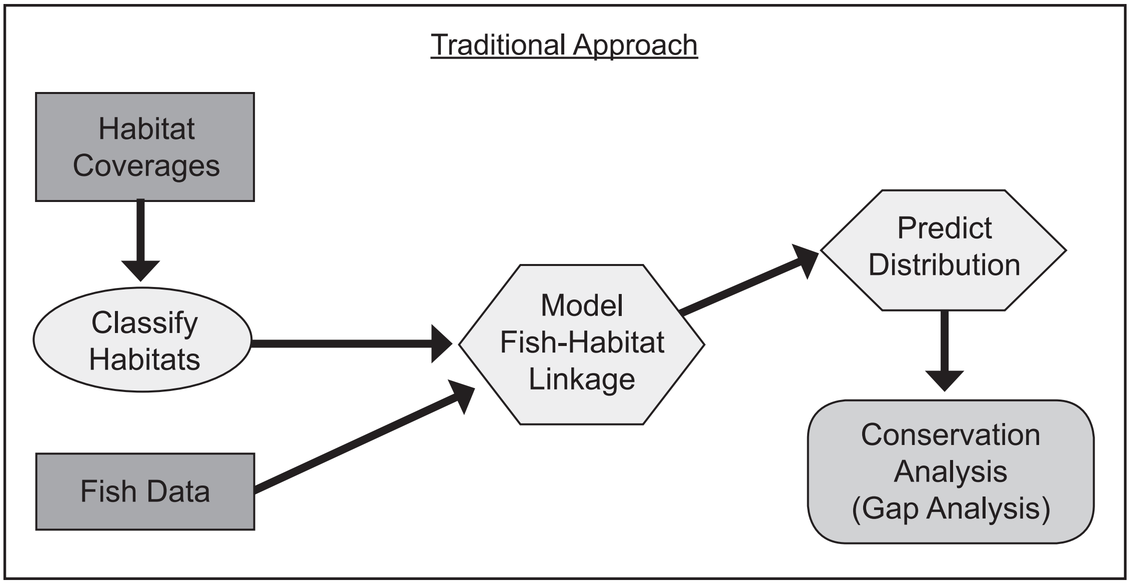

Figure 1. The traditional modeling approach classifies habitats based on environmental characteristics and relates species information to those classifications.

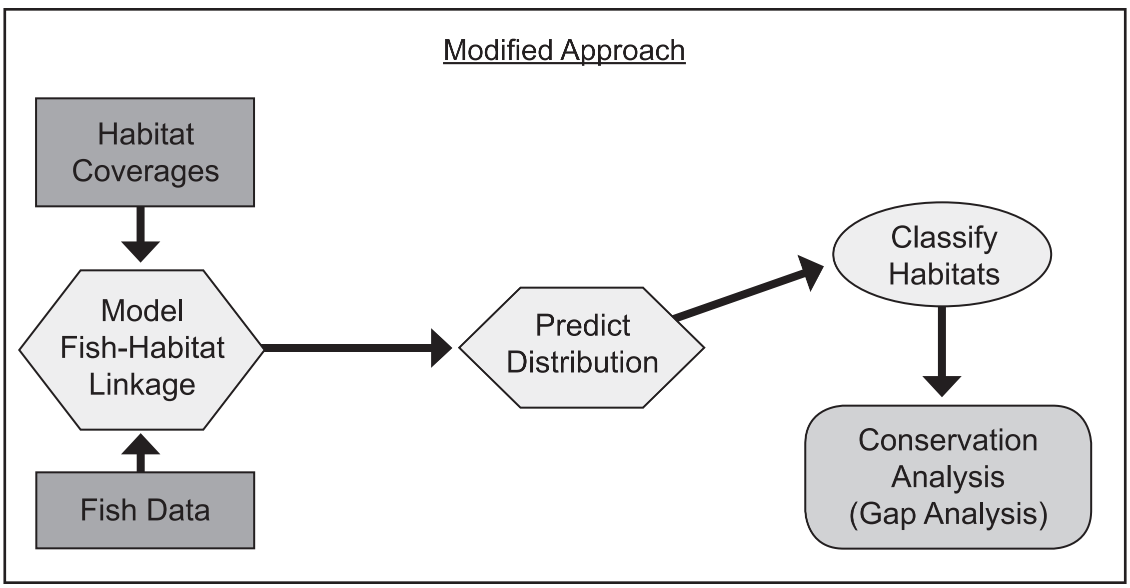

Figure 2. The modified approach used for the aquatic gap analysis allows the species information to define the natural breaks in the habitat.

project, the coastal zone is defined as the area from the mean lake water line to the depth of water at which prevailing wave conditions no longer rework sediment or 10 meters of water, whichever is larger:

Depth of Water at outer boundary = $((\sqrt{(g - h)} \bullet T) / 2)$ or 10 meters depth

g = accelerations due to gravity (9.8 m/s)
h = wave height
T = time period

For example, waves 2 m high every 3 seconds will potentially rework sediment to a depth of 6.6 m.

