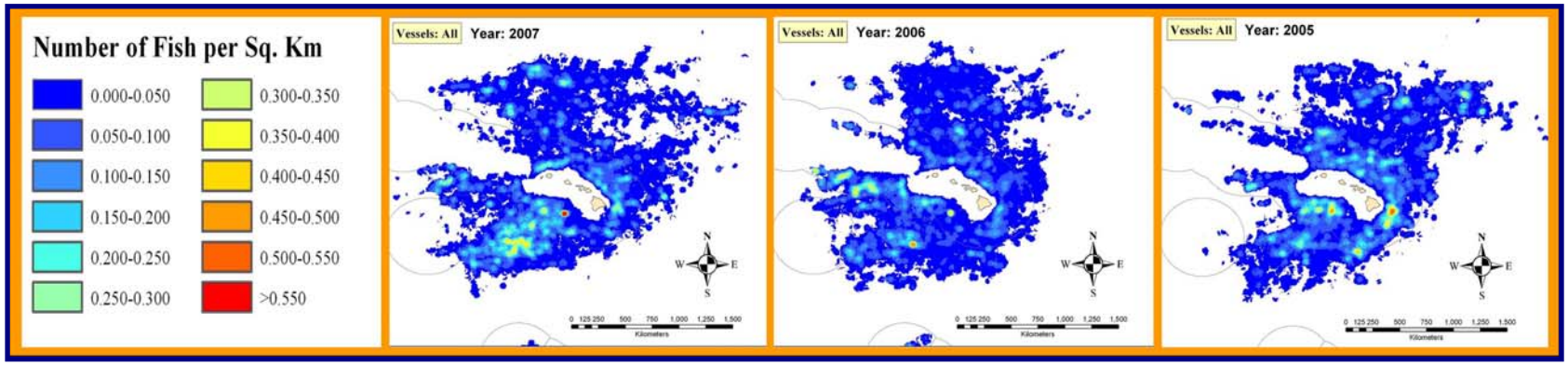
Fishery Analyst for ArcGIS 9.x



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ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

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 ArcObjetcs

- 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)
- Asses 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.

LOGBOOK	FISHDATE	VESSELNAME	CONFCODE	EFFORT	EFFORT_UN	SPEC_NAME	NUMKEPT	NUMRELEASE	X1	Y1	....optional fields
4056	7/5/1998	Laos	Laos	1000	HOOKS	BLUE MARLIN	120	56	157.547	24.886	.....
4056	7/5/1998	Laos	Laos	1000	HOKKS	ALBACORE	106	49	156.847	25.570	.....
4056	7/5/1998	Laos	Laos	1000	HOOKS	BIGEYE	131	61	157.294	23.987	.....
4056	7/5/1998	Laos	Laos	1000	HOKKS	YELLOWFIN	29	13	157.019	25.135	.....
4051	7/2/1998	Burundi	Burundi	950	HOOKS	BLUE MARLIN	134	62	160.358	22.101	.....
4051	7/2/1998	Burundi	Burundi	950	HOKKS	SWORDFISH	134	20	160.843	21.709	.....
4051	7/2/1998	Burundi	Burundi	950	HOOKS	BLUE SHARK	42	38	159.081	23.057	.....
4051	7/2/1998	Burundi	Burundi	950	HOKKS	THRESHER	24	11	159.092	22.107	.....
4051	7/2/1998	Burundi	Burundi	950	HOOKS	MAHIMAHI	8	4	160.946	22.785	.....
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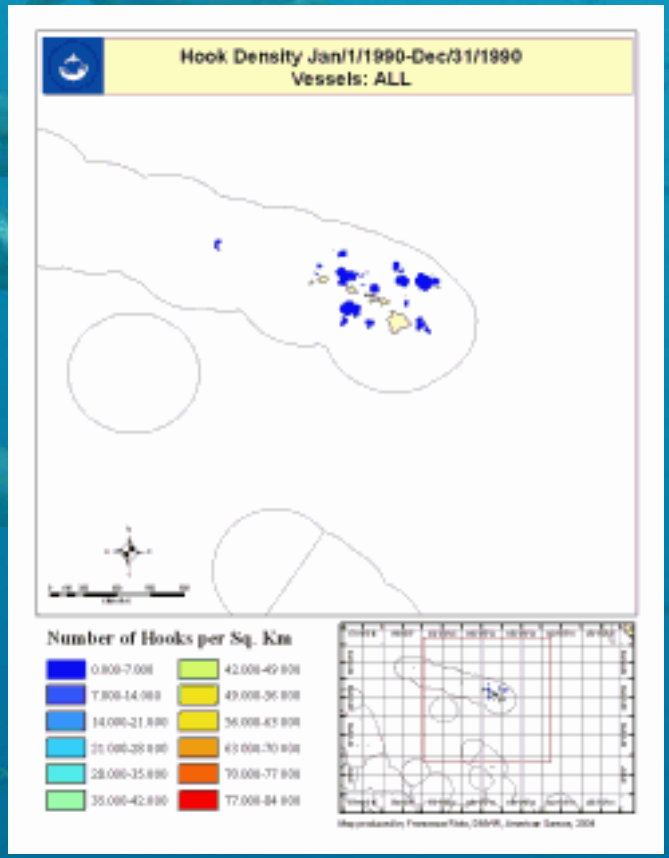
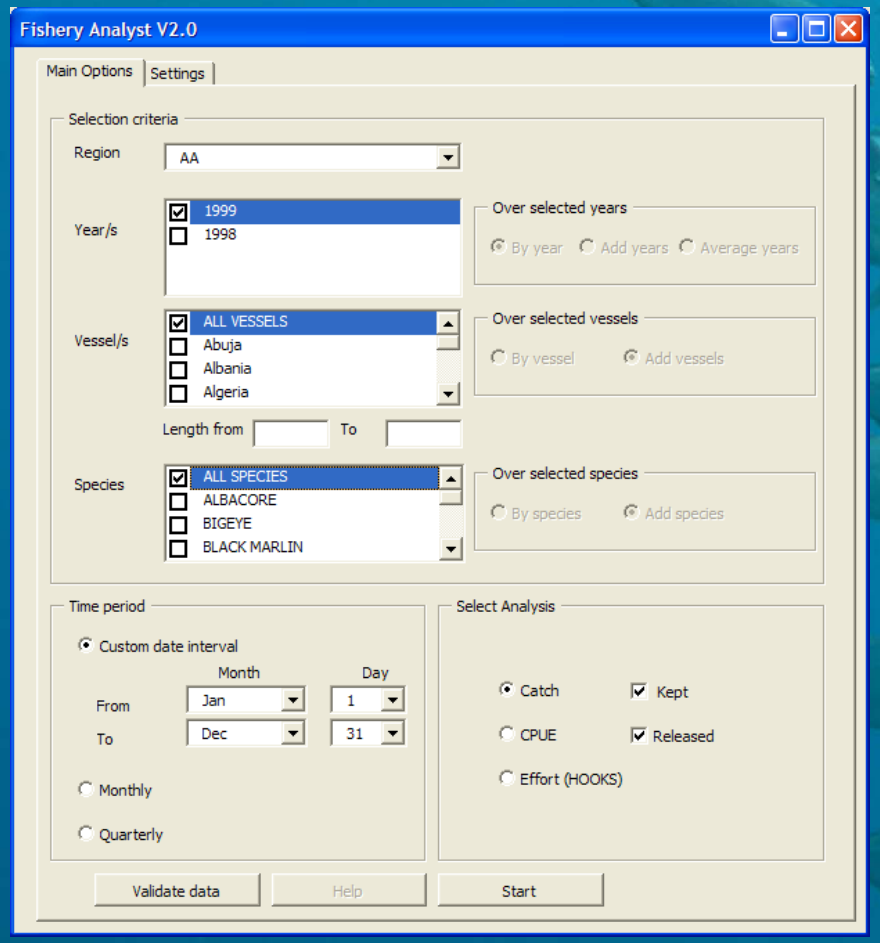
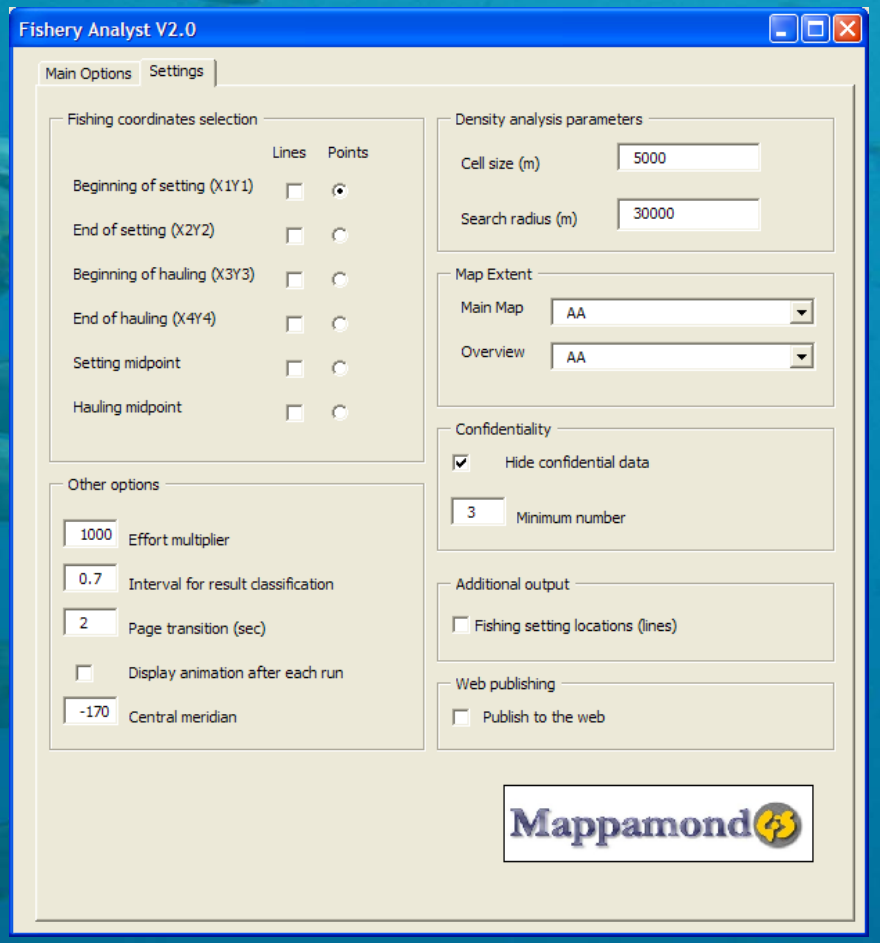


VBA/ArcObjects Routines

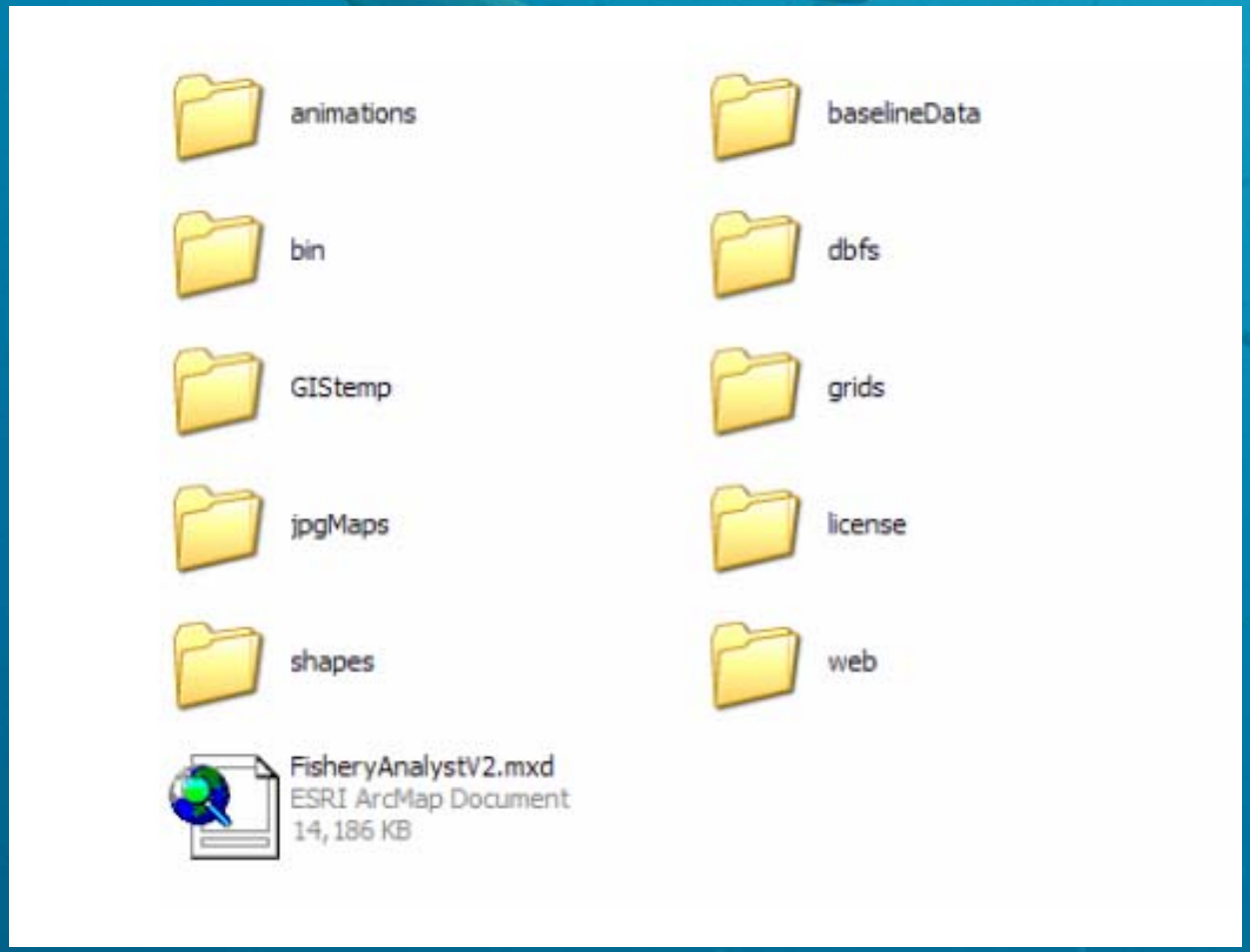
- Batch processing capabilities
- Convert raw tabular data to vector spatial datasets, points and line representation (SHAPEFILES)
- Perform catch, CPUE and effort calculation based on selection criteria
- Generate density analysis outputs in raster format (GeoTIFFS)
- Map layouts into graphic files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

INTERFACE


Fishery Analyst V2.0
Main Options
Settings
Selection criteria
Region
AA
Year/s
1999
1998
Over selected years
By year
Add years
Average years
Vessel/s
ALL VESSELS
Abuja
Albania
Algeria
Over selected vessels
By vessel
Add vessels
Length from
To
Species
ALL SPECIES
ALBACORE
BIGEYE
BLACK MARLIN
Over selected species
By species
Add species
Time period
Custom date interval
Month
Day
From
Jan
1
To
Dec
31
Monthly
Quarterly
Select Analysis
Catch
Kept
CPUE
Released
Effort (HOOKS)
Validate data
Help
Start

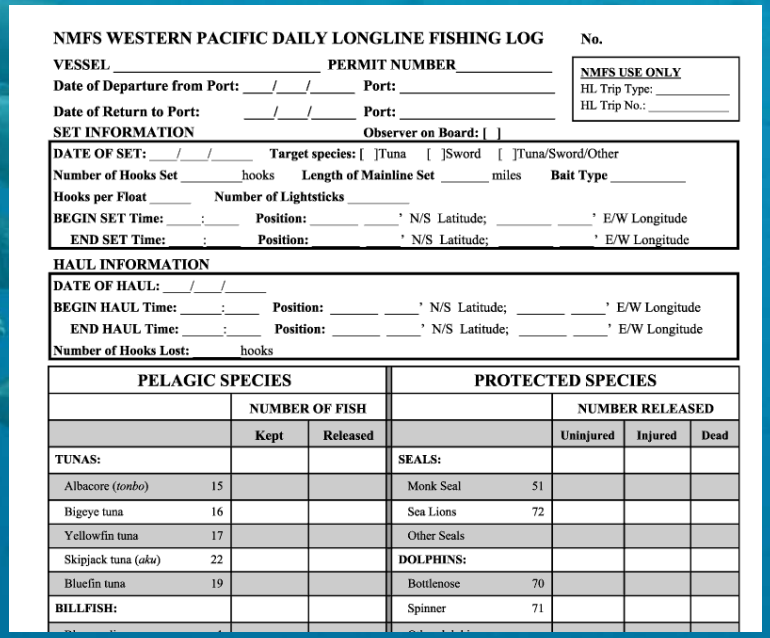

Fishery Analyst V2.0
Main Options
Settings
Fishing coordinates selection
Lines
Points
Beginning of setting (X1Y1)
End of setting (X2Y2)
Beginning of hauling (X3Y3)
End of hauling (X4Y4)
Setting midpoint
Hauling midpoint
Other options
1000
Effort multiplier
0.7
Interval for result classification
2
Page transition (sec)
Display animation after each run
-170
Central meridian
Density analysis parameters
Cell size (m)
5000
Search radius (m)
30000
Map Extent
Main Map
AA
Overview
AA
Confidentiality
Hide confidential data
3
Minimum number
Additional output
Fishing setting locations (lines)
Web publishing
Publish to the web
Mappamond

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



NMFS WESTERN PACIFIC DAILY LONGLINE FISHING LOG No.

