

ECO-GIS: DEVELOPING GIS TOOLS FOR ECOSYSTEM APPROACHES TO FISHERIES MANAGEMENT

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INTRODUCTION

Ecosystem Approaches to Management are adaptive, geographically specified, take account of ecosystem knowledge and uncertainties, consider multiple external influences, and strive to balance diverse societal objectives (NOAA 1999, Garcia et al. 2003). With the recognition that traditional single-species Fishery Management Plans do not meet all of these criteria, Ecosystem Approaches to Management are gaining favor among fisheries managers and scientists (SAFMC 2004, Murawski 2005). Regional Fishery Management Councils are developing Ecosystem Pilot Projects and Fishery Ecosystem Plans (SAFMC 2004), which will help fisheries managers to meet future requirements put forth by the Magnuson-Stevens Act (Public Law 94-265). Spatial analysis using Geographical Information Systems (GIS) is recognized as an essential tool in moving towards Ecosystem Approaches to Fisheries Management (Busch et al. 2003).

The EcoGIS project was launched in September 2004 to develop a custom suite of GIS tools to use with diverse marine datasets to better enable both fisheries scientists and managers to adopt ecosystem approaches to fisheries management. EcoGIS is a collaborative effort between NOAA's National Ocean Service (NOS), National Marine Fisheries Service (NMFS), and four regional Fishery Management Councils. The need for these types of tools was highlighted in a September 2004 workshop in Charleston, SC, attended by fishery scientists and managers from NOAA, Fishery Management Councils, academia, and NGOs (NOAA 2004). GIS needs expressed at the workshop ranged from simple map-based queries to complex ecosystem modeling. Additional input from the EcoGIS steering committee and users narrowed the project's tool development focus to four priority areas:

Fishing Catch and Effort Analysis: Where, when, and how do fisheries operate within a given area? How have fisheries been impacted as a result of regulatory changes?

Area Characterization: Within a selected area, what are the physical parameters (e.g. sediment type), and biological parameters (e.g. species abundance), and regulatory framework?

Bycatch Analysis: What are the trends in bycatch among different fisheries, geographic areas, time periods, depth ranges, and habitat types?

Habitat Interactions: What types and amount of habitats have been fished using bottom-tending gear?

These tools are being developed as an extension for ArcGIS 9.2, and generate spatial and temporal analyses using specified criteria from a variety of data sources, including base map layers and fishery-dependent and -independent data. The end products will enable simplified and more efficient data query, the ability to visualize data over time and to synthesize multidimensional data from diverse sources, and to provide new information for analyzing specific issues from an ecosystem perspective. Ultimately these abilities will result in better understanding of fisheries and better support for decision-making.

OUTREACH

The initial scope and objectives of the EcoGIS project were based on the results of the September 2004 workshop (NOAA 2004), and discussions with the Steering Committee. Since then, the EcoGIS team has conducted a series of meetings with Fishery Management Council and NMFS staff to demonstrate the prototype tools, get feedback and new ideas, recruit potential users and learn their specific needs. A few key points gained from these meetings include:

- Coordinate closely with related projects to add value and avoid duplication of efforts.
- The Fishery Mapper tool must ensure the confidentiality of individual catch and revenue in fishery-dependent data.
- The tools must allow a user to import their own data sets (shapefile, geodatabase, dbf), and not be hard-coded to prescribed data sources.
- The tools must be able to use Microsoft Access as a local data source, and also allow log-in to Oracle or other server-based DBMS.
- There is no universally accepted means of estimating fishing effort – it varies among regions, gear types, species, etc.
- The tools must be able to use a variety of fishery-dependent data types, including ACCSP, Vessel Trip Report, and Observer.
- The tools may have unexpected uses, not related to fisheries management – such as creating a summary grid from benthic sampling points.

