Fishery Analyst for ArcGIS 9.x

EBM Tools Network demonstration presented by Francesca Riolo – 10th December 2008
Background

- Although fishery positioning data are being collected often no explicit use of them is made.
- Graphs and written report have been the main format to display and present fisheries data and statistics.
- There is often a lack of understanding of the spatial distribution of fishing activities even where fishing coordinates are collected.
- GIS and Spatial Analysis techniques are used to analyze and display the entity, distribution and success of fisheries activities.
Fishery Analyst

- Based on ESRI ArcGIS 9.x software and Spatial Analyst
  (Originally developed on ArcGIS 8.3)

- Customized interface developed using Visual Basic for Application and ESRI ArcObjects

- Routines for data retrieval, conversion, analysis and output production.
Main Functions

- Convert tabular data into GIS enabled datasets (e.g. vector shapefiles and raster GeoTIFFs)
- Quantitative estimation and visualization of catch, effort and CPUE
- Variation in space and time (time series animation)
- Assess fishing vessel utilization
- Data quality control
- Information on the location of important economical and threatened species.
- Handling of data confidentiality in output production to meet data policy during public outreach.

www.mappamondogis.com
<table>
<thead>
<tr>
<th>LOGBOOK</th>
<th>FISHDATE</th>
<th>VESSELNAME</th>
<th>COMPNAME</th>
<th>EFFORT</th>
<th>EFFORT UN</th>
<th>SPEC NAME</th>
<th>NUMKPT</th>
<th>NUMRELEASE</th>
<th>X1</th>
<th>Y1</th>
<th>YY</th>
<th>EXCEPT</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>4559</td>
<td>7/5/1999</td>
<td>Line</td>
<td>Line</td>
<td>9000</td>
<td>HOOKS</td>
<td>BLUE WHALE</td>
<td>120</td>
<td>90</td>
<td>167,547</td>
<td>24,802</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4563</td>
<td>7/5/1999</td>
<td>Line</td>
<td>Line</td>
<td>9000</td>
<td>HOOKS</td>
<td>ALBACORE</td>
<td>106</td>
<td>49</td>
<td>160,847</td>
<td>25,570</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4566</td>
<td>7/5/1999</td>
<td>Line</td>
<td>Line</td>
<td>9000</td>
<td>HOOKS</td>
<td>BIG EYE</td>
<td>131</td>
<td>81</td>
<td>157,244</td>
<td>23,867</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4559</td>
<td>7/5/1999</td>
<td>Line</td>
<td>Line</td>
<td>9000</td>
<td>HOOKS</td>
<td>YELLOWHIN</td>
<td>28</td>
<td>13</td>
<td>157,015</td>
<td>23,135</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4561</td>
<td>7/10/1999</td>
<td>Burundi</td>
<td>Burundi</td>
<td>980</td>
<td>HOOKS</td>
<td>BLUE MARLIN</td>
<td>134</td>
<td>62</td>
<td>168,730</td>
<td>23,644</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4561</td>
<td>7/10/1999</td>
<td>Burundi</td>
<td>Burundi</td>
<td>980</td>
<td>HOOKS</td>
<td>SHOLOBASI</td>
<td>134</td>
<td>30</td>
<td>160,843</td>
<td>23,770</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4561</td>
<td>7/10/1999</td>
<td>Burundi</td>
<td>Burundi</td>
<td>980</td>
<td>HOOKS</td>
<td>BLUE SHARK</td>
<td>134</td>
<td>30</td>
<td>168,081</td>
<td>23,867</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4561</td>
<td>7/10/1999</td>
<td>Burundi</td>
<td>Burundi</td>
<td>980</td>
<td>HOOKS</td>
<td>TRESHER</td>
<td>134</td>
<td>30</td>
<td>155,832</td>
<td>22,107</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>4561</td>
<td>7/10/1999</td>
<td>Burundi</td>
<td>Burundi</td>
<td>980</td>
<td>HOOKS</td>
<td>MAHIMAHA</td>
<td>134</td>
<td>30</td>
<td>168,441</td>
<td>23,367</td>
<td>409</td>
<td>.....</td>
<td></td>
</tr>
</tbody>
</table>
VBA/ArcObjects Routines

- Batch processing capabilities
- Convert raw tabular data to vector spatial datasets, points and line representation (SHAPEFILES)
- Perform catch, CPUE and effort calculation based on selection criteria
- Generate density analysis outputs in raster format (GeoTIFFS)
- Map layouts into graphic files (GIFs)
- Time series animations (PDFs)
- Handling of data confidentiality
- 3500 lines of code
Directory structure
Fishery Data

- FA can be used on data from any fishery where geographic information is available.