VESSEL _____ PERMIT NUMBER_____

Date of Departure from Port: ___/___/_____ Port: _____

Date of Return to Port: ___/___/_____ Port: _____

NMFS USE ONLY
HL Trip Type: _____
HL Trip No.: _____

SET INFORMATION Observer on Board: [ ]

DATE OF SET: ___/___/_____ Target species: [ ]Tuna [ ]Sword [ ]Tuna/Sword/Other

Number of Hooks Set _____hooks Length of Mainline Set _____ miles Bait Type _____

Hooks per Float _____ Number of Lightsticks _____

BEGIN SET Time: ____:____ Position: _____ ____' N/S Latitude; _____ ____' E/W Longitude

END SET Time: ____:____ Position: _____ ____' N/S Latitude; _____ ____' E/W Longitude

HAUL INFORMATION

DATE OF HAUL: ___/___/_____

BEGIN HAUL Time: ____:____ Position: _____ ____' N/S Latitude; _____ ____' E/W Longitude

END HAUL Time: ____:____ Position: _____ ____' N/S Latitude; _____ ____' E/W Longitude

Number of Hooks Lost: _____hooks

PELAGIC SPECIES		NUMBER OF FISH	
		Kept	Released
TUNAS:			
Albacore (*tonbo*)	15		
Bigeye tuna	16		
Yellowfin tuna	17		
Skipjack tuna (*aku*)	22		
Bluefin tuna	19		
BILLFISH:			

PROTECTED SPECIES		NUMBER RELEASED		
		Uninjured	Injured	Dead
SEALS:				
Monk Seal	51			
Sea Lions	72			
Other Seals				
DOLPHINS:				
Bottlenose	70			
Spinner	71			

Fishery Data

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

LOGBOOK	FISHDATE	VESSELNAME	CONFCODE	EFFORT	EFFORT_UN	SPEC_NAME	NUMKEPT	NUMRELEASE	X1	Y1	....optional fields
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Fishery Data

FIELD NAME	DESCRIPTION
LOGBOOK	**Unique identifier for each deployed fishing set**
FISHDATE	**Date in which the fishing set was deployed**
VESSELNAME	**Name of the fishing vessel**
CONFCODE	**Confidentiality code unique for each owner or vessel or else depending on policies**
LENGTH	Length of the fishing vessel (optional, for analysis based on vessel length)
EFFORT	**Fishing effort expressed as number of deployed hooks, fishing time or other parameter**
EFFORT_UN	**Fishing effort unit (e.g. hooks, hours)**
SPEC_NAME	**Name of the species caught**
NUMKEPT	**Number of individuals caught and kept for the above species**
NUMRELEASE	Number of individuals caught and released for the above species (optional)
X1	**Longitude of the location in which the deployment of the fishing set started**
Y1	**Latitude of the location in which the deployment of the fishing set started**
X2	Longitude of the location in which the deployment of the fishing set ended (optional)
Y2	Latitude of the location in which the deployment of the fishing set ended (optional)
X3	Longitude of the location in which the hauling of the fishing set started (optional)
Y3	Latitude of the location in which the hauling of the fishing set started (optional)
X4	Longitude of the location in which the hauling of the fishing set ended (optional)
Y4	Latitude of the location in which the hauling of the fishing set ended (optional)

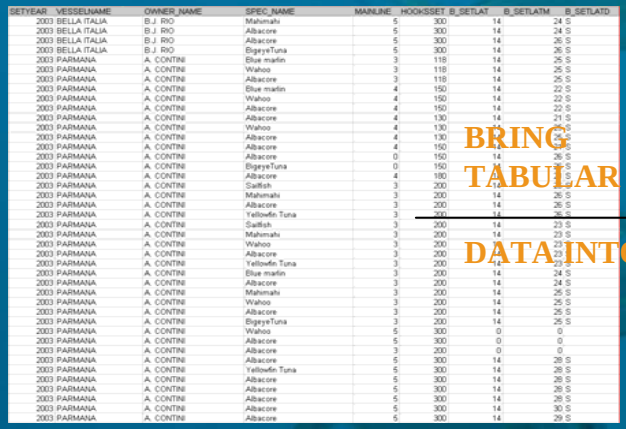
Flexibility

- Once familiar with the logic behind the data processing it will be possible to use the available fields in a wider way then 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 then species, etc.

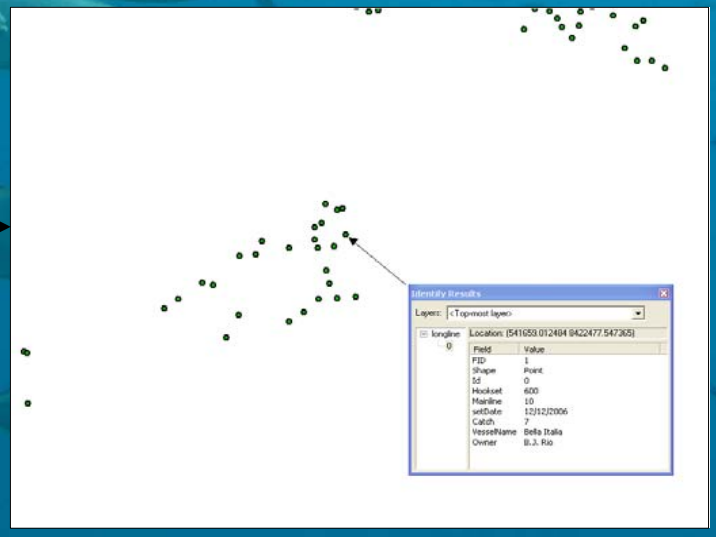
Output

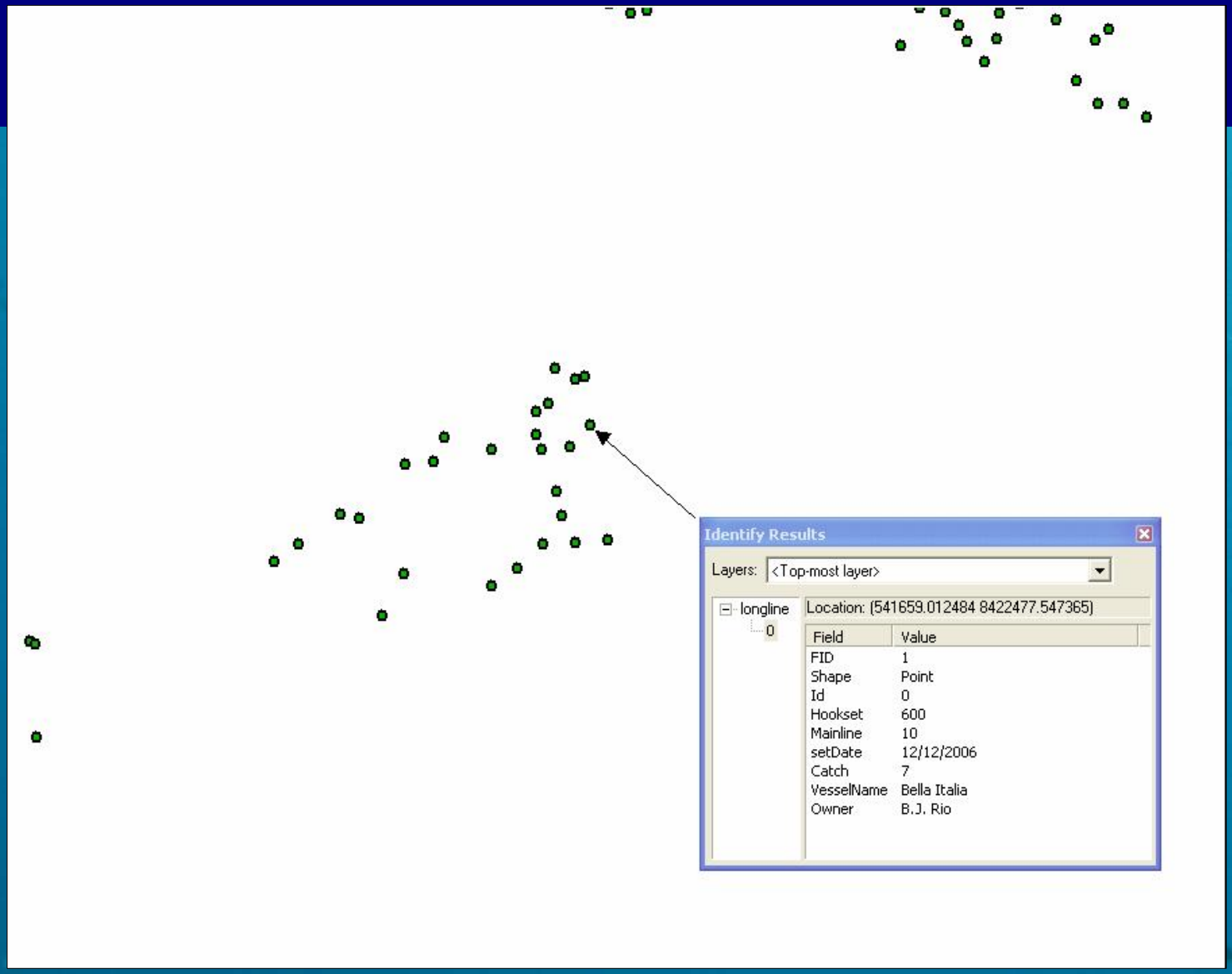
Vector output: Fishing set location

- 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



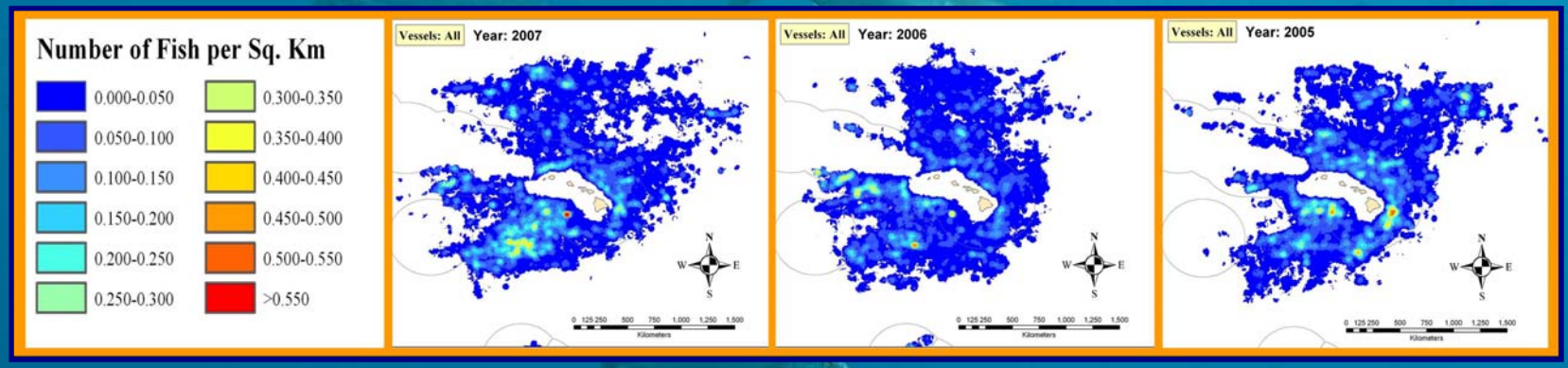
BRING TABULAR DATA INTO GIS




Identify Results
Layers: <Top-most layer>
longline
0
Location: (541659.012484 8422477.547365)
Field Value
FID 1
Shape Point
Id 0
Hookset 600
Mainline 10
setDate 12/12/2006
Catch 7
VesselName Bella Italia
Owner B.J. Rio

Raster output: Catch, Effort, CPUE

- Density analysis
- Map algebra

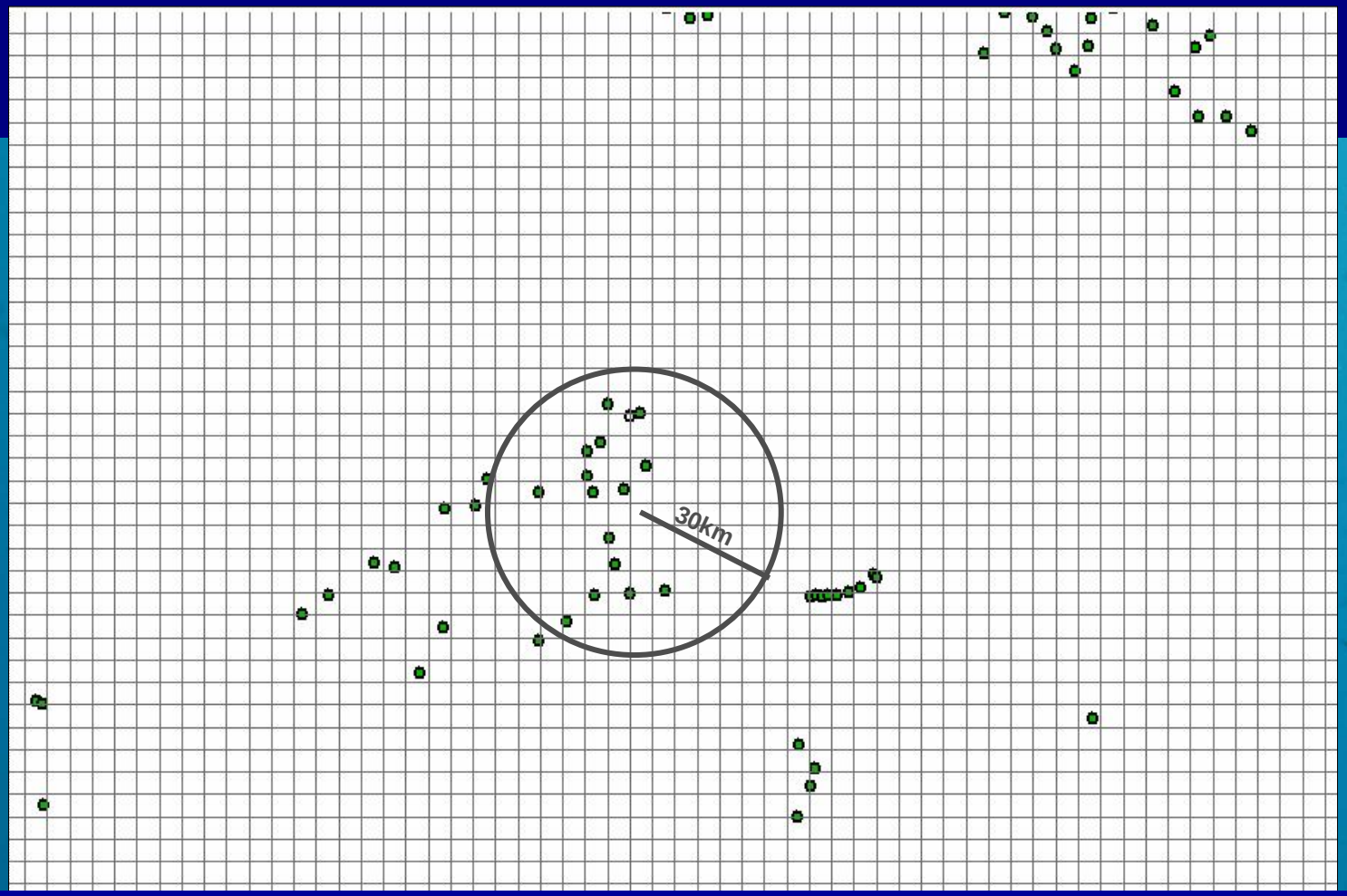


Density analysis

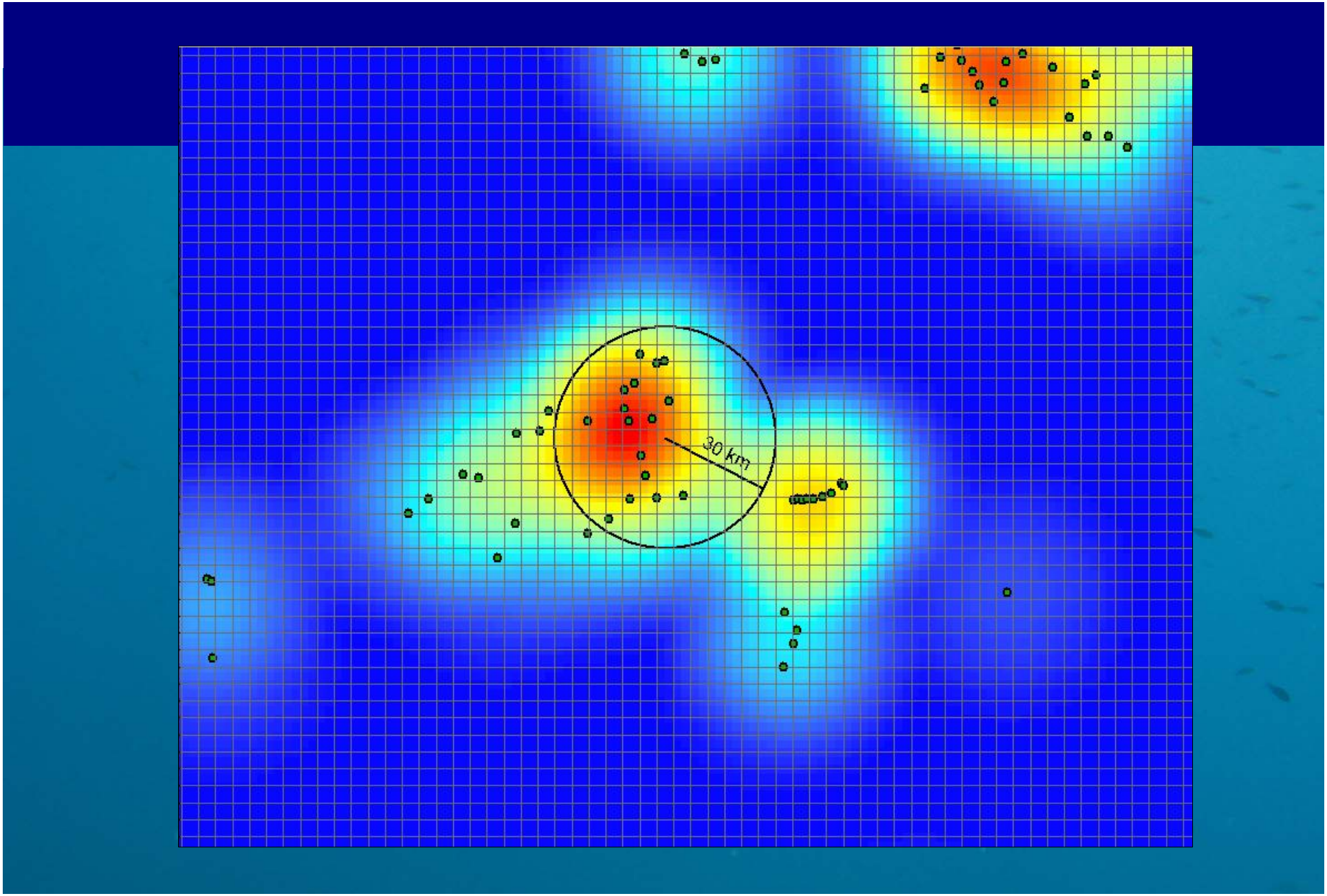
- The GIS analysis that can best represent the pattern of non-continuous phenomena (fishing is a discrete phenomenon in space and time) is the density analysis.
- A density analysis allows calculating and displaying the concentration of discrete features in space (e.g. density of fishing points) or also of a feature attribute

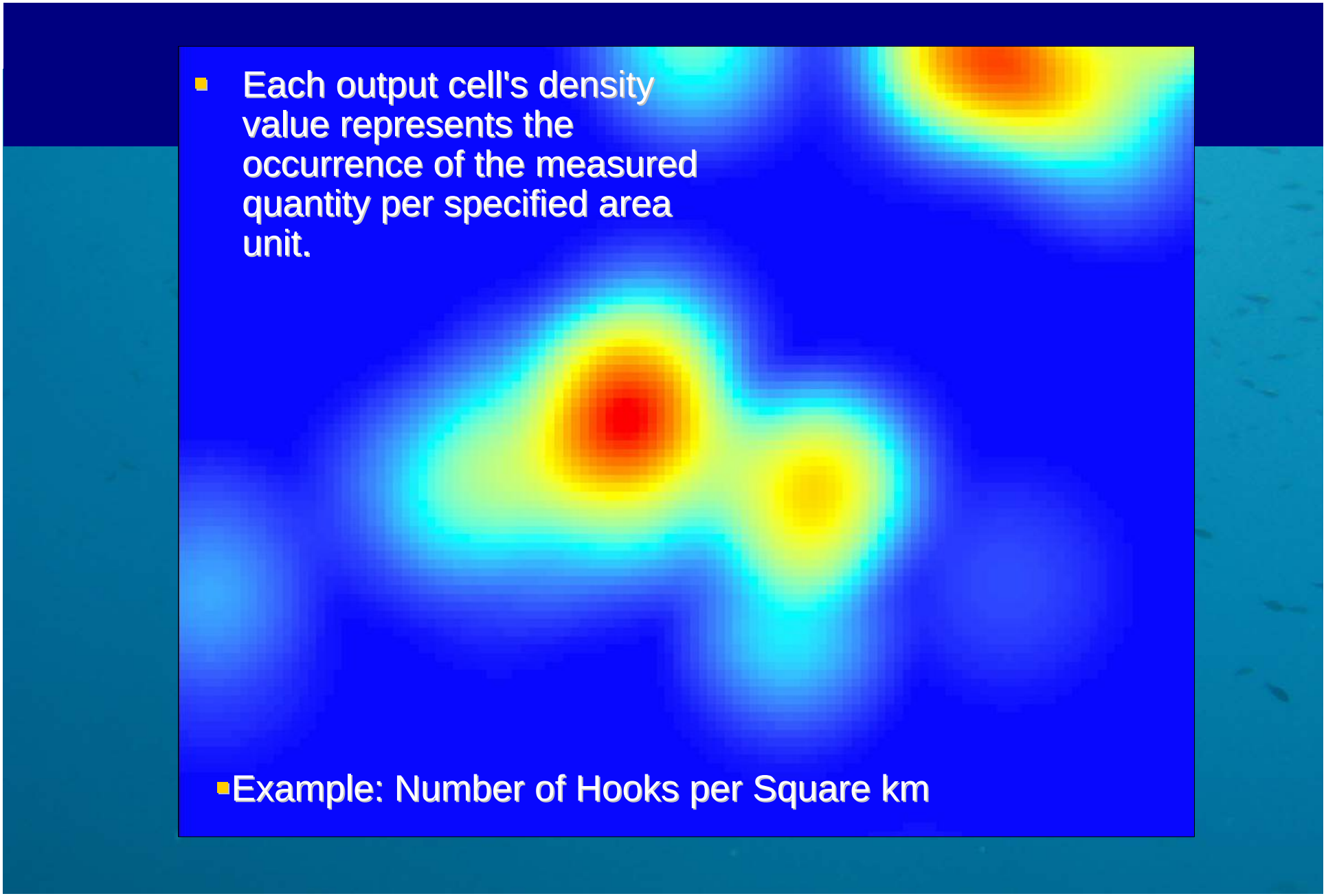
Density analysis

- 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.

