

**INTEGRATED BENTHIC HABITAT MAP SYSTEM
FOR FRENCH FRIGATE SHOALS, NORTHWEST HAWAIIAN ISLANDS**

Written by Gillian Clague on 1/29/2008
Available for download from:
http://www.soest.hawaii.edu/pibhmc/pibhmc_nwhi_ffs.htm

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I. Introduction

Overview

This is an integrated benthic habitat map system which consists of a number of separate map layers including multibeam bathymetry, acoustic backscatter imagery, hyperlinked underwater photographs and/or video still framegrabs of the benthos, seafloor classification results of living cover and substrate from optical imagery, derived depth contours, layers of geomorphic information (slope, rugosity, Bathymetric Position Index Structures, and Bathymetric Position Index Zones), digital NOAA nautical charts, Ikonos satellite imagery where available, and terrestrial topography (if available). These data are incorporated into independent ArcMap and ArcReader projects. ArcReader is a software package that can be downloaded and installed free of charge (see link below), and enables the user to view and perform limited manipulations of these map layers. The download of the ArcReader program is required to view the benthic habitat map system if ArcGIS is not already installed on your computer.

The philosophy behind this map system is based on the realization that one set of habitat boundaries cannot be applied to all life stages of all species of interest in a coral reef ecosystem. As an alternative, a suite of map layers have been produced that display different biologically important seafloor characteristics that are logistically and technologically feasible to map. These layers of multibeam bathymetry, acoustic backscatter imagery, geomorphic information, substrate and living cover classifications (which can be checked against the hyperlinked still frames of the benthos), can be utilized by managers and scientists in unique combinations to address specific management and research questions.

Software Requirements

To open the included ArcMap project, the user must have ArcGIS 9.2 installed. If a user does not have ArcGIS 9.2 installed, the download of ArcReader version 9.2 is required to view the benthic habitat map system.

Downloading ArcReader

To download ArcReader, go to the following website:

<http://www.esri.com/software/arcgis/arcreader/download.html>

Double click on 'Download ArcReader 9.2 for Windows' and the program will automatically download. A window will appear and ask if you want to open a file entitled ArcReader92.zip (the file is approximately 176 MB in size). Click Yes. To learn more about the use of the program, double click on 'ArcReader Tutorial' to download the introductory tutorial.

II. Using the ArcReader Benthic Habitat Map System


To open the integrated Benthic Habitat Map System, select the ArcReader program. When the window appears, select File > Open. Browse in the main folder and double click on 'FFS_HabitatMapSystem.pfm' to open the map system. *If the map image does not appear when the project is first opened, select and deselect any layer; this will cause the project to refresh and redraw all layers.

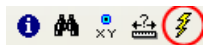
Important! *If choosing to use ArcMap instead of ArcReader, the user must copy the entire FFS_HabitatMapSystem folder directly onto the C drive of their computer, without rearranging the internal structure. The pathway should read:*

C:\FFS_HabitatMapSystem. Only copying the entire folder onto the C drive will make the project look to the correct location for the files, and therefore will allow all layers to be linked properly to the project.

Note: Upon opening, the following layers are already selected and activated: Hyperlinked Photos, Optical Data Locations, Contours, 20 meter bathymetry and hillshade.