- Example: Data collected as part of the US federal logbook system
Fishery Data

- Each record in the dataset represents the information for an individual fishing set (and logbook) and a specific species caught.
# Fishery Data

<table>
<thead>
<tr>
<th>FIELD NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGBOOK</td>
<td>Unique identifier for each deployed fishing set</td>
</tr>
<tr>
<td>FISHDATE</td>
<td>Date in which the fishing set was deployed</td>
</tr>
<tr>
<td>VESSELNAME</td>
<td>Name of the fishing vessel</td>
</tr>
<tr>
<td>CONF_CODE</td>
<td>Confidentiality code unique for each owner or vessel or else depending on policies</td>
</tr>
<tr>
<td>LENGTH</td>
<td>Length of the fishing vessel (optional, for analysis based on vessel length)</td>
</tr>
<tr>
<td>EFFORT</td>
<td>Fishing effort expressed as number of deployed hooks, fishing time or other parameter</td>
</tr>
<tr>
<td>EFFORT_UN</td>
<td>Fishing effort unit (e.g. hooks, hours)</td>
</tr>
<tr>
<td>SPEC_NAME</td>
<td>Name of the species caught</td>
</tr>
<tr>
<td>NUMKEPT</td>
<td>Number of individuals caught and kept for the above species</td>
</tr>
<tr>
<td>NUMRELEASE</td>
<td>Number of individuals caught and released for the above species (optional)</td>
</tr>
<tr>
<td>X1</td>
<td>Longitude of the location in which the deployment of the fishing set started</td>
</tr>
<tr>
<td>Y1</td>
<td>Latitude of the location in which the deployment of the fishing set started</td>
</tr>
<tr>
<td>X2</td>
<td>Longitude of the location in which the deployment of the fishing set ended (optional)</td>
</tr>
<tr>
<td>Y2</td>
<td>Latitude of the location in which the deployment of the fishing set ended (optional)</td>
</tr>
<tr>
<td>X3</td>
<td>Longitude of the location in which the hauling of the fishing set started (optional)</td>
</tr>
<tr>
<td>Y3</td>
<td>Latitude of the location in which the hauling of the fishing set started (optional)</td>
</tr>
<tr>
<td>X4</td>
<td>Longitude of the location in which the hauling of the fishing set ended (optional)</td>
</tr>
<tr>
<td>Y4</td>
<td>Latitude of the location in which the hauling of the fishing set ended (optional)</td>
</tr>
</tbody>
</table>
Once familiar with the logic behind the data processing it will be possible to use the available fields in a wider way than the one specified.

These are just some examples: in the field NUMKEPT and NUMRELEASE the weight of the catch could be stored rather than the number of fish caught. In the SPEC_NAME it could be interesting to put fish size classes rather than species, etc.
Vector output: Fishing set location

- **Points:**
  - Up to 6 coordinate choices (e.g. start and end of settings, start and end of hauling, setting midpoint, hauling midpoint)

- **Lines:**
  - Combination of 2 or more (up to 6) coordinates for each fishing set
Raster output: Catch, Effort, CPUE

- Density analysis
- Map algebra
Density analysis

- The GIS analysis that can best represent the pattern of non-continuous phenomena (fishing is a discrete phenomenon in space and time) is the density analysis.

- A density analysis allows calculating and displaying the concentration of discrete features in space (e.g. density of fishing points) or also of a feature attribute
Density analysis

- Density surfaces are created in the GIS as a raster layer. This is a grid of cells where each cell is allocated a density value based on the number of features within an area around the cell center.
- The area around the cell is called neighborhood and is based on a search radius.
- For each cell in the raster the GIS totals the number of features that fall within the neighborhood and divides that number by the area of the neighborhood and refers it to a chosen uniform area unit.
- This results in a smoothed surface representing feature density.
If we are mapping hook density based on the number of hooks deployed at each fishing point, the GIS would identify the fishing points that fall in the neighbourhood, sum the number of hooks associated to these fishing points and divide the number by the area of the neighbourhood.
Each output cell's density value represents the occurrence of the measured quantity per specified area unit.