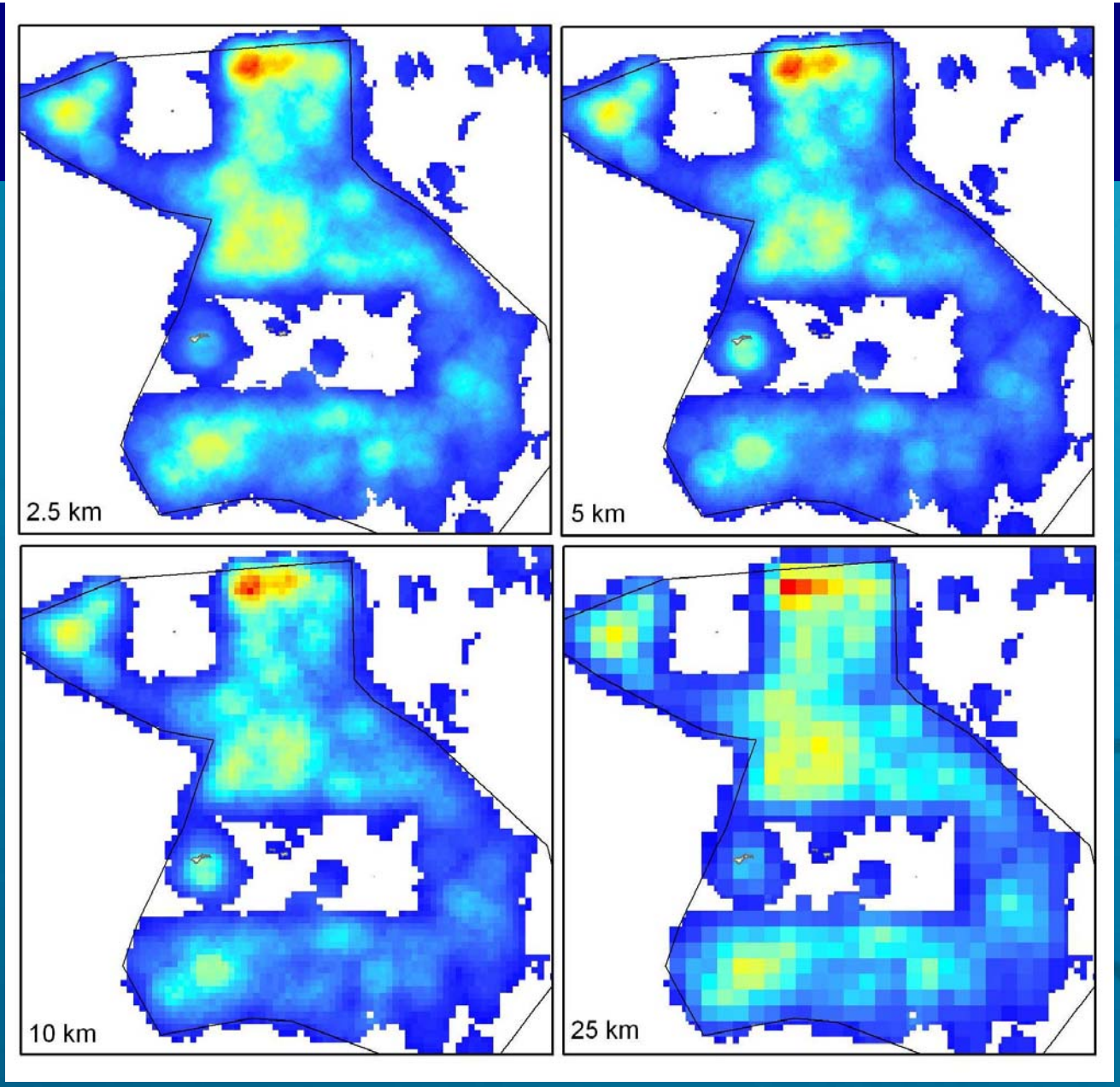

30 km


Each output cell's density value represents the occurrence of the measured quantity per specified area unit.
Example: Number of Hooks per Square km

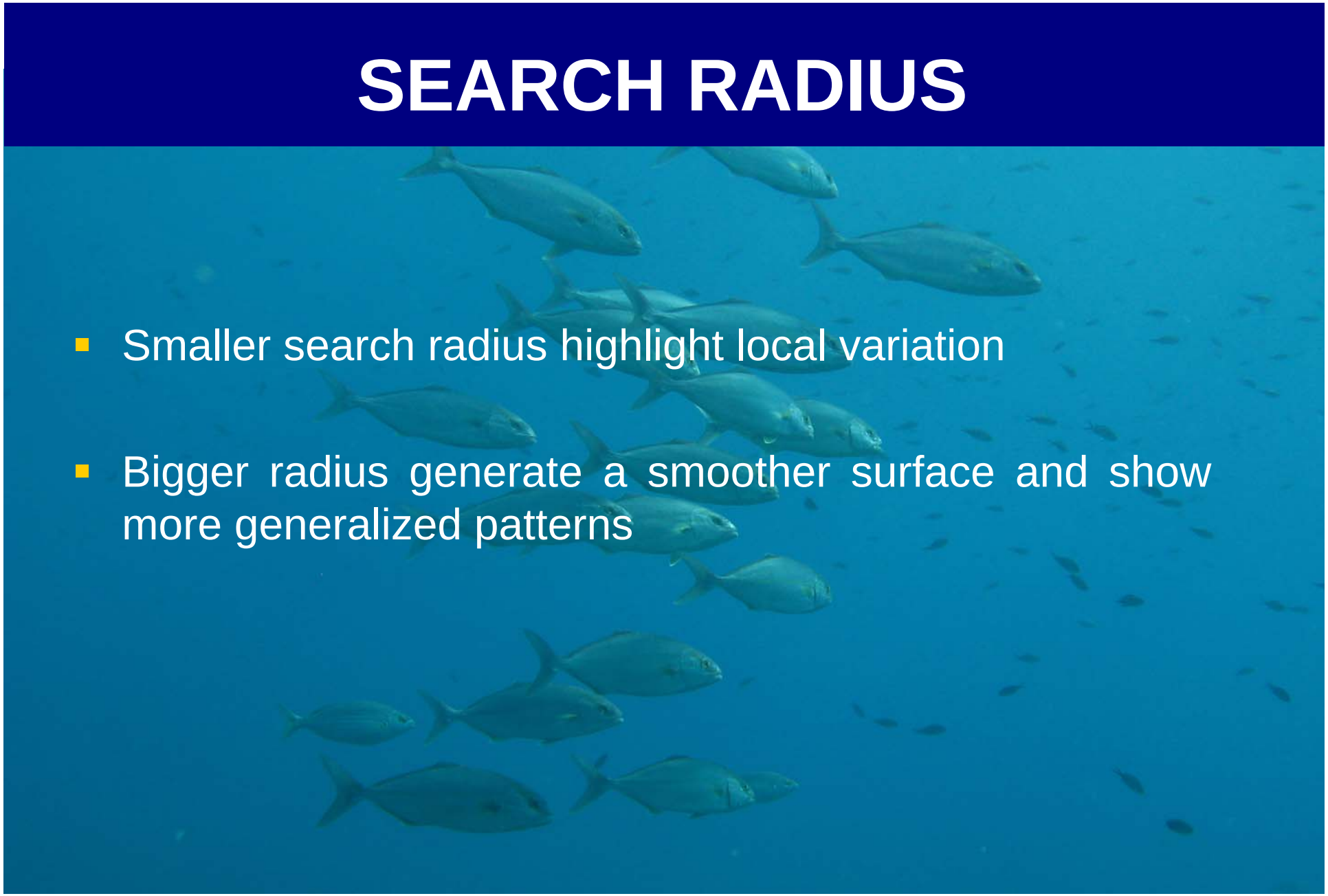
CELL SIZE

- 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

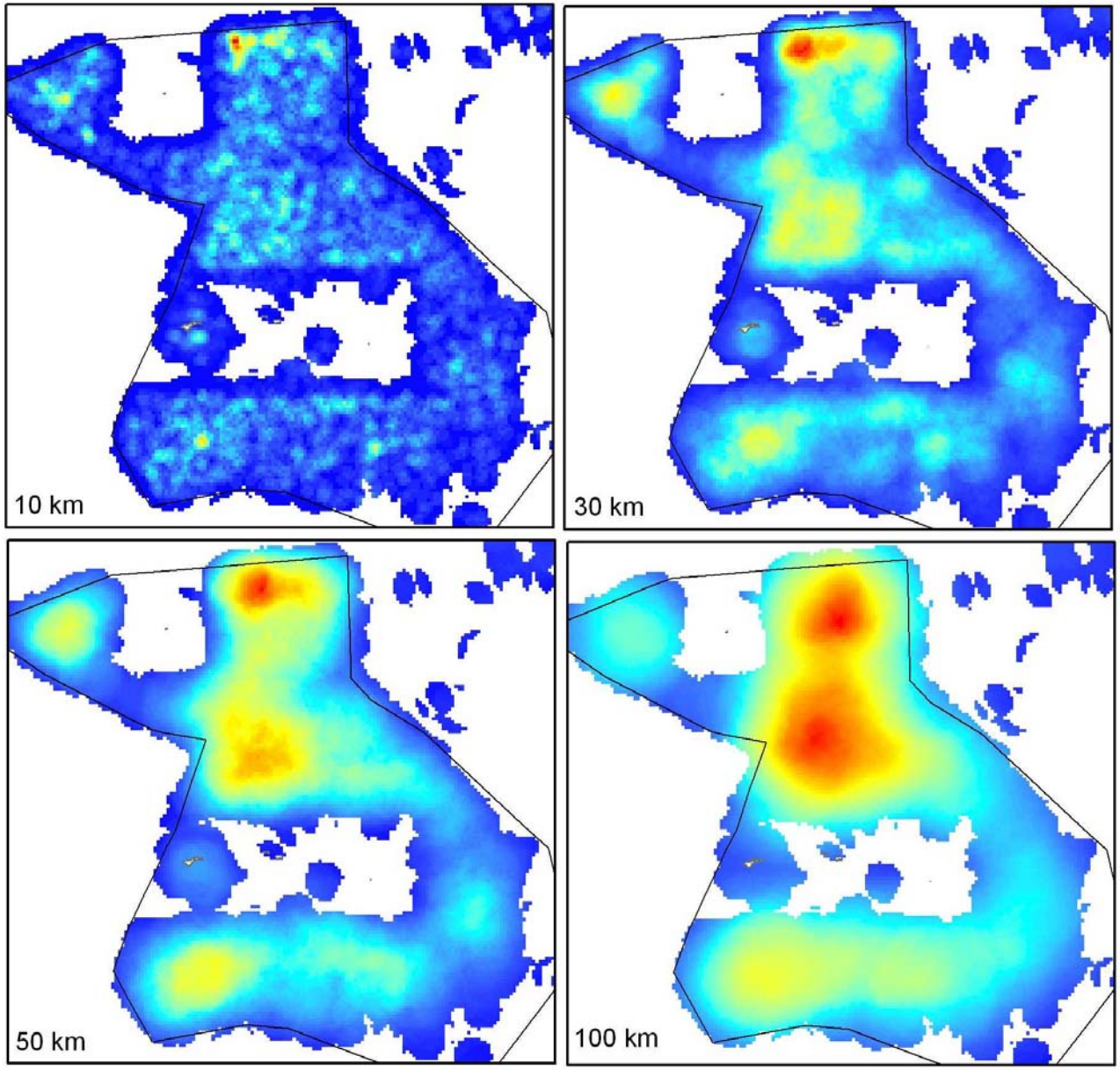


SEARCH RADIUS



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

EFFECT OF SEARCH RADIUS



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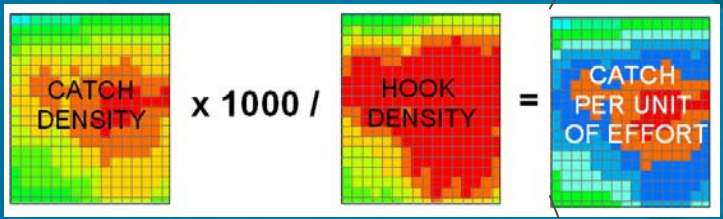
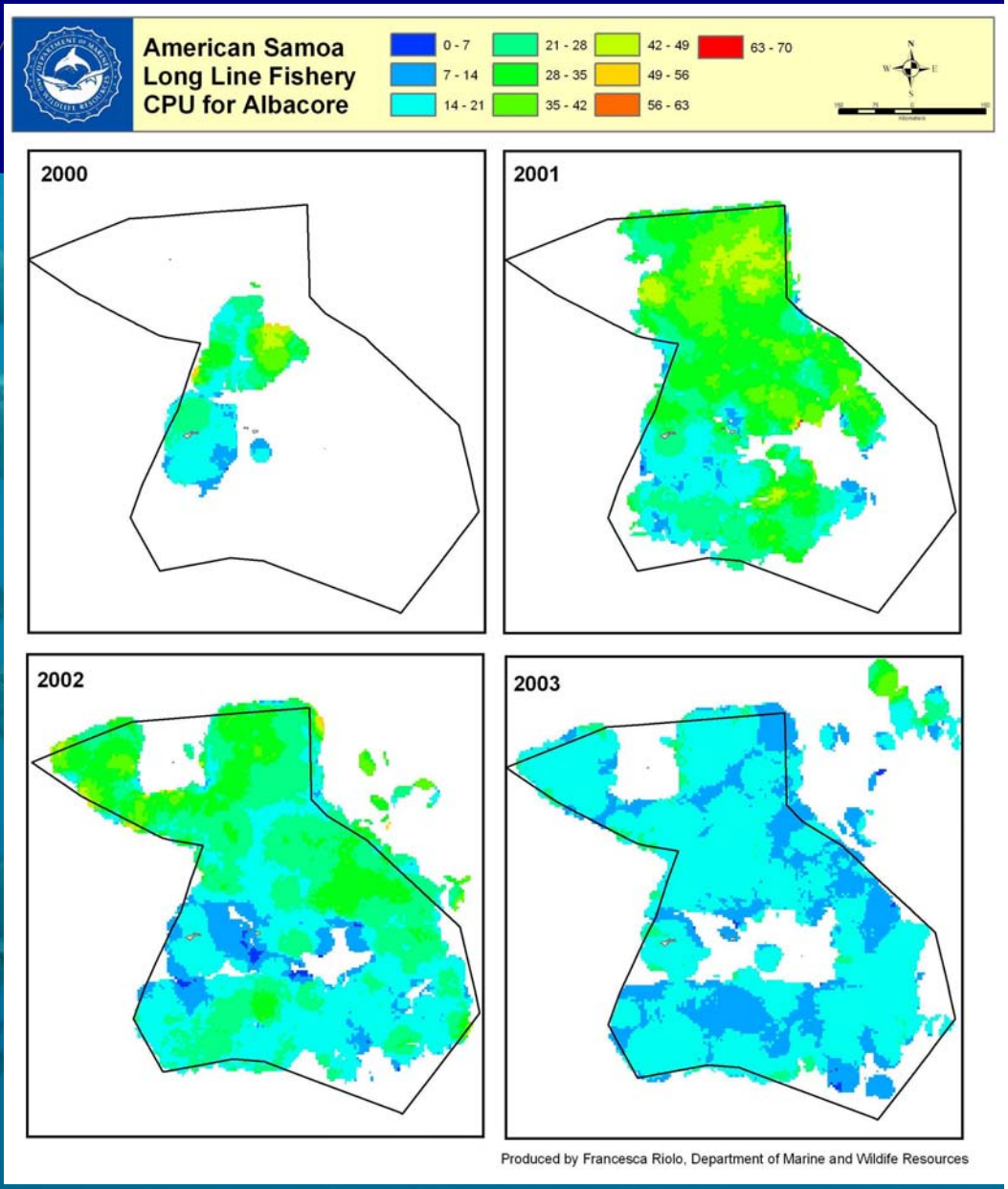
The density of fishes in each cell in the catch density raster is divided by the density of effort units in the correspondent cell in the effort density raster to obtain the catch per unit of effort raster.

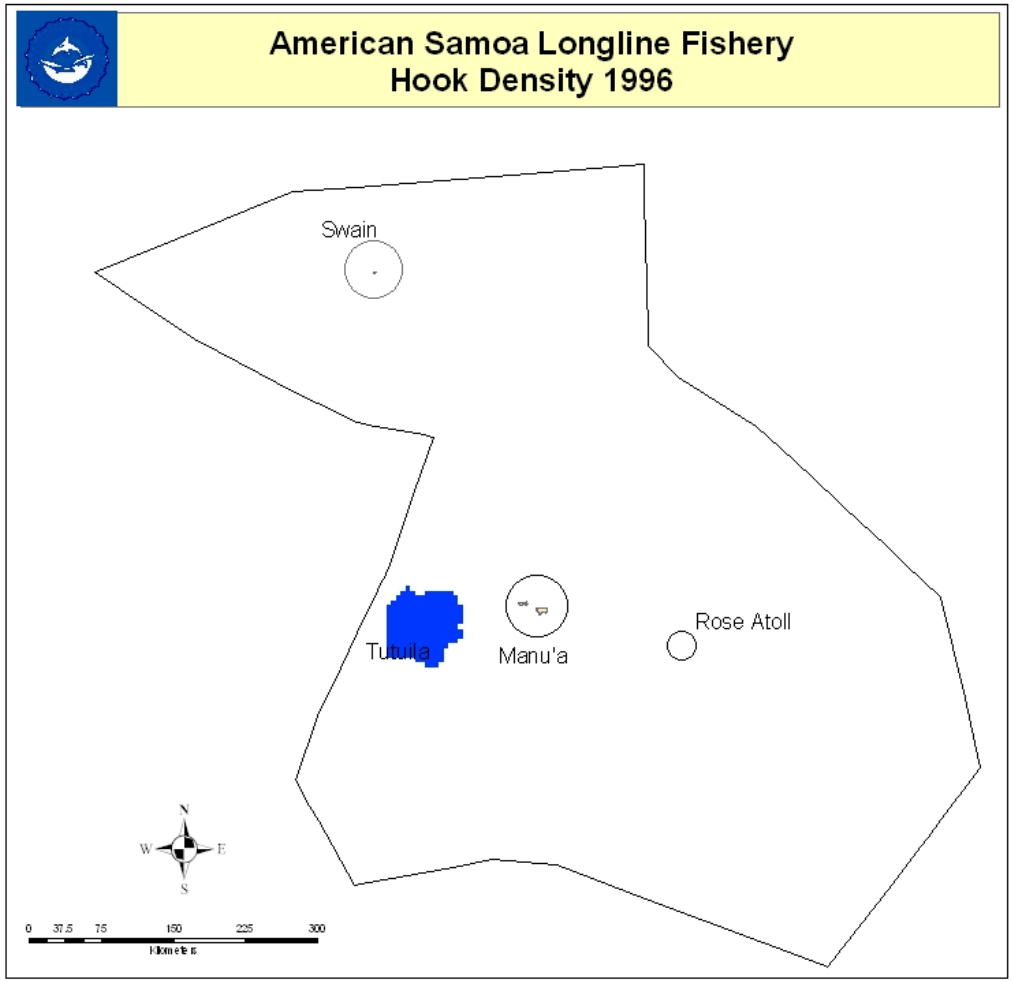


Manipulating or combining information from one or more input rasters into an output raster, on a cell by cell base, is a GIS operation referred to as ‘‘map algebra’’.