APPLICATION DEVELOPMENT

Of the four functional areas described above, the project team has first focused on developing a working prototype for the Fishery Mapper tool. The team has made considerable progress in this area and has a working prototype, developed in Visual Basic 6, that was released to a select group of beta-testers in early 2007.

Observer, Vessel Trip Report (VTR or logbook), and fishery-independent trawl survey data for development and testing of the tool were acquired from NOAA/NMFS Northeast Regional Office and Northeast Fisheries Science Center, and loaded into a secure duplicate Oracle database environment at the NMFS Office of Science and Technology. These data were also loaded into a Microsoft Access database for testing the tool in a non-networked setting. The project team has also acquired access rights through Atlantic Coast Cooperative Statistics Program (ACCSP) to confidential trip ticket and landings data for the entire Atlantic Coast, and is adapting the Fishery Mapper tool to connect and utilize data from the ACCSP data warehouse and other data sources for users who have been granted access to these data.

FISHERY MAPPER TOOL

The Fishery Mapper tool creates time-and-area summarized maps of fishing effort and catch from logbook, observer, or fishery-independent survey data sets. This ArcGIS extension (Dynamic-link Library, or DLL) allows a user to query the selected source data by species and gear, specify a time frame and time step, set up bins for spatial summary (regular grid or predefined polygons), and choose the variable to summarize (catch, discards, effort). Source data may come from Oracle, Microsoft Access, or file-based formats such as CSV files.

CASE EXAMPLE – APPLICATION OF FISHERY MAPPER TOOL

In this Case Example, the Fishery Mapper tool is applied to New England Vessel Trip Report (VTR) data. The first step in the mapping process is to define query conditions, time range, and time steps.

Define Query Conditions: The user first launches the Fishery Mapper tool from the first button on a custom toolbar within ArcGIS, then selects data set of interest - in this case, VTR or logbook. User chooses the time period, time step, one or more gear types, and one or more species. When these criteria are applied, an SQL query retrieves all trips and related catch/discard records that meet the criteria. Next a map layer of points is created, with each point representing the location where a species was caught. User is prompted to save this point layer to a shapefile.

Create spatial analysis bins and join with points: Next the user must choose how to summarize the data geographically. Spatial analysis “bins” may be specified by creating a grid, drawing polygons on the screen, or selecting preexisting polygons. In this example we are creating an ordered set of bins. The spatial extent and cell size of analysis area are specified, the selected area is autopopulated with specified bins, then saved as shapefile. A Spatial Join of point and bin shapefiles creates stand-alone table, summarizing catch and effort by bin and time-step.

Render catch and fishing effort through time: The user specifies how to summarize the binned data temporally and display by time-step by launching a rendering “data slice” tool from the toolbar that allows the user to examine all variables for one time step, or one variable for all time steps. Time step is specified (e.g. month, quarterly, or custom), and analysis parameter (e.g. catch, days-at-sea, calculated effort). “Forward” and “Backward” buttons may be used to move rendered data through time steps. “Calculate” button applies map algebra to sum or subtract results between time steps.

Explore relationship between fishery data and environmental base layers: The third button on the EcoGIS toolbar allows the user to apply bin algebra to summarize how changes in a given variable (e.g. catch or effort) are apportioned to a variable represented by another map layer. This might be useful in comparing the interactions between fishing activities and habitat before and after some regulatory or environmental change. Available habitat layers include bathymetry, sediment type, sea surface temperature, and other environmental parameters (Reid et al. 2005, Sheridan et al. 2002).