Example: Number of Hooks per Square km
CELL SIZE

- Shall be based on:
  - Original data resolution (coordinates are stored in degree and minutes)/ minimum distance between points
  - Processing time
  - Desired smoothness of the results at the chosen scale (American Samoa EEZ)
EFFECT OF CELL SIZE
SEARCH RADIUS

- Smaller search radius highlight local variation
- Bigger radius generate a smoother surface and show more generalized patterns
EFFECT OF SEARCH RADIUS

10 km

30 km

50 km

100 km
The density of fishes in each cell in the catch density raster is divided by the density of effort units in the correspondent cell in the effort density raster to obtain the catch per unit of effort raster.

Manipulating or combining information from one or more input rasters into an output raster, on a cell by cell base, is a GIS operation referred to as “map algebra”.
Examples of output
American Samoa Longline Fishery
Hook Density 2002

Legend:
Number of Hook per Square Km

- 0.0 - 15.0
- 15.0 - 30.0
- 30.0 - 45.0
- 45.0 - 60.0
- 60.0 - 75.0
- 75.0 - 90.0
- 90.0 - 105.0
- 105.0 - 120.0
- 120.0 - 135.0
- 135.0 - 150.0

Produced by Francesca Rich, Department of Marine and Wildlife Resources
American Samoa Long Line Fishery
Hook Density January 2002

Legend:
Number of Hooks per Square Km
- 0,000 - 5,000
- 5,000 - 10,000
- 10,000 - 15,000
- 15,000 - 20,000
- 20,000 - 25,000
- 25,000 - 30,000
- 30,000 - 35,000
- 35,000 - 40,000
- 40,000 - 45,000
- 45,000 - 50,000

Produced by Francesca Ricks, Department of Marine and Wildlife Resources
American Samoa Long Line Fishery
Hook Density May 2002

Legend:
Number of Hooks per Square Km

- 0,000 - 5,000
- 5,000 - 10,000
- 10,000 - 15,000
- 15,000 - 20,000
- 20,000 - 25,000
- 25,000 - 30,000
- 30,000 - 35,000
- 35,000 - 40,000
- 40,000 - 45,000
- 45,000 - 50,000

Produced by Francesca Risk, Department of Marine and Wildlife Resources
Demo
Web component

The web component allows to easily serve pre-made plots over the web as animations or single graphic files by offering to the users a friendly and immediate searching and animation building interface.
Who is using FA

The Pacific Islands Fisheries Science Center/NOAA Fisheries - Hawaii
Wide variety of fisheries monitoring and research in the Pacific Islands Region and surrounding international waters.

National Institute of Aquatic Resources of the Technical University of Denmark
study fisheries and stock spatial dynamics of key commercial species such as herrings, flounders and cod in the North Sea and North Atlantic.
Who is using FA

Gulf of Mexico Sustainable Fisheries Division, National Marine Fisheries Service (NMFS) - USA
Fishery Analyst to analyse catch and effort data on red snapper, shrimp, reef fish and spiny lobsters fisheries.

Department of Marine and Wildlife Resources - American Samoa
Spatial distribution of commercial longline fishery activities

www.mappamondogis.com
CONCLUSIONS

- FA adds the intrinsic spatial component to the original data providing a powerful analysis and visualization tool to be used for scientific analysis and decision making processes.
- Rise interesting questions/answers
- Highlights patterns
- The system is flexible and able to answer several questions spanning several spatial and temporal scales
Example of further elaborations

- Study of the relation of fishery dynamics with other physical and biological parameters (e.g. Sea Surface Temperature and Ocean Color)

Statistical Inference on CPU Trends, Fishing Area estimations
ACKNOWLEDGEMENT

- Fisheries Monitoring and Socioeconomics Division of the NOAA Pacific Island Fishery Science Center and David Hamm, chief of the division, have provided large contribution to the development of Fishery Analyst recognising it was a much needed product.
CONTACT INFO

Francesca Riolo
GIS Specialist
Mappamondo GIS

URL: http://www.mappamondogis.it/fisheryanalyst_en.htm
Email: francesca.riolo@mappamondogis.com
Ph: +39 3386246285