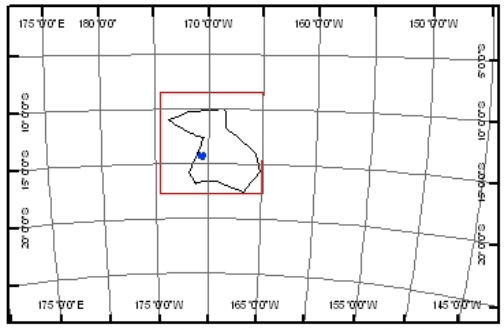
Examples of output

American Samoa Longline Fishery
Hook Density 1996



Legend:
Number of Hook per Square Km

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



Produced by Francesca Riolo, Department of Marine and Wildlife Resources

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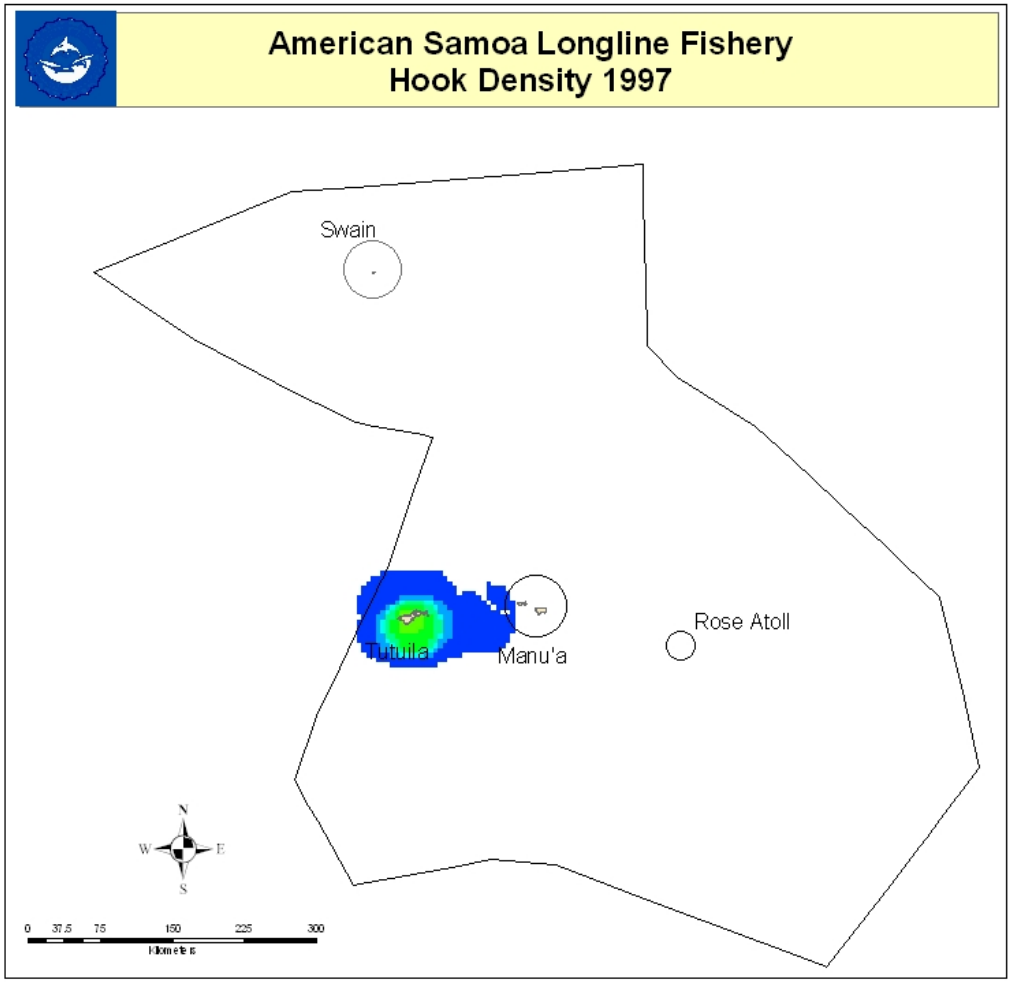
EBM ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Longline Fishery
Hook Density 1997



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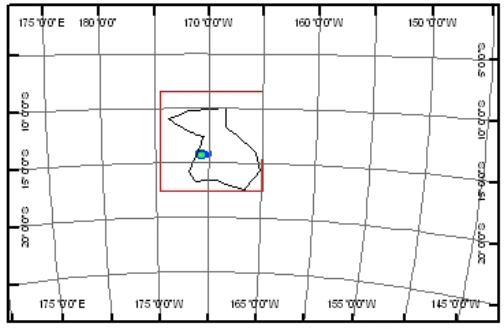

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ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Longline Fishery
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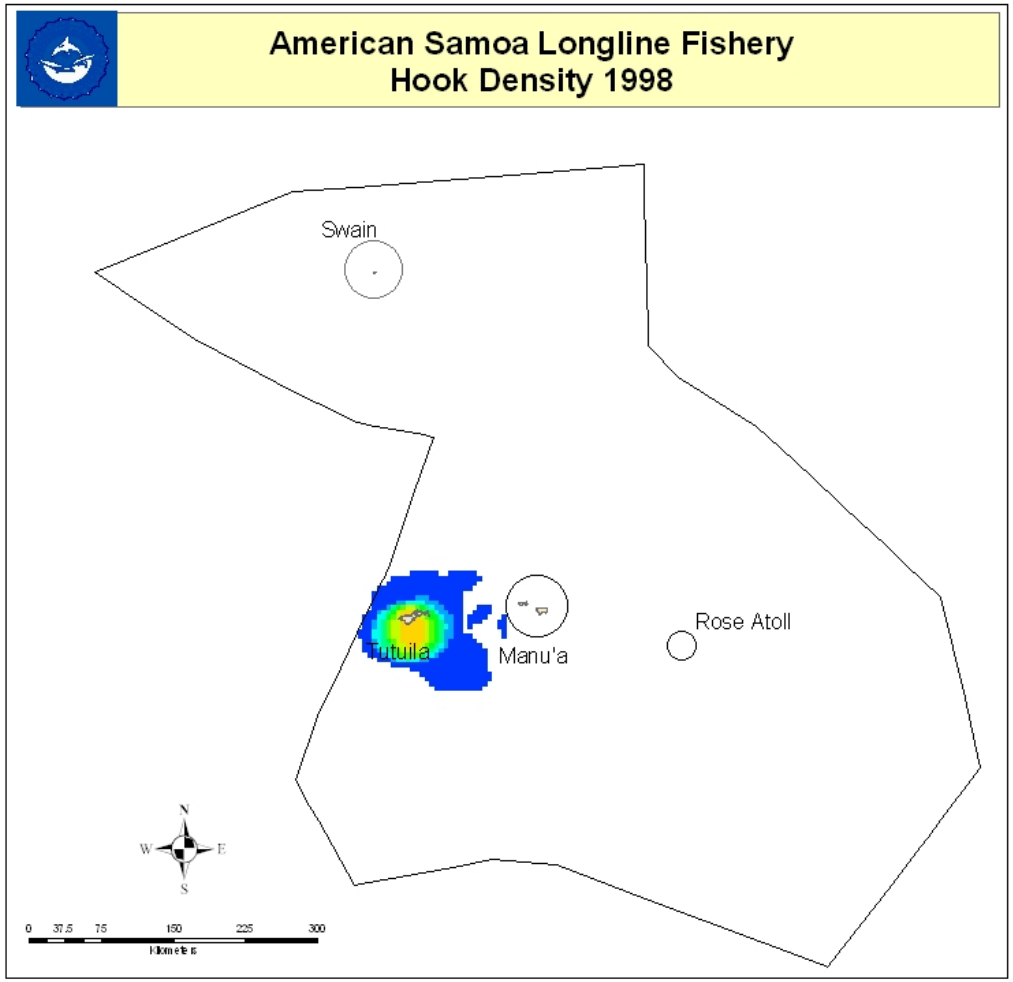

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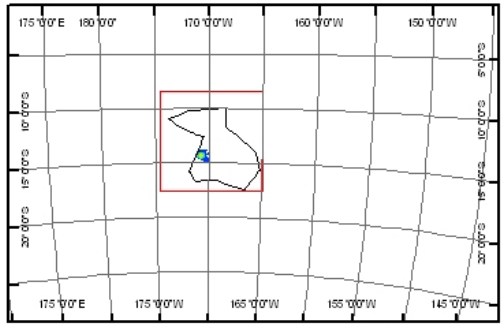

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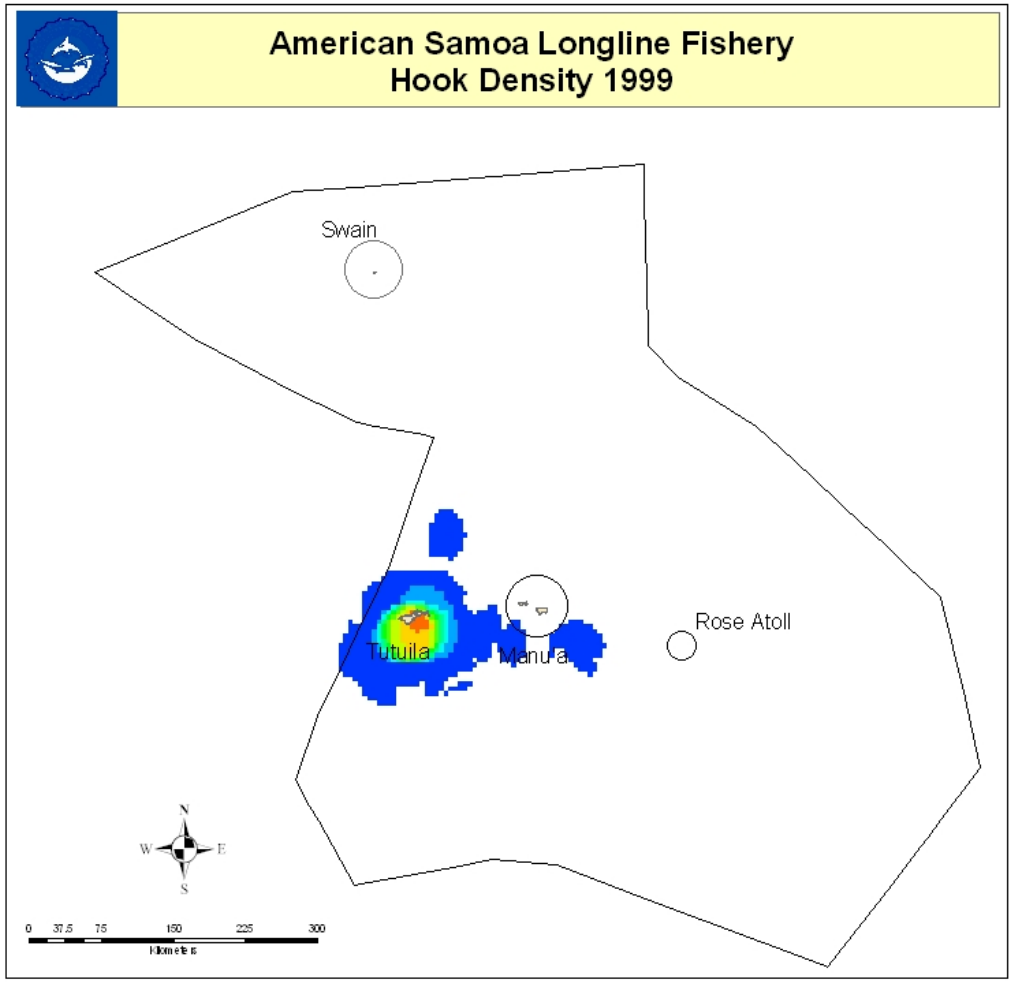

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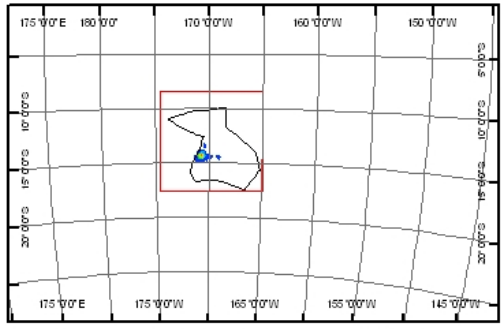

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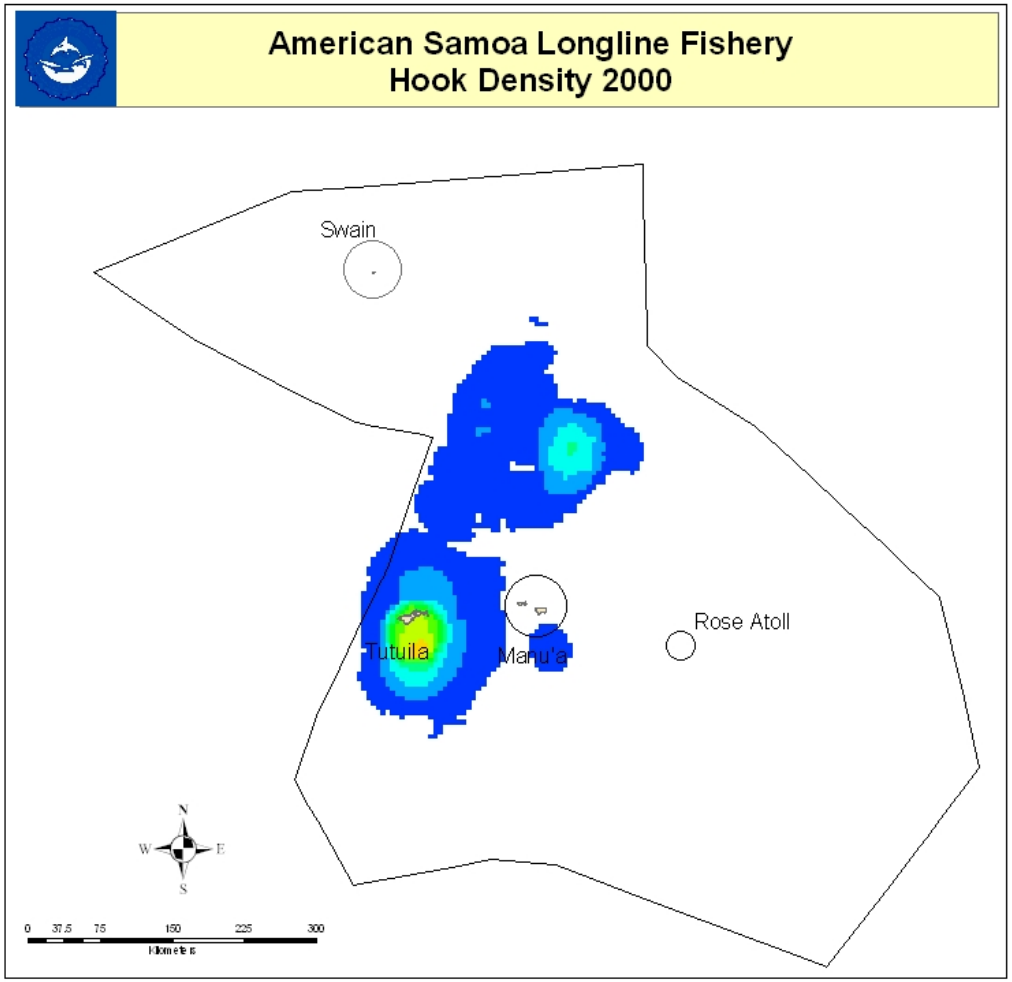
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Longline Fishery
Hook Density 2000



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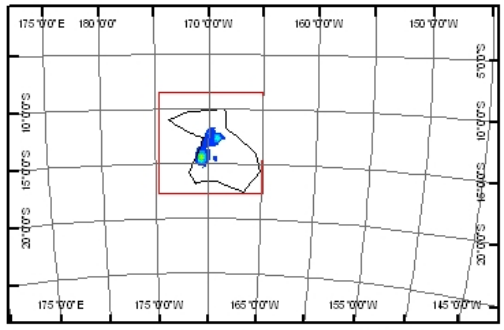

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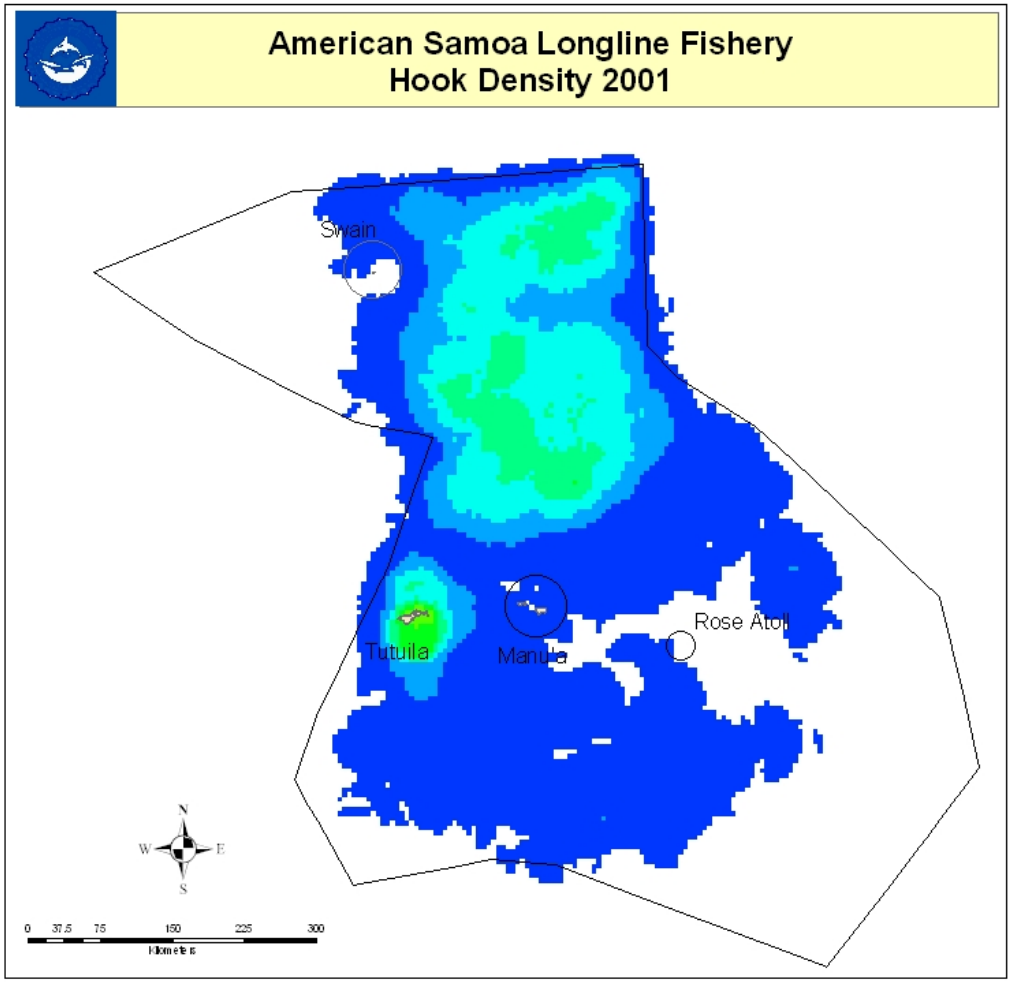
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Longline Fishery
Hook Density 2001