Within this nearshore area, each lake has distinct differences in the distribution of its habitat and the range of values for the habitat. Many of these habitat characteristics were available from published or unpublished sources or derived through analysis of those data. The characteristics identified for this project include subaquatic vegetation (SAV), geomorphology, geologic formations, submerged substratum, submerged slope and aspect, and circulation and currents. We believe these characteristics have a significant influence on the location and distribution of aquatic species.

One of the more important habitat characteristics for our model is the prediction of subaquatic vegetation. In Figure 3, we have applied Minns's algorithm (Minns et al. 1995) to define this variable for our project in the following steps:

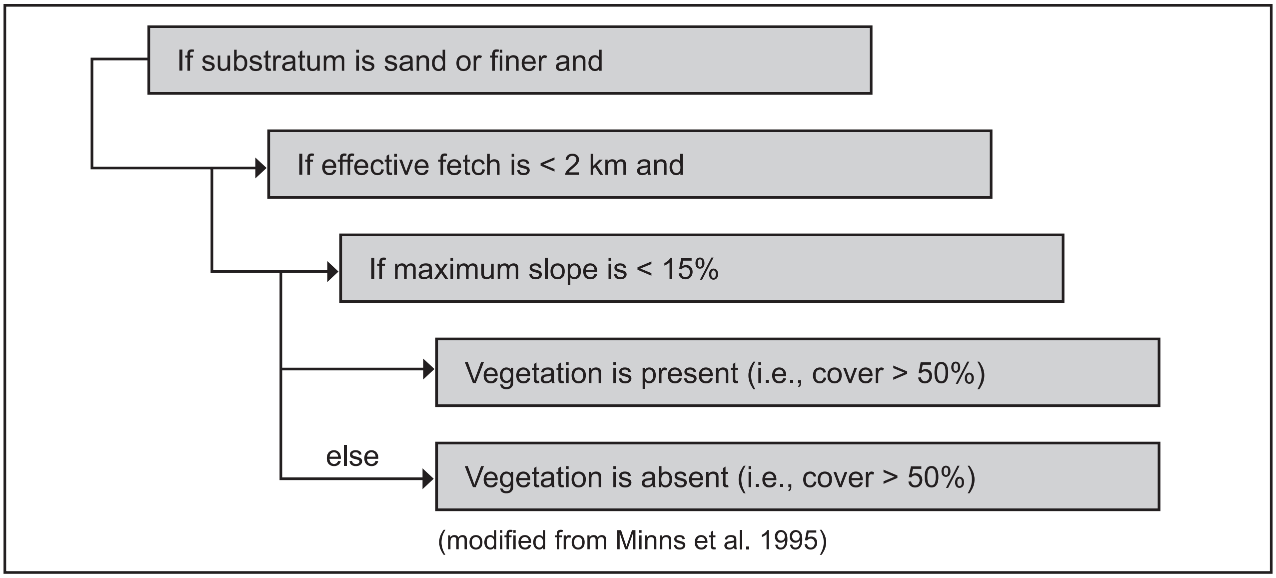

Figure 3. Steps used to predict subaquatic vegetation occurrence.

Geomorphology of the coast ranges from sandy beaches and mud flats to sheer cliffs and headlands. The coast is also marked by bays, inlets, coastal ponds, large and small river mouths, wetlands, and other features that disrupt the coastline and regulate much of the flow of water into the lakes. Orientation and relation of these nearshore features to other coastal features, water influences, and physical characteristics can also affect the character of coastal habitat. Circulation and currents influence the large-scale movement of water through the basin, within each lake, and within the connecting channels. The relationship to large tributaries and other sources of water movement and currents can provide a major resource of organic content, temperature, water chemistry, and food sources. Most of these enduring features are being used and tested as surrogates for the habitat characteristics that we believe are the most influential and readily available for modeling the aquatic species.

The final stages of gathering basic habitat data are being completed. Fish databases have been compiled and modeling fish-habitat linkages for each species will begin shortly. Predicted distributions and identification of distinct habitat types will follow. The resulting geographic information system will then be available for conservation analyses.

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