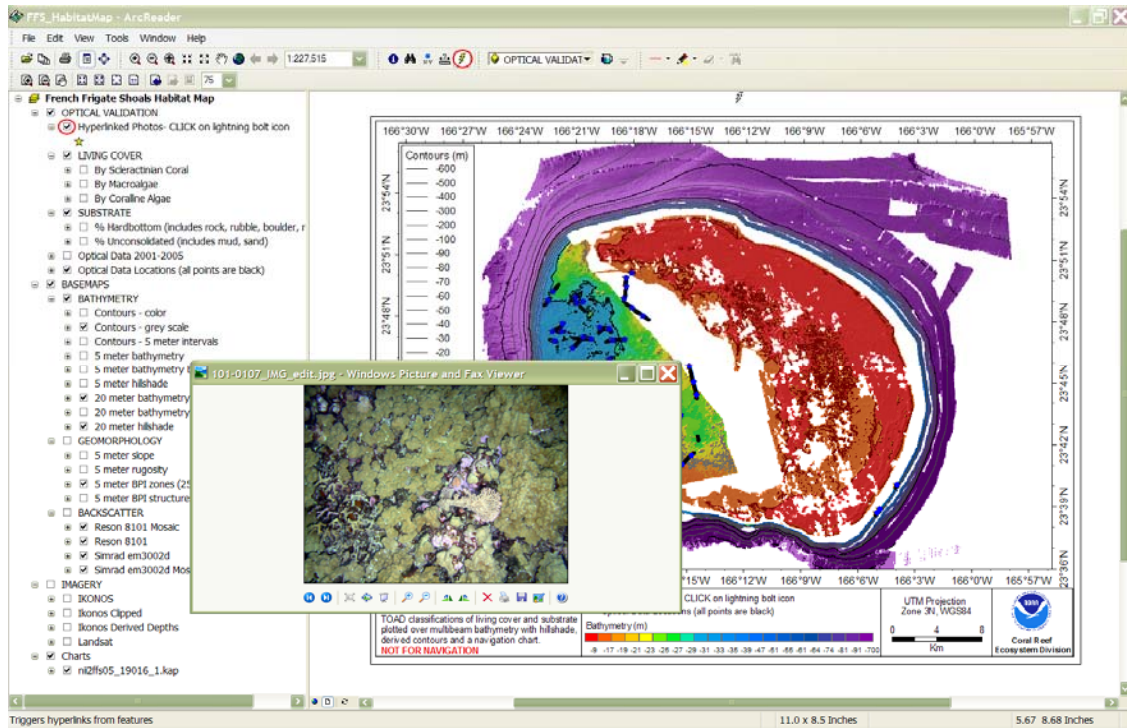
Hyperlinked Images of the Seafloor

*Upon opening, be aware that the 'Hyperlinked Photos' layer is selected but is not activated. To activate, the user must select the Lightning Bolt Icon  in the toolbar at the top of the window.



This icon will enable the hyperlinks to photos of the benthos at the locations marked by stars. Once the hyperlinks are enabled the stars and the lightning bolt will turn blue, indicating that an image is available at the selected location. Click on a blue star, and a window will appear with the file path locations; each is a link to an individual image. Double click on a pathway, and the image of the seafloor will appear in another window. (All original image files are located in 'Stills' within the FFS_HabitatMap folder).

Note: If the user has ArcMap and has already copied the entire FFS_HabitatMapSystem folder onto their C drive, they are now able to create other published map documents if they wish. , They must go to the Document Properties option under the File menu, and take out all information in the 'Hyperlinked base' field. The hyperlinks will only work in the published map document if this window is empty when the map is created. To publish the map, the user should go to the Publisher extension, and go down to 'Publish Map'. After publishing the map, retype the file pathway to the folder of image files in the 'Hyperlinked Base' field. (This pathway is preset to C:\FFS_HabitatMapSystem). This field must be filled in to make the hyperlinked images work in ArcMap.

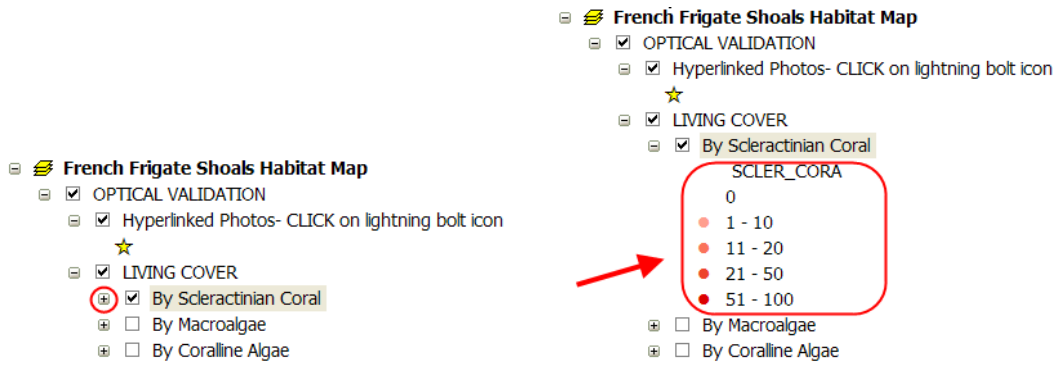


Selecting Layers

While using the ArcReader project, you must select specific layers to allow the values to appear on the map. To view a layer, check the box to the corresponding layer. This will cause the project to redraw the chosen combination of layers, and will now display the layer(s) of interest. An important detail to be aware of is that the general, more encompassing layer groups must also be selected. For example, to view the values for percent scleractinian coral cover collected by TOAD video, the user must be sure that all Optical Validation>Living Cover>By Scleractinian Coral are selected. If the Living Cover box was not checked, none of the underlying layers would be activated.

- French Frigate Shoals Habitat Map**
 - OPTICAL VALIDATION**
 - Hyperlinked Photos- CLICK on lightning bolt icon
 - ★
 - LIVING COVER**
 - By Scleractinian Coral
 - By Macroalgae
 - By Coralline Algae


To see the legend for any layer, click on the box with a (+) sign, and this will cause the legend (containing information such as percent values or color ramps) for the layer to drop down.



To view more information about each layer, right click on the layer in the table of contents and choose Properties from the drop down menu. This opens the Properties dialog box which indicates the source file for the layer.