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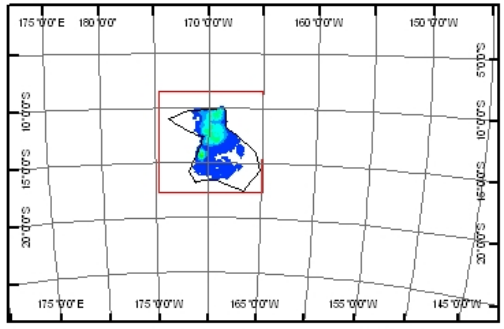
0.0 - 15.0	75.0 - 90.0
15.0 - 30.0	90.0 - 105.0
30.0 - 45.0	105.0 - 120.0
45.0 - 60.0	120.0 - 135.0
60.0 - 75.0	135.0 - 150.0



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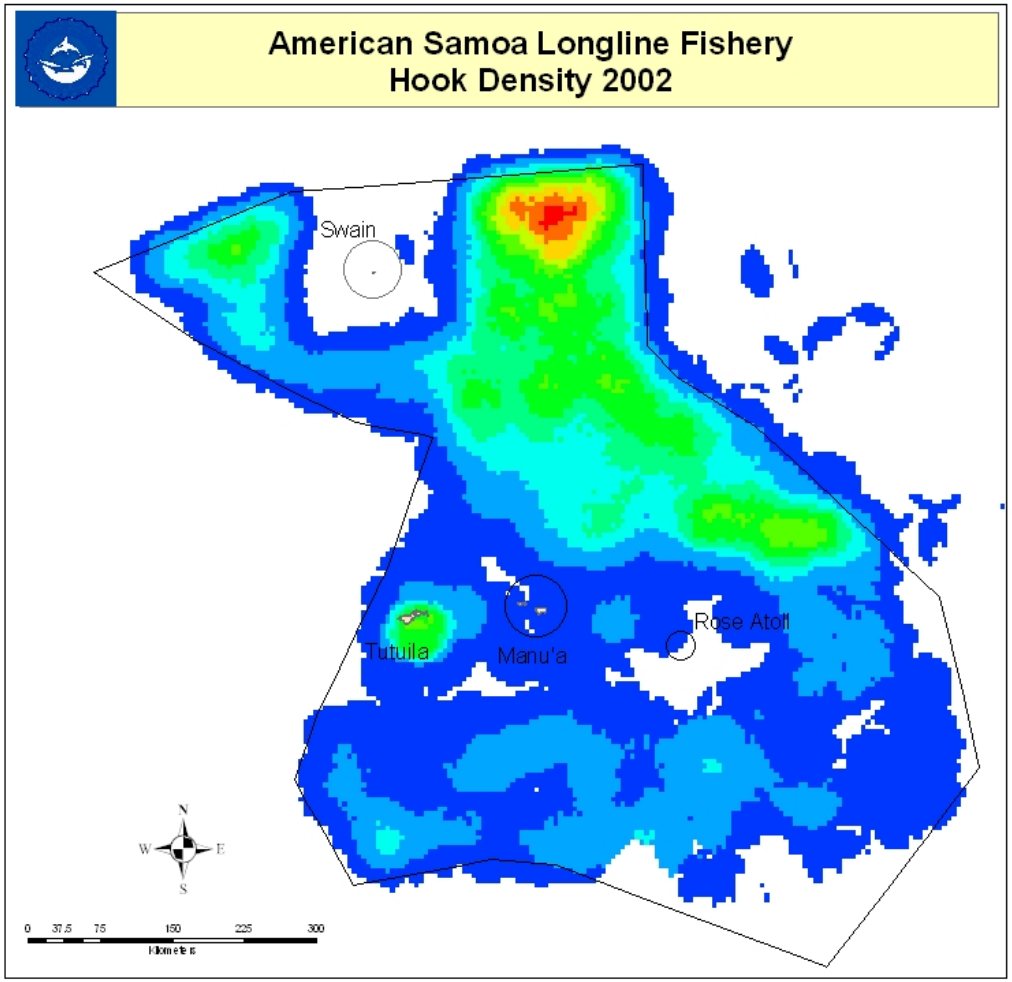
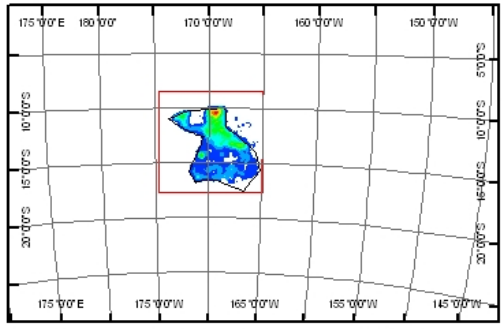
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Longline Fishery
Hook Density 2002



Legend:
Number of Hook per Square Km

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



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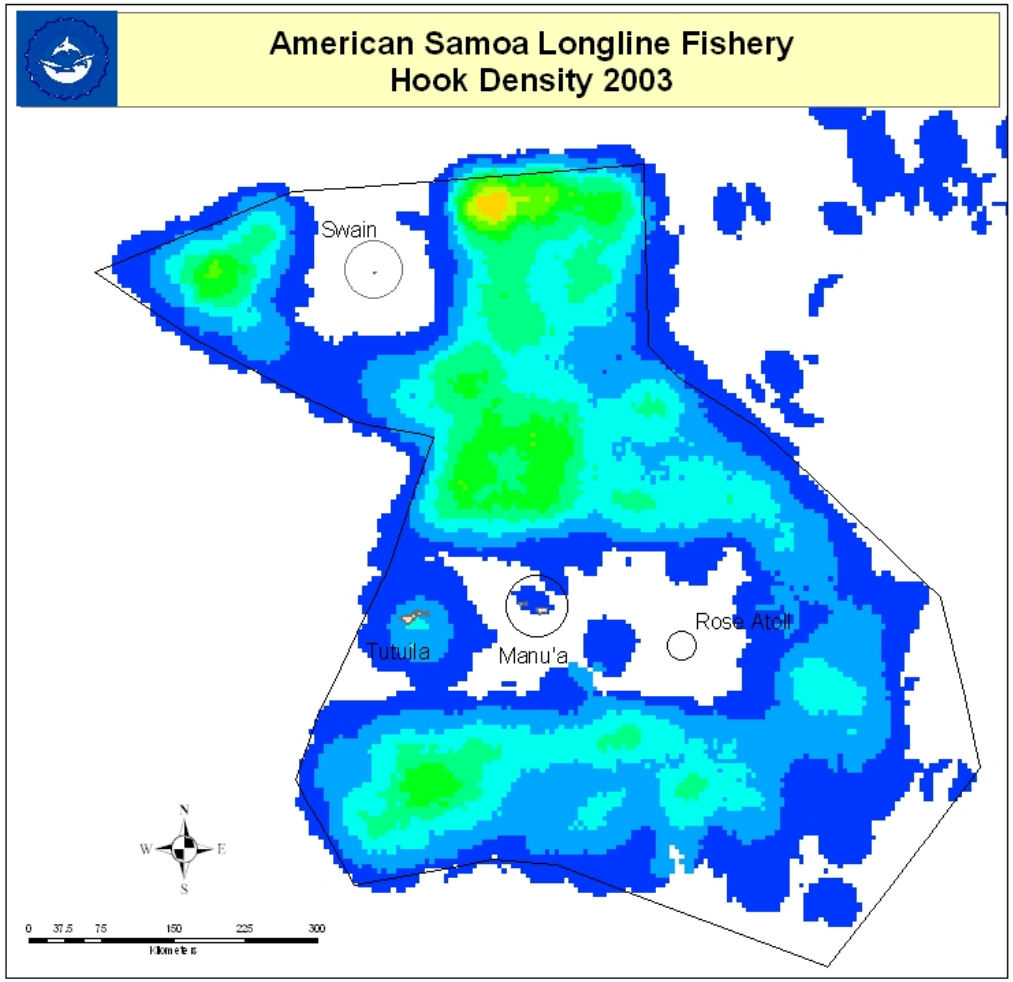
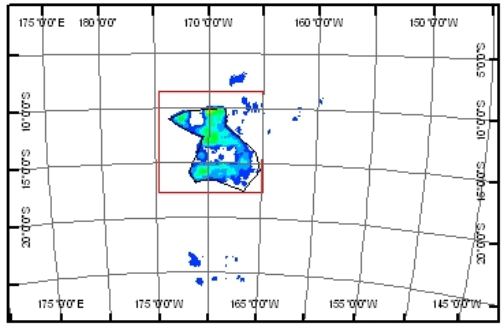
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Longline Fishery
Hook Density 2003



Legend:
Number of Hook per Square Km

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



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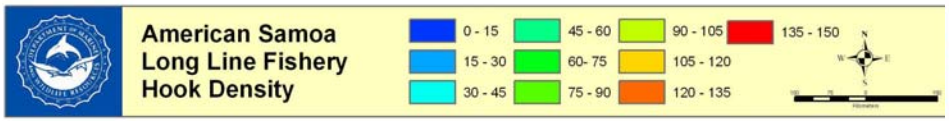
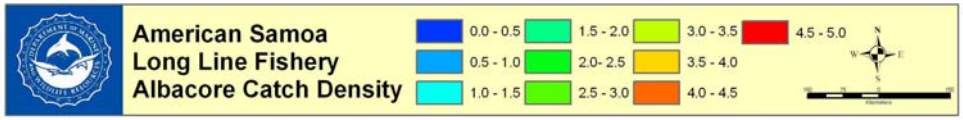
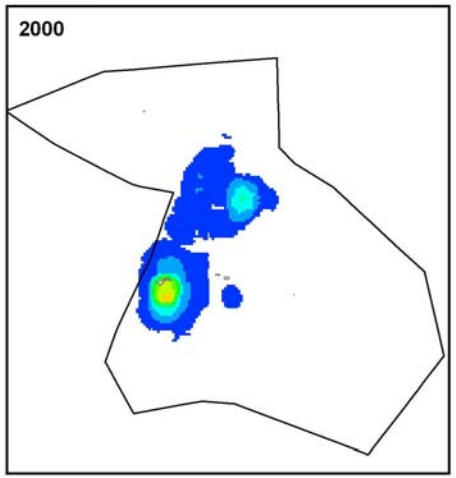
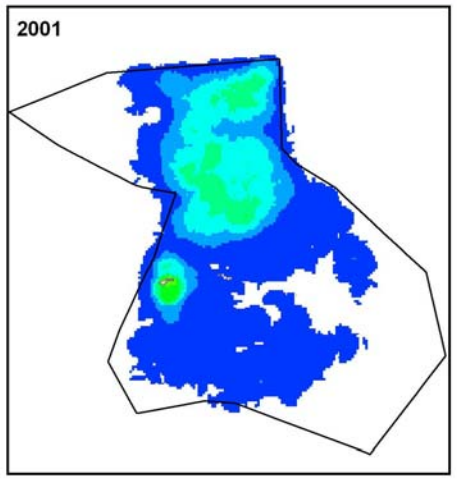
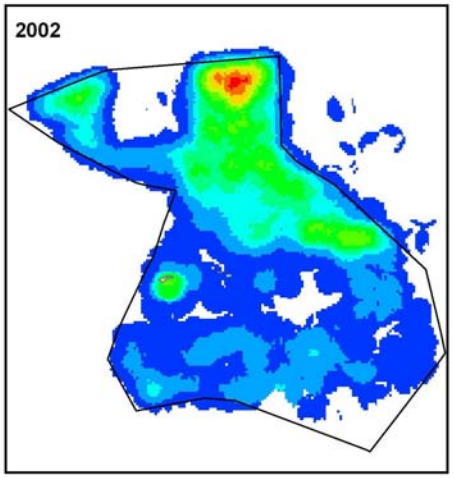
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

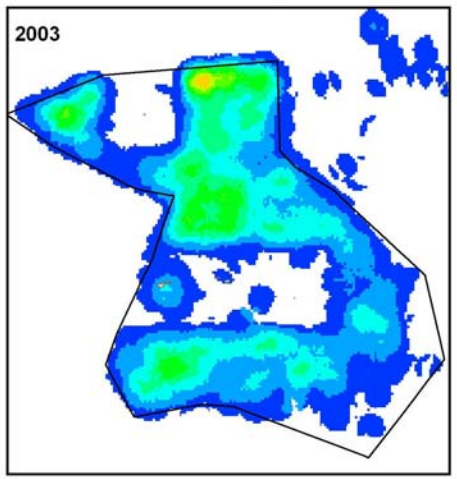












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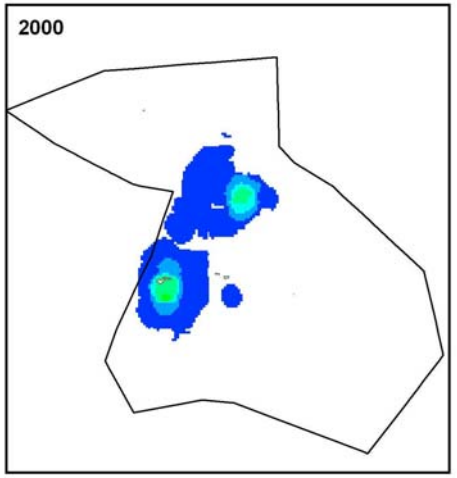

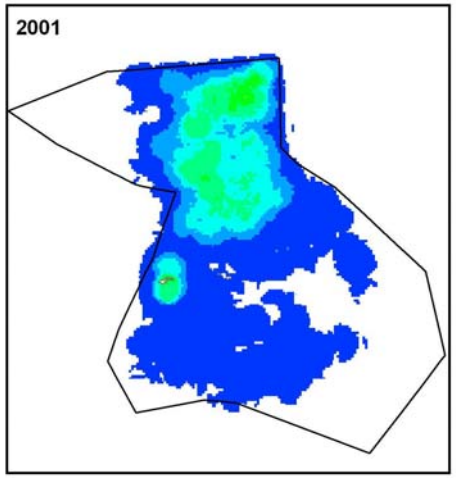

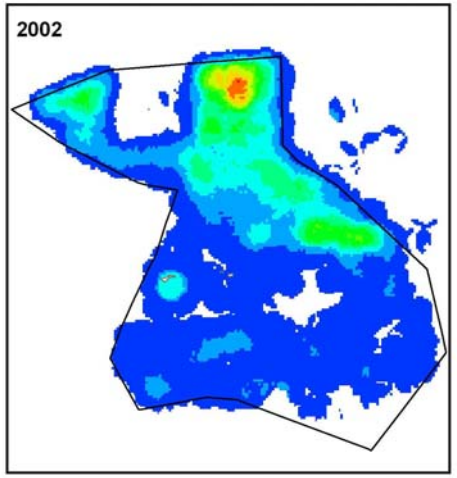

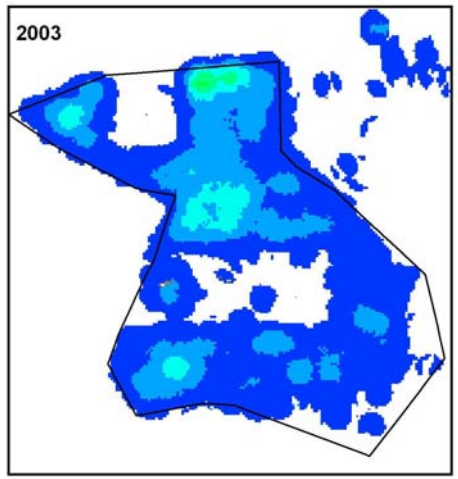

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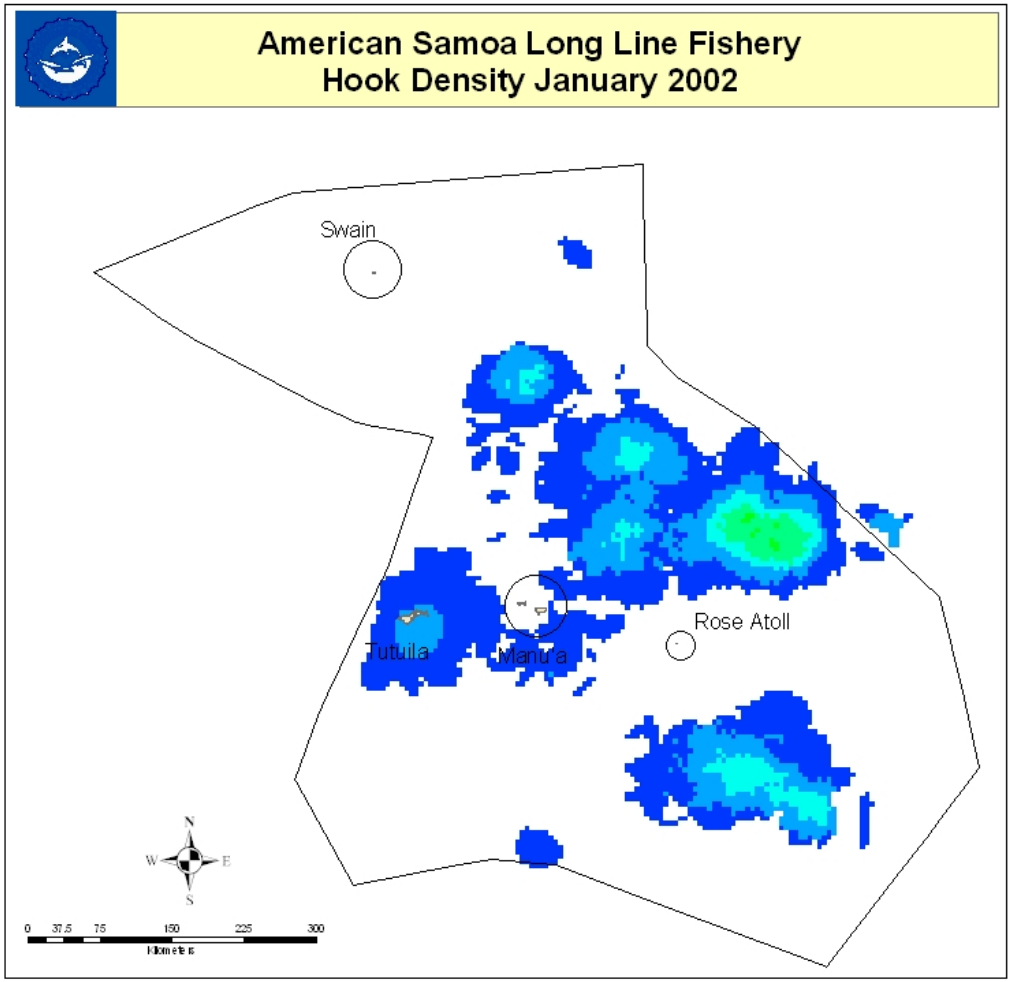
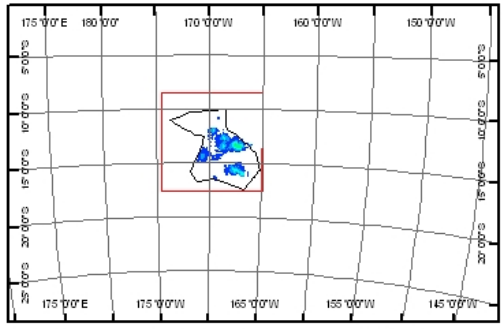
American Samoa Long Line Fishery
Hook Density January 2002