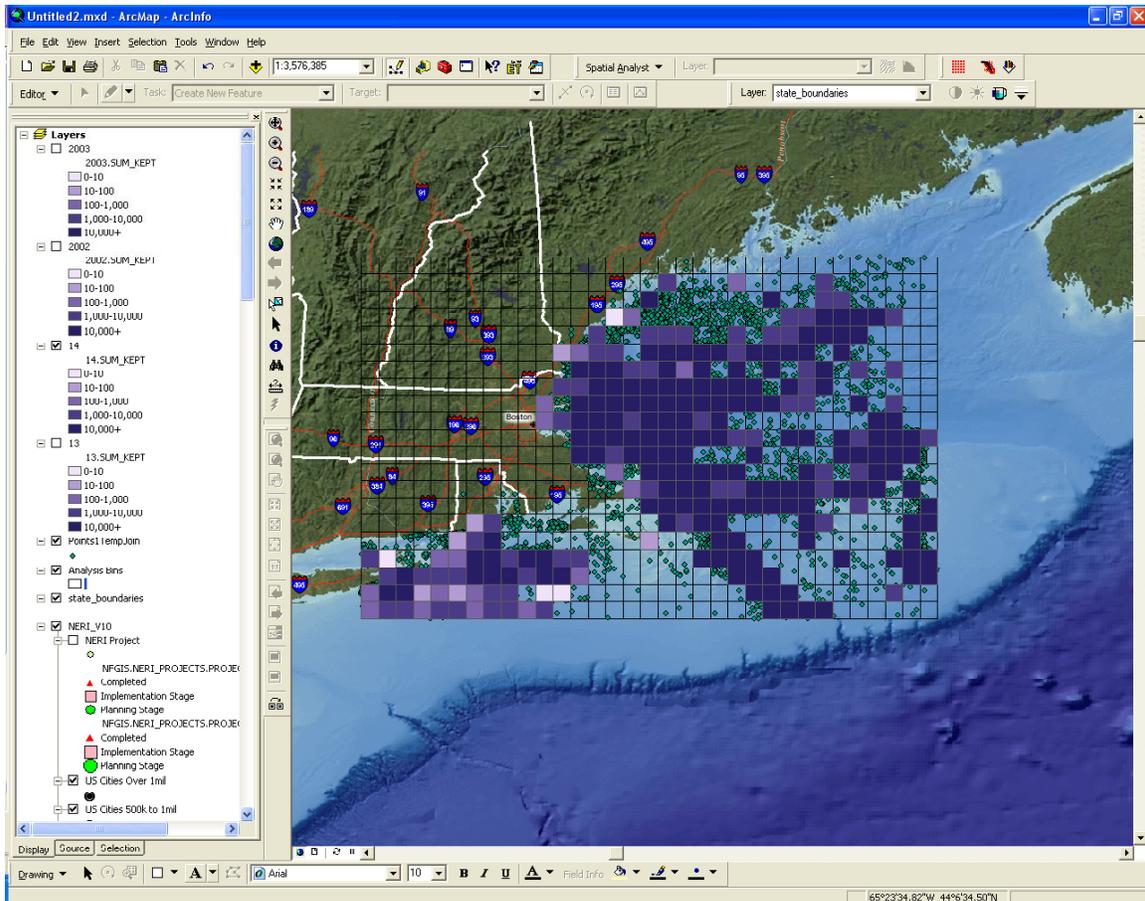


Figure 1. Case Example – Applying the Fishery Mapper tool to New England VTR data to render fishery catch and effort through space and time.

STATUS AND NEXT STEPS

In early 2007, a beta-version of the Fishery Mapper DLL was provided with documentation to interested users to perform their own analyses. Feedback from beta-testers will be used to debug the prototype, enhance performance, and add features. In addition, a summary report to describe the new tools and capabilities for GIS to keep pace with science and management was completed in May 2007. Expected future developments include:

- Adapting Fishery Mapper tool to better address issues of bycatch and fishery/habitat interactions.
- Adapt tools to fit existing data models in other regions, and allow user to define the organization of the data, the attributes of interest, and how those attributes are coded and summarized.
- Improve the flexibility of the tool by breaking it into discrete components that could be combined in any number of ways in a user-defined process model.
- Define additional management questions and scientific hypotheses that can be addressed within a blueprint for future development.

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