** Note: The layer that is closest to the top of the list will be drawn over the other layers if multiple layers are selected. This allows some restrictions on what values are visible. Keep this detail in mind when selecting layers and looking at close-up details of a map.





Refresh

This icon  is located where the table of contents window and the display window adjoin. Selecting this icon will cause all layers to reload in the display window, and is especially useful when the program has difficulties drawing certain layers.

Zooming

Often zooming into a defined feature or area is advantageous to see the individual values of optical data and also the details of the underlying basemaps (e.g., bathymetry, backscatter, and any of the geomorphology layers). There are several options for zooming; all of these icons are located on the standard toolbar and are indicated below. In addition, they are available under Tools > Navigation and also Layout.




To zoom in, select the looking glass with the plus (+) sign , and the project will refresh itself zoomed in on the area of choice. To zoom out, select the looking glass with the negative (-) sign . In addition to zooming in manually, there is an option of fixed zooming. On the standard toolbar, the icon with the arrows aiming out from the center of the square  causes the entire map to zoom out, and the one with arrows aiming in  causes the map to zoom in.

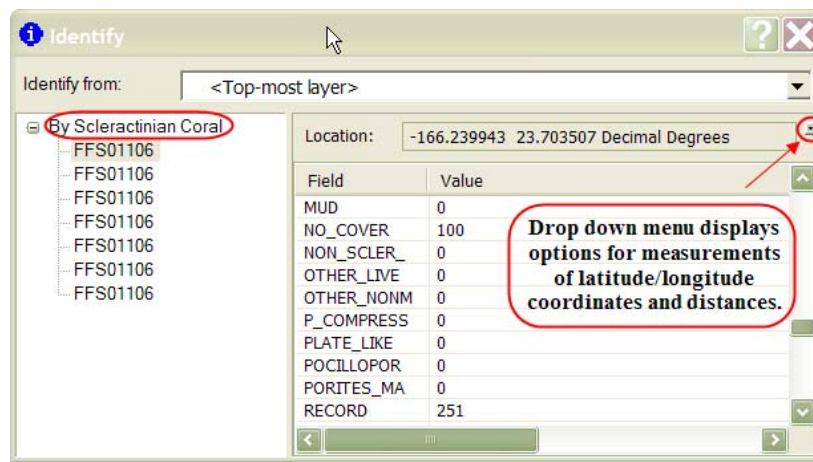
Panning

To pan the view, select the hand symbol  from the toolbar. This will change the area of the map that is displayed.




Identify

When this icon  is selected and the user clicks on any point on the map, a window will appear that displays information, i.e. latitude and longitude in multiple formats. If the selected point has optical data, it will also include values for all classification categories. To select a different coordinate display method, In the Location field there is a small down arrow icon. If selected, a drop down menu appears which includes Decimal Degrees and 'Degrees Minutes Seconds' among other options, as well as different distance measurements, including meters, centimeters, and kilometers, etc.



Measure

Click on the measure icon , and then select any point on the map. If the user continues to click, the first field will display the distance of that segment, and the second will display the accumulated distance. When you close this window, all segments will be gone from the map display. To keep the lines in place, the user should draw in the desired lines with the Drawing tool.

Drawing Tools





The line icon (left) will draw a line of three differing widths, selected by pulling down the small arrow next to the icon. The highlighter icon (center) will highlight any desired area with either a yellow, green or blue highlighter. This is useful when drawing a reader's attention to a specific area of interest or set of features. When any drawing is completed on the map, the Eraser icon will become activated. With the Eraser (right), the user can select to erase an entire ink stroke, or erase using a small, medium or large eraser.