Legend:
Number of Hooks per Square Km

0.000 - 5.000	25.000 - 30.000
5.000 - 10.000	30.000 - 35.000
10.000 - 15.000	35.000 - 40.000
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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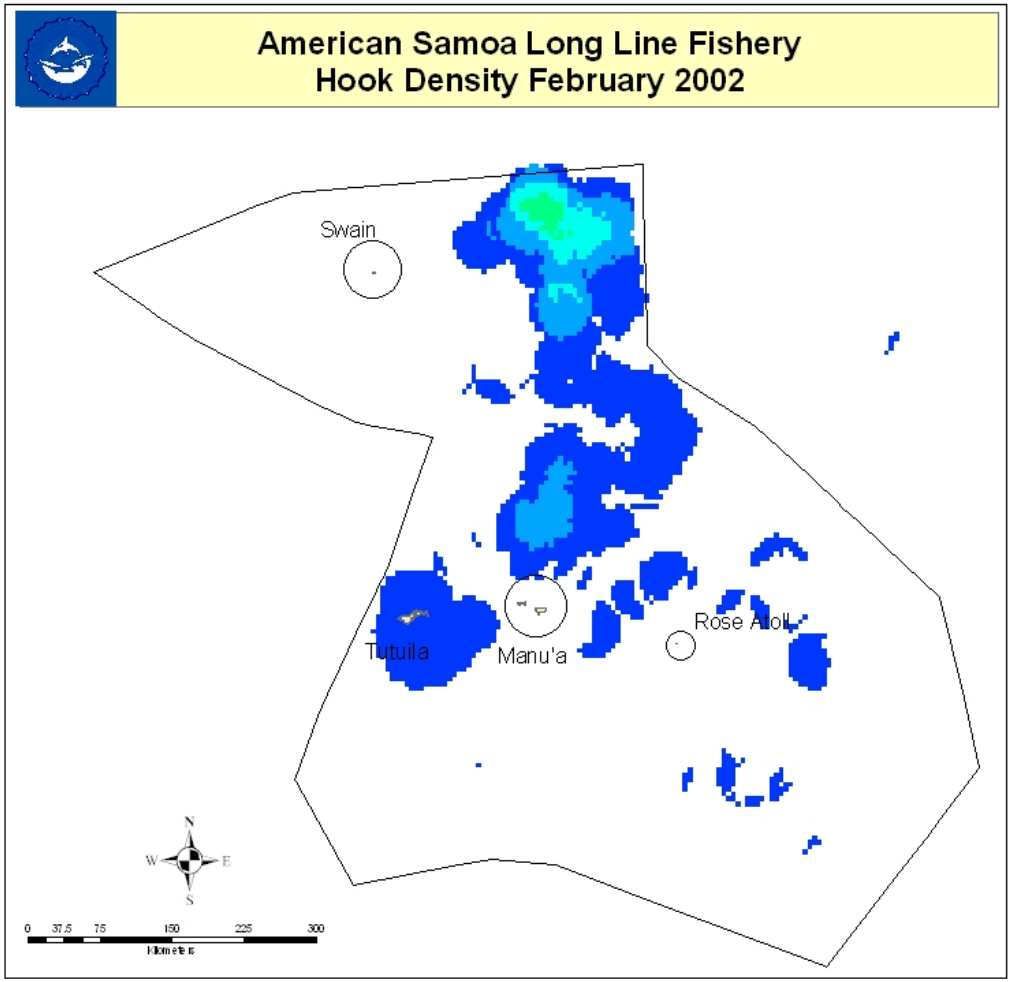
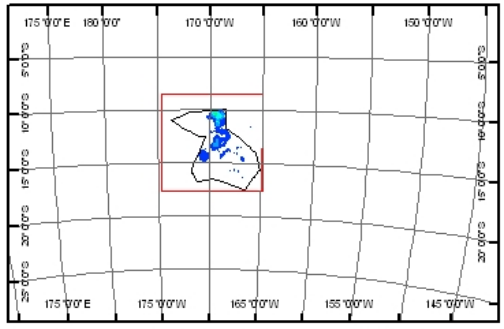
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density February 2002



Legend:
Number of Hooks per Square Km

0.000 - 5.000	25.000 - 30.000
5.000 - 10.000	30.000 - 35.000
10.000 - 15.000	35.000 - 40.000
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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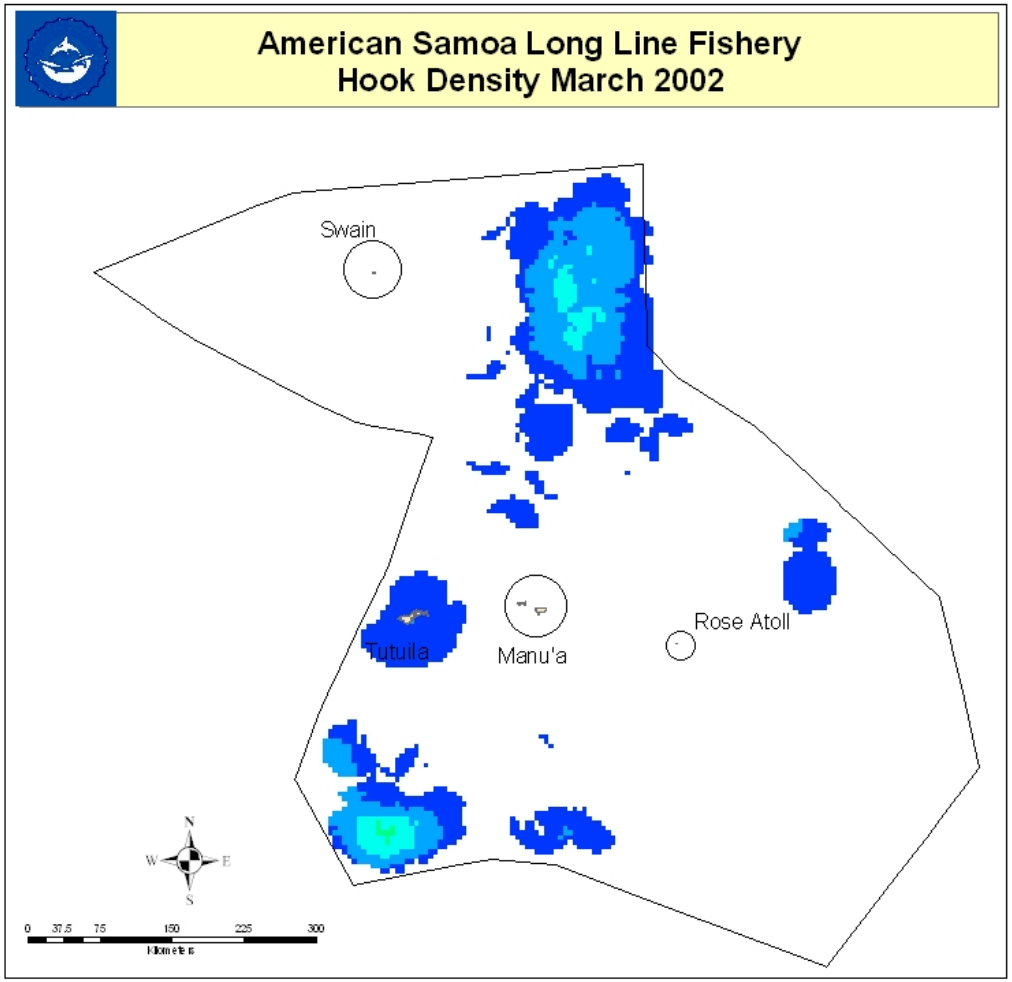
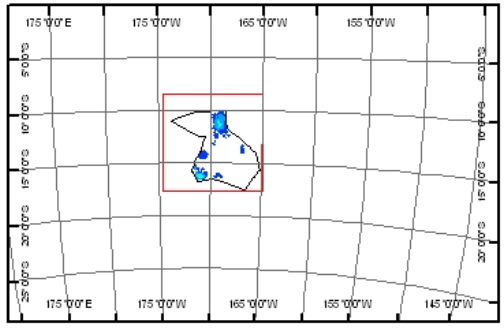
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density March 2002



Legend:
Number of Hooks per Square Km

0.000 - 5.000	25.000 - 30.000
5.000 - 10.000	30.000 - 35.000
10.000 - 15.000	35.000 - 40.000
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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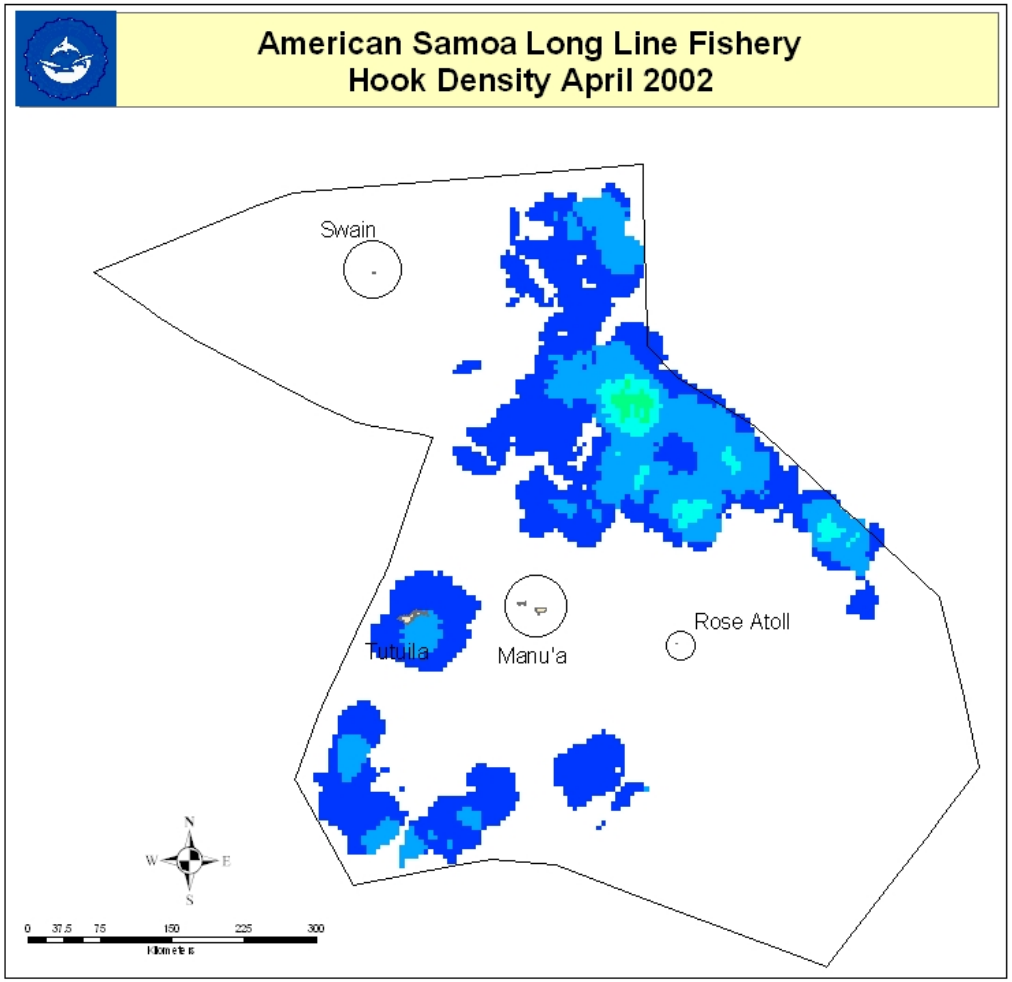
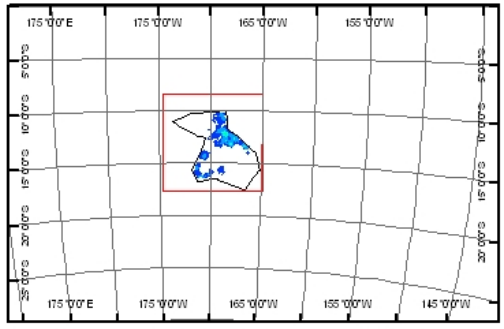
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density April 2002



Legend:
Number of Hooks per Square Km

0.000 - 5.000	25.000 - 30.000
5.000 - 10.000	30.000 - 35.000
10.000 - 15.000	35.000 - 40.000
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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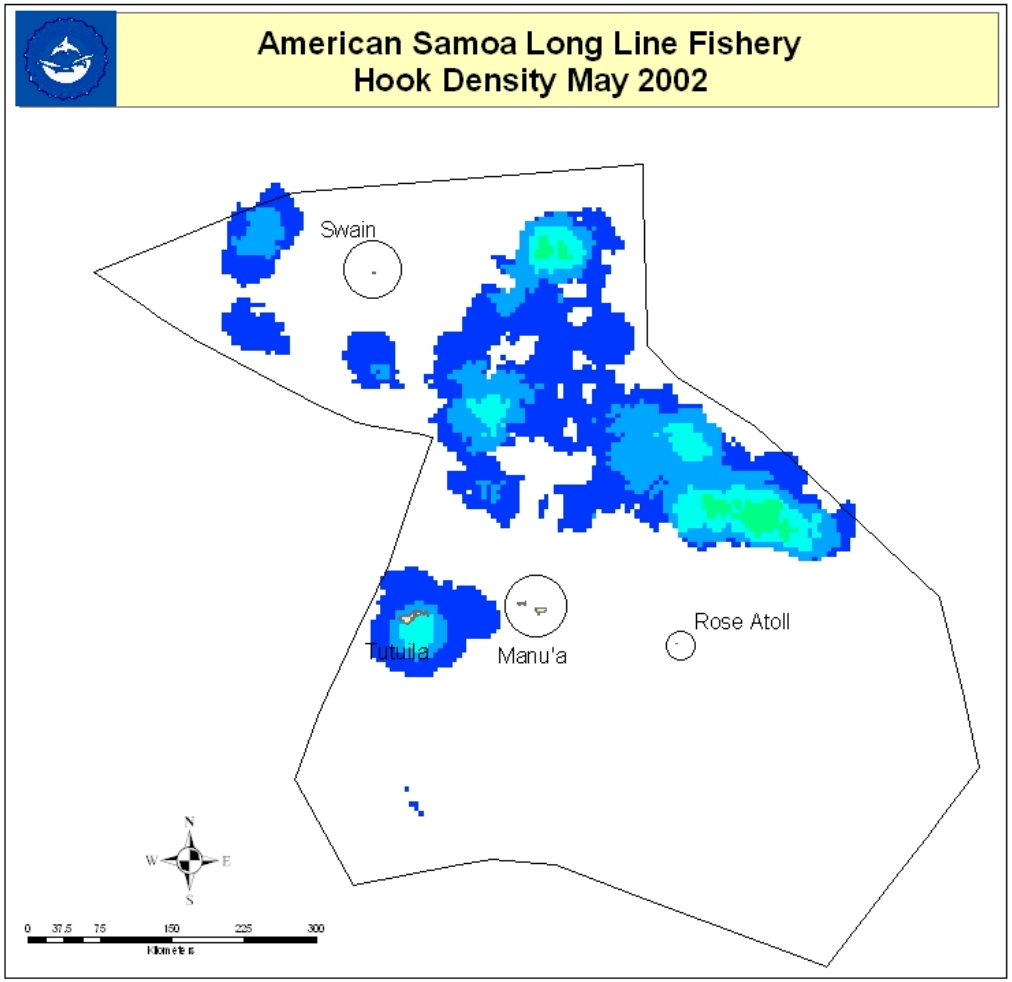
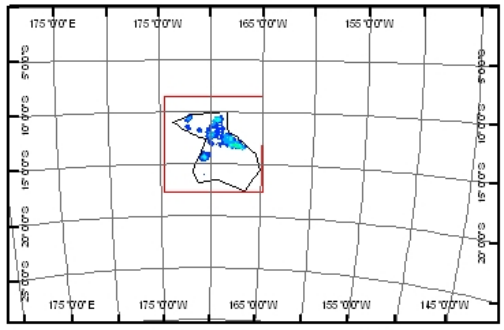
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density May 2002



Legend:
Number of Hooks per Square Km

0.000 - 5.000	25.000 - 30.000
5.000 - 10.000	30.000 - 35.000
10.000 - 15.000	35.000 - 40.000
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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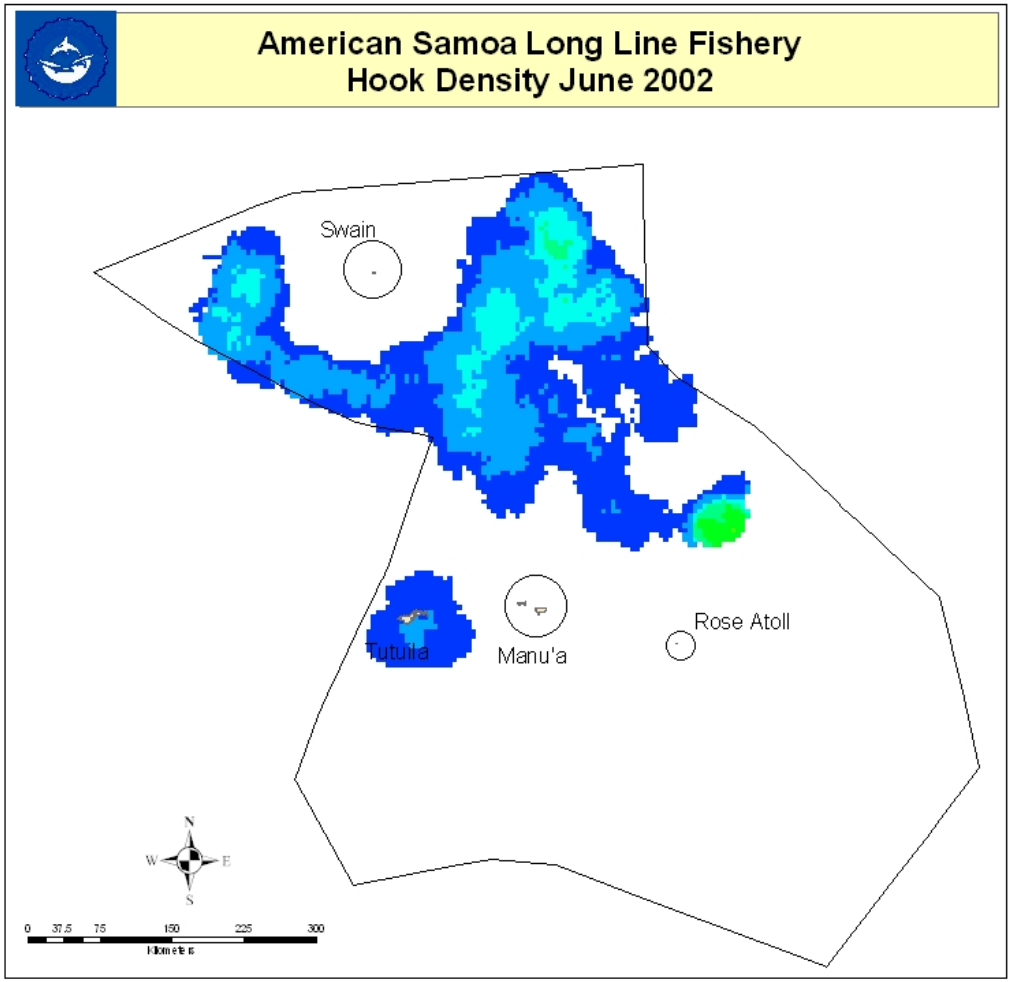
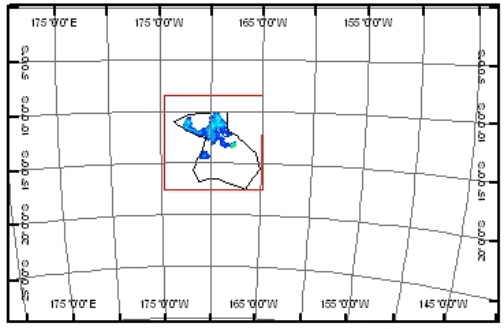
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density June 2002



Legend:
Number of Hooks per Square Km

0.000 - 5.000	25.000 - 30.000
5.000 - 10.000	30.000 - 35.000
10.000 - 15.000	35.000 - 40.000
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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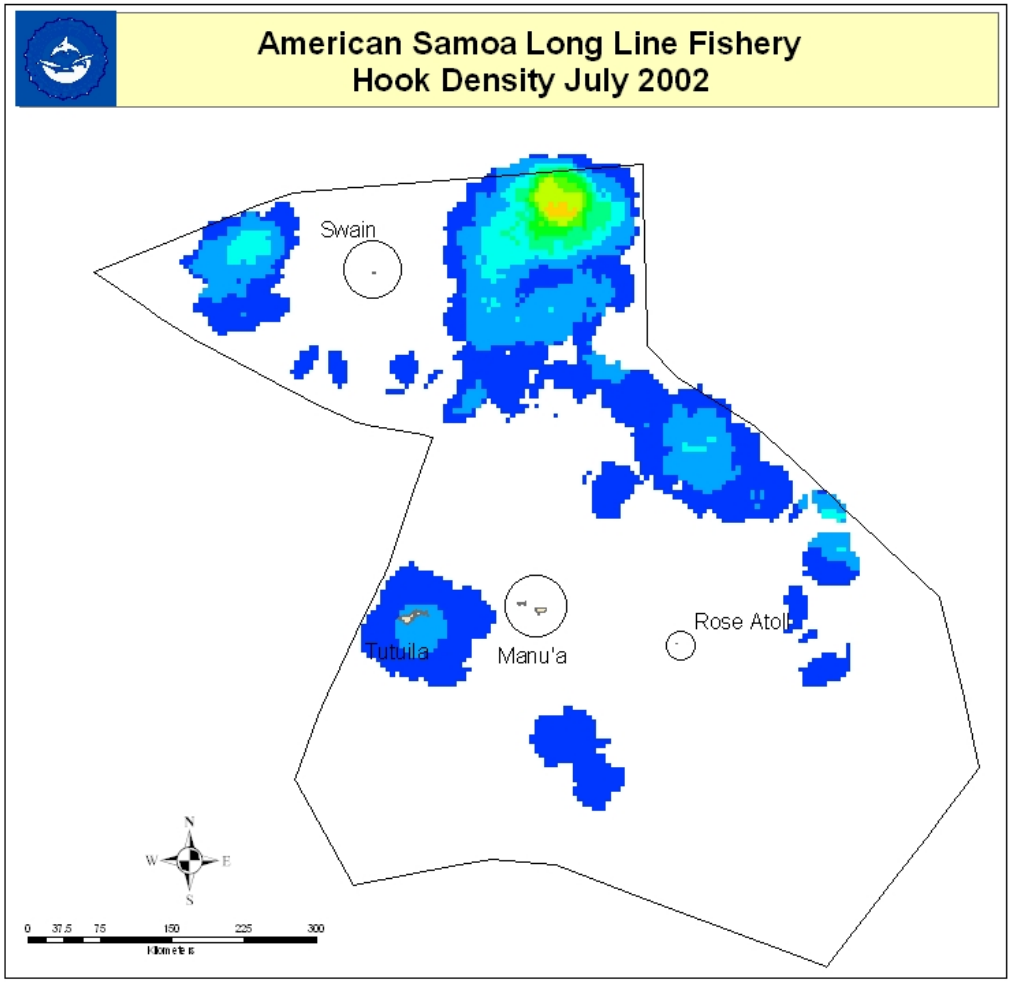
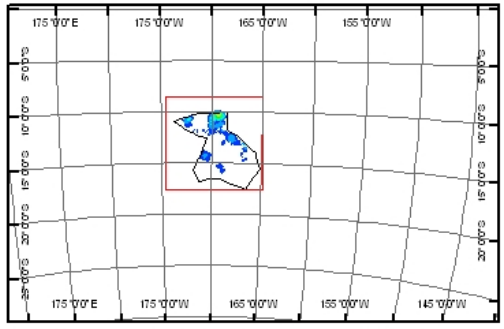
EBM ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density July 2002



Legend:
Number of Hooks per Square Km

0.000 - 5.000	25.000 - 30.000
5.000 - 10.000	30.000 - 35.000
10.000 - 15.000	35.000 - 40.000
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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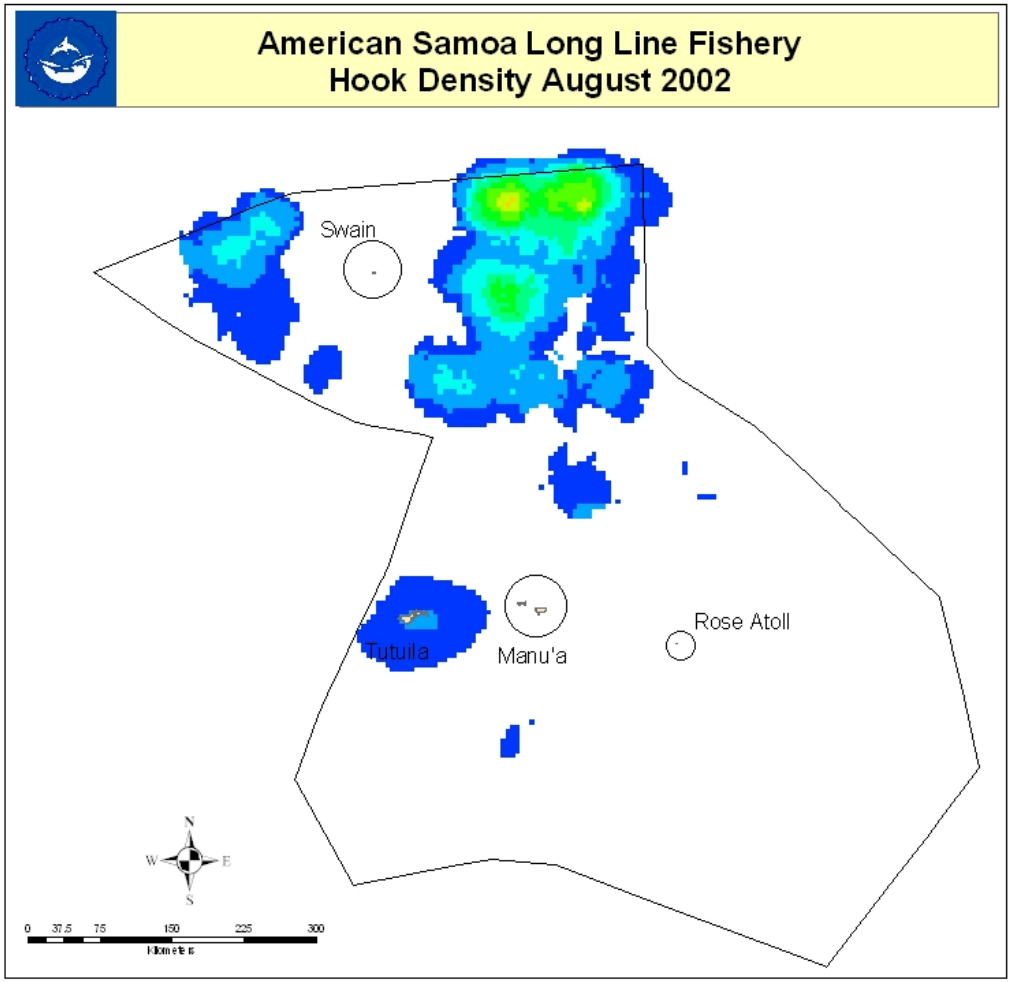
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density August 2002



Legend:
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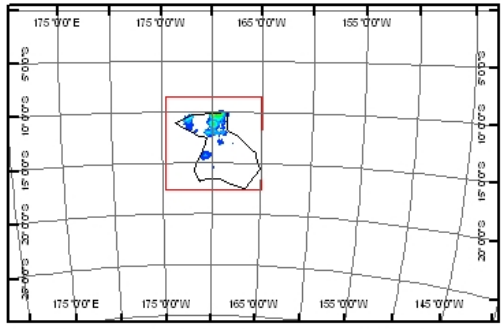
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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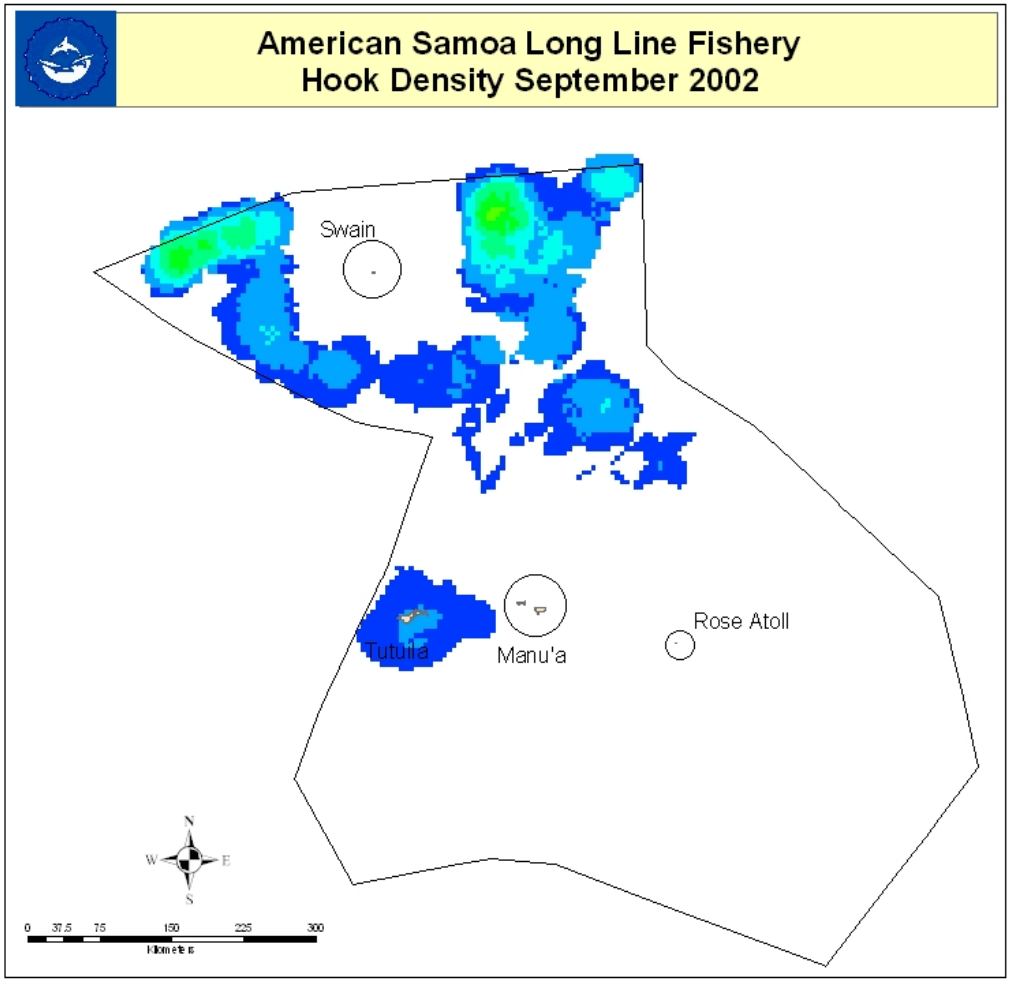
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density September 2002



Legend:
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5.000 - 10.000	30.000 - 35.000
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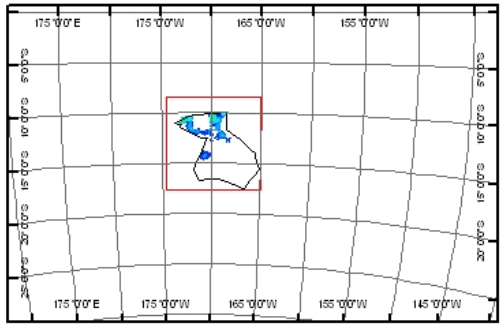
15.000 - 20.000	40.000 - 45.000
20.000 - 25.000	45.000 - 50.000



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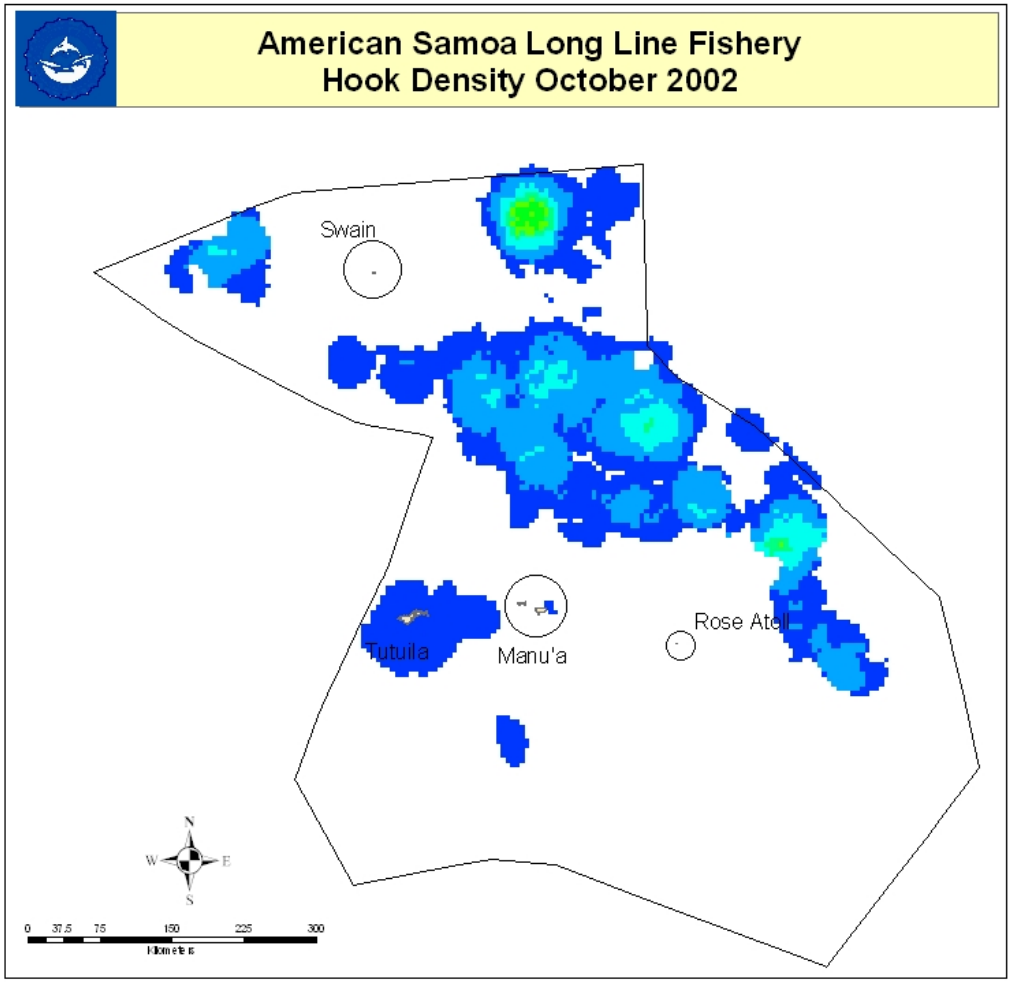
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density October 2002



Legend:
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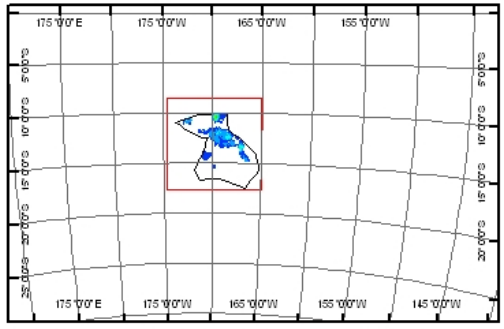

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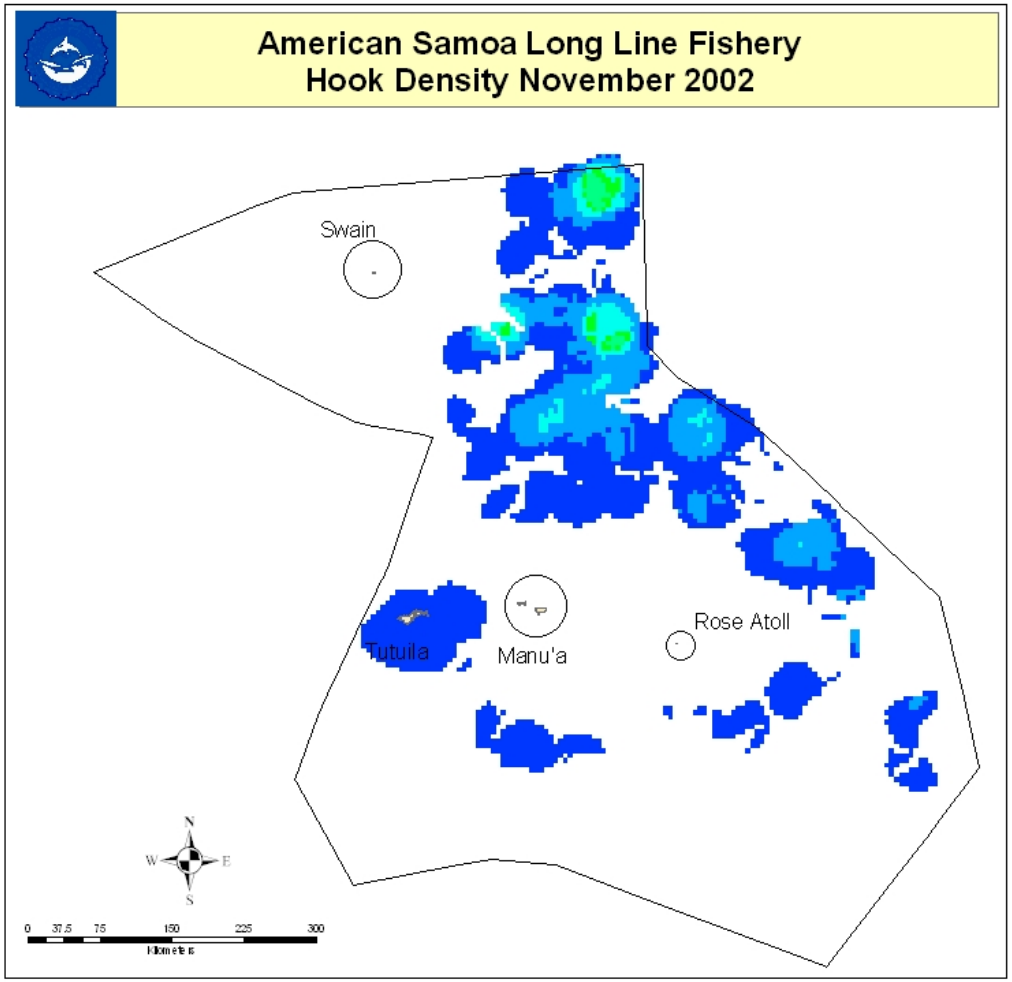
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density November 2002



Legend:
Number of Hooks per Square Km

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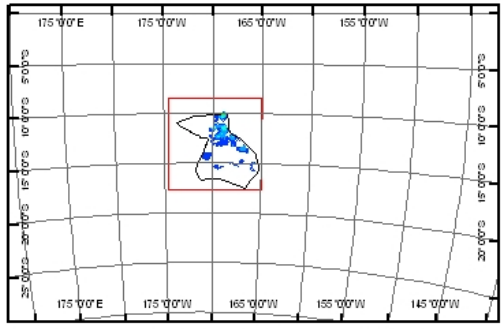

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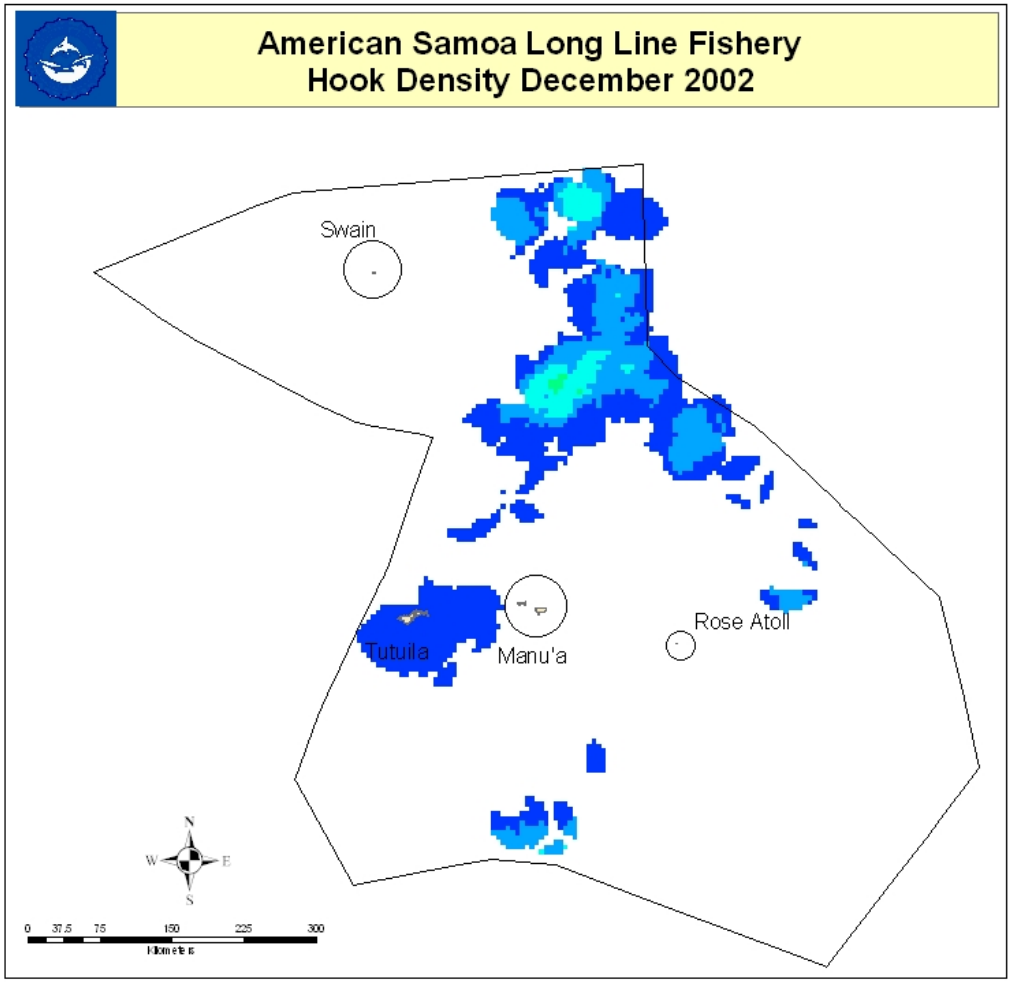
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK

American Samoa Long Line Fishery
Hook Density December 2002



Legend:
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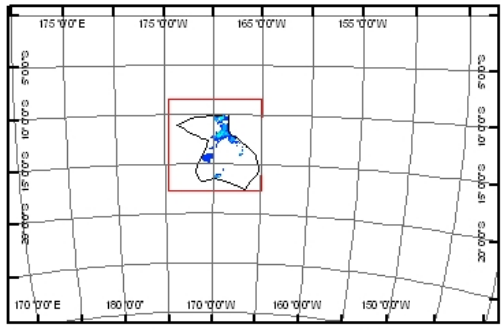

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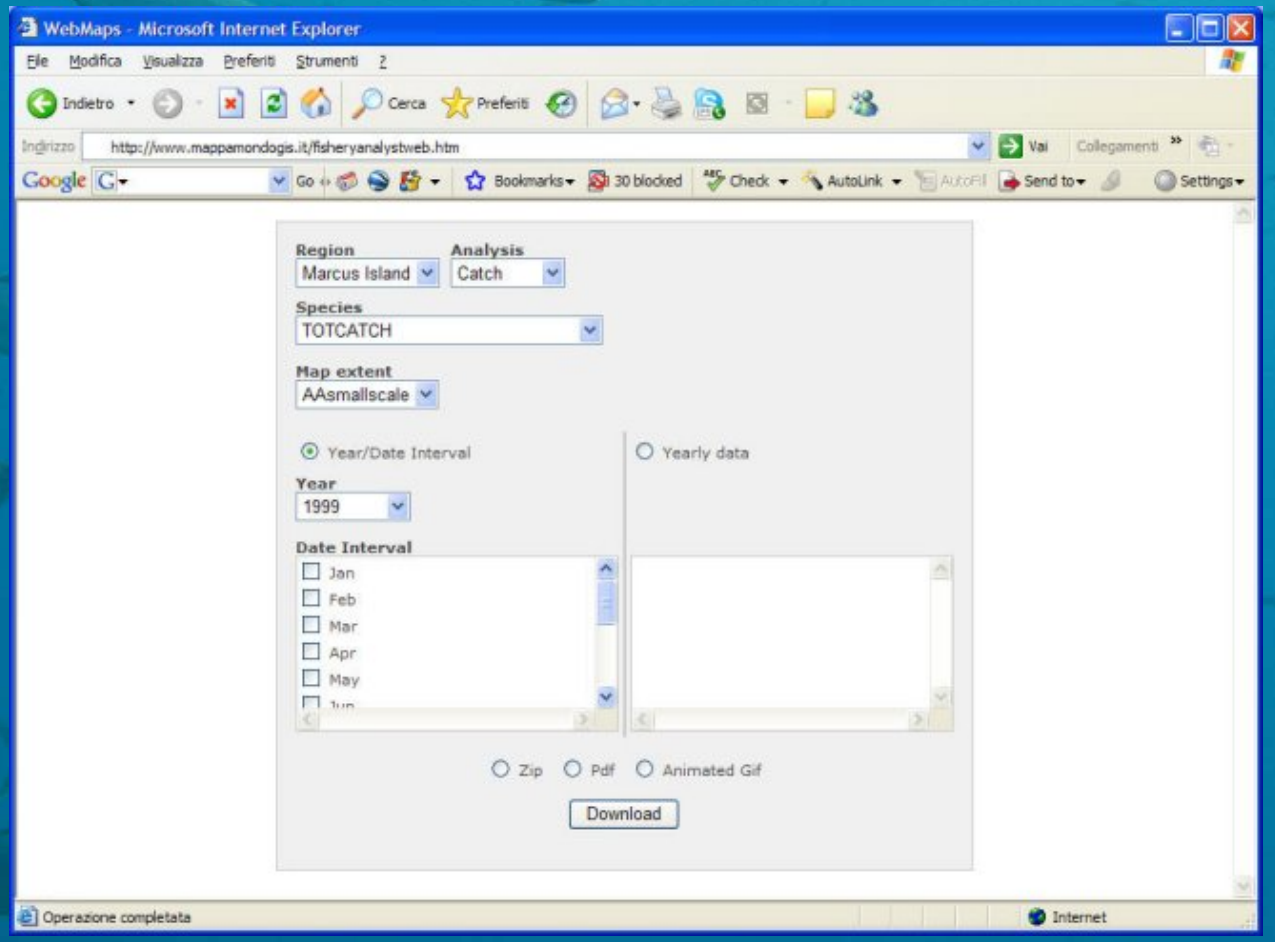
ECOSYSTEM-BASED MANAGEMENT TOOLS NETWORK


Demo

Web component

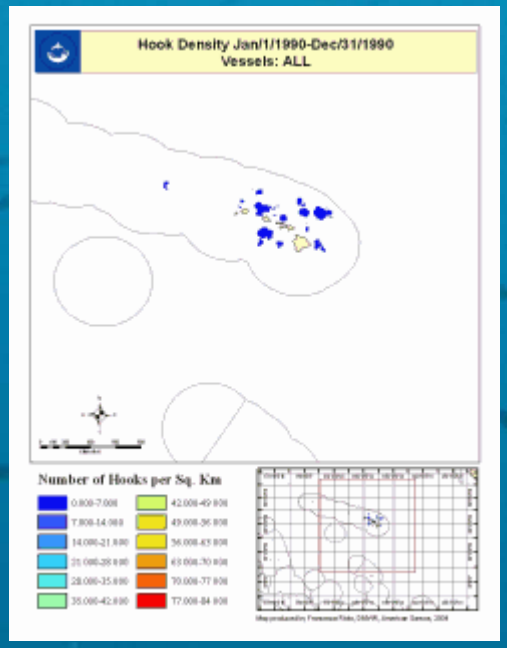
The web component allows to easily serve pre-made plots over the web as animations or single graphic files by offering to the users a friendly and immediate searching and animation building interface.



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.

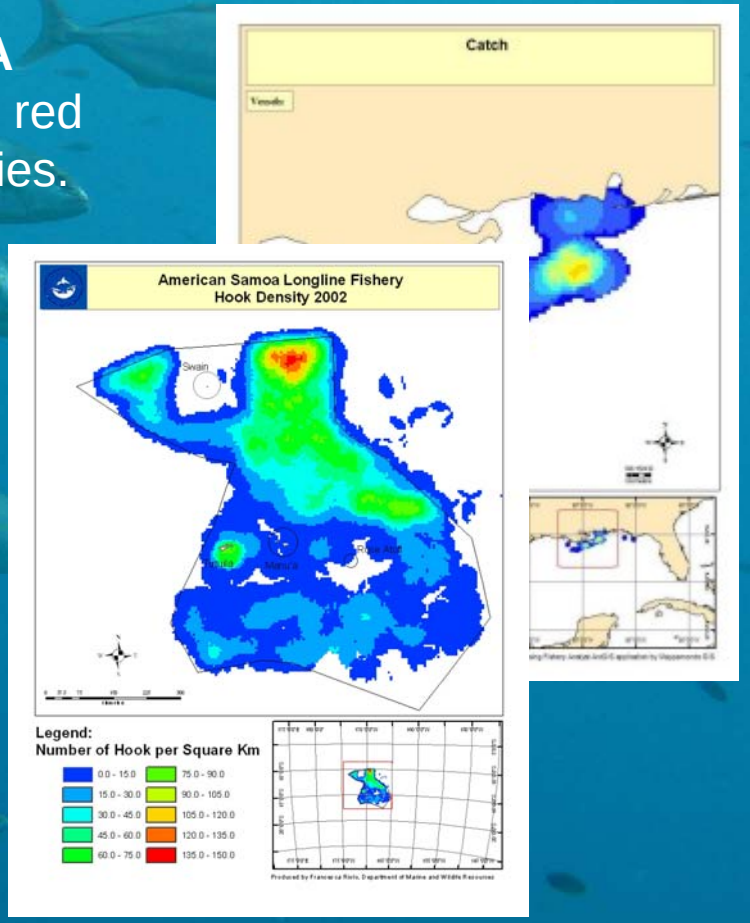
National Institute of Aquatic Resources of the Technical University of Denmark
study fisheries and stock spatial dynamics of key commercial species such as herrings, flounders and cod in the North Sea and North Atlantic.



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.

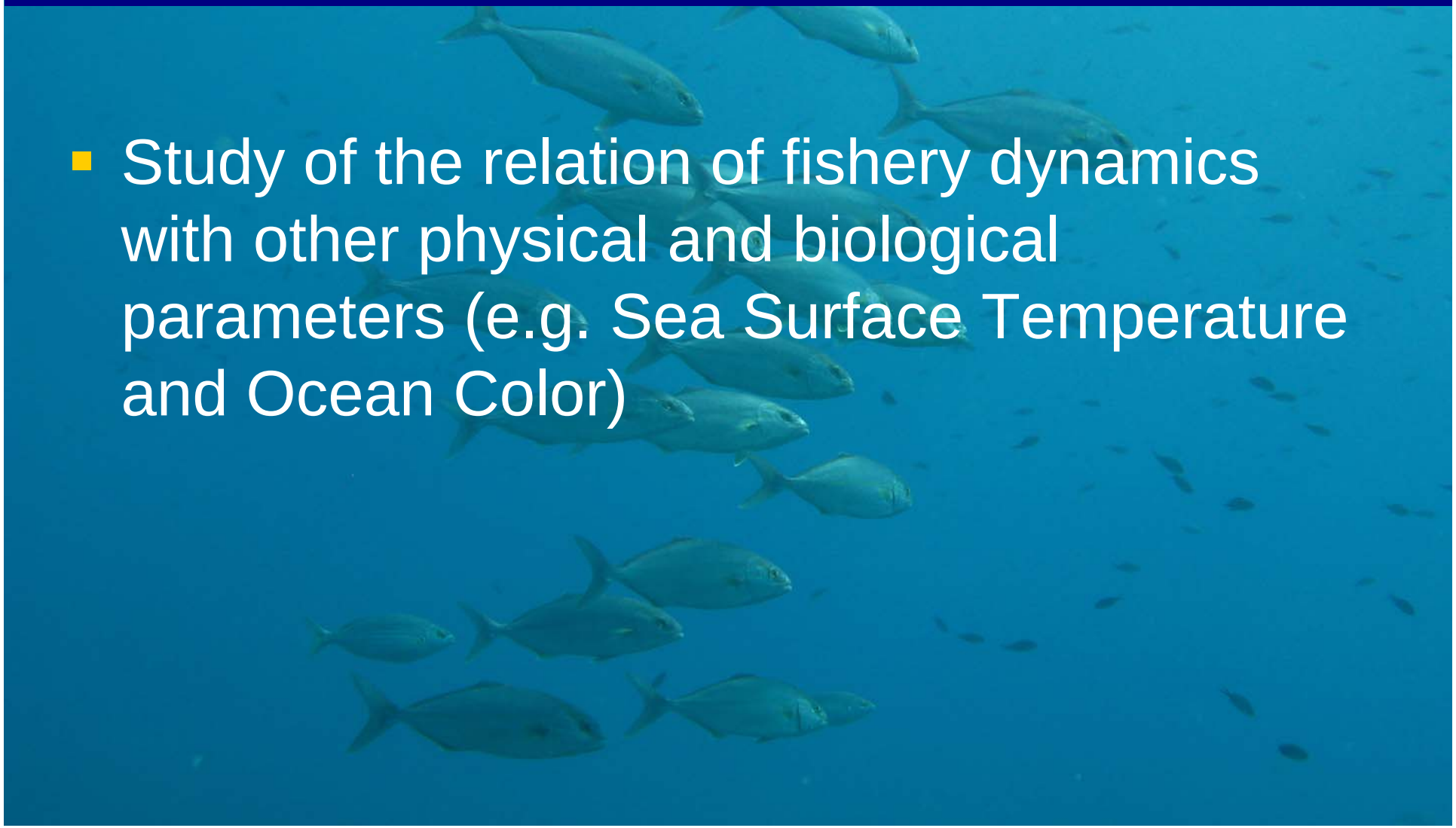
Department of Marine and Wildlife Resources - American Samoa
Spatial distribution of commercial longline fishery activities



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

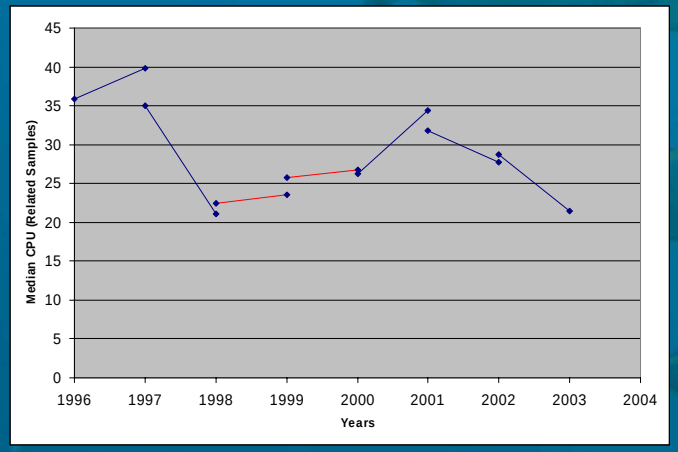


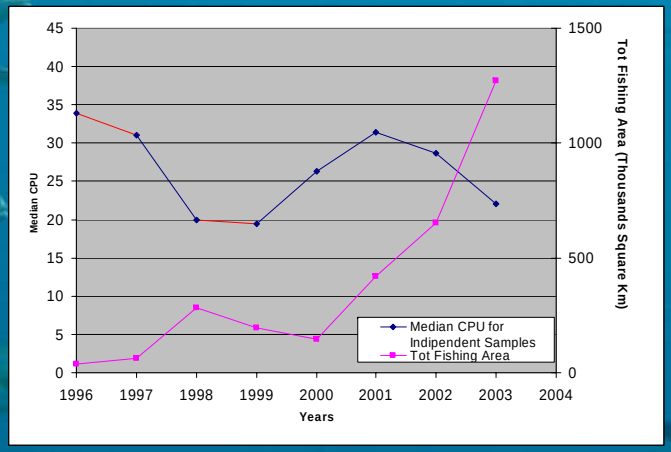
- Study of the relation of fishery dynamics with other physical and biological parameters (e.g. Sea Surface Temperature and Ocean Color)

Additional reading

- Francesca Riolo, 2006. A Geographic Information System for fishery management in American Samoa. Environmental Modeling and Software Volume/Issue 21/7 pp. 1025-1041.

Statistical Inference on CPU Trends, Fishing Area estimations





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CONTACT INFO

Francesca Riolo

GIS Specialist

Mappamondo GIS

URL: http://www.mappamondogis.it/fisheryanalyst_en.htm

Email: francesca.riolo@mappamondogis.com

Ph: +39 3386246285