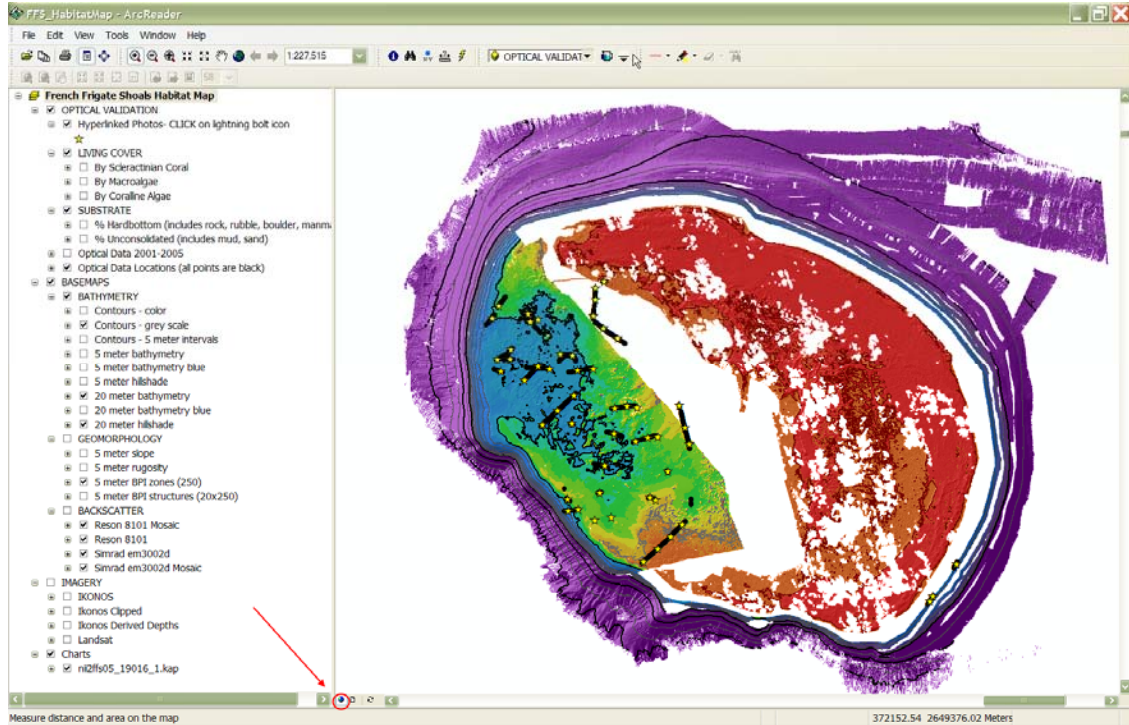
Note: In addition to the icons at the top of the window, the same drawing tools are also available under Tools; select Data for Identify, Measure (and Hyperlink) and Markup for the Pen, Highlighter and Eraser abilities.

Data and Layout Views

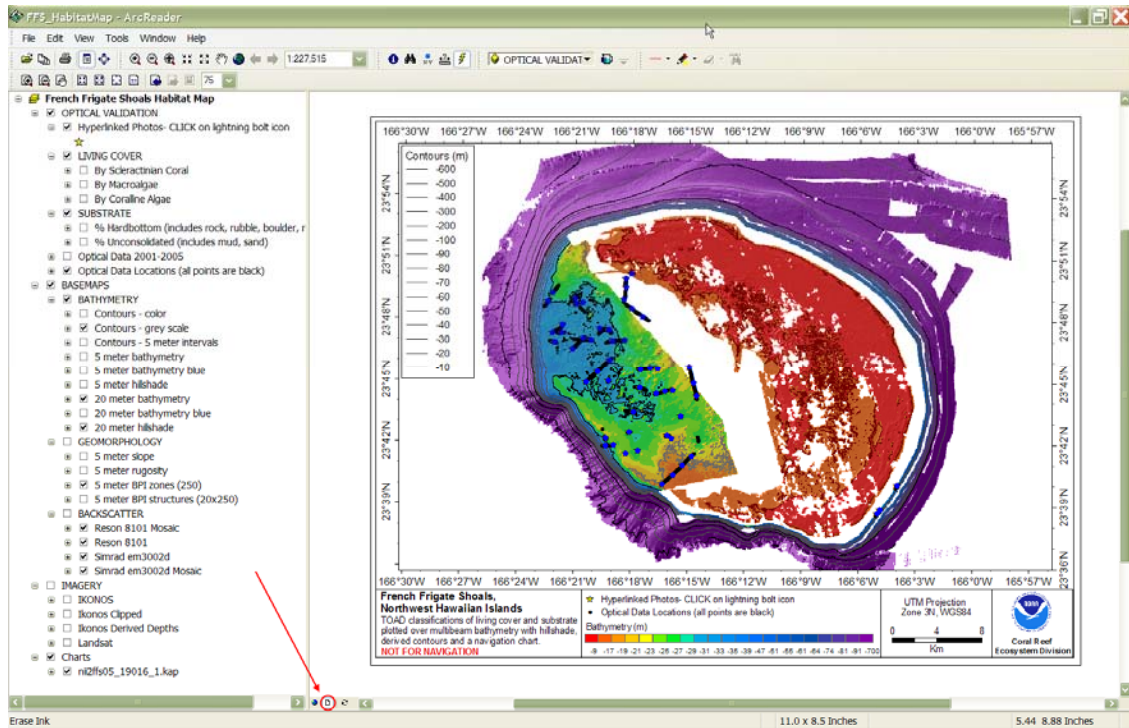
The two view options are Data View and Layout View, and the two icons are located where the map window and the table of contents windows meet.

Selecting the Data View  (small globe icon) will only display the data within the mapping window. Layout View  will display the data in the format of a published map, and includes information such as a scale bar, latitude and longitudinal lines, title and description, and legends.

Data View: (small GLOBE icon is selected, indicated by red circle)



Layout View: (small PAGE icon is selected, indicated by red circle)



Exporting and Printing Maps

When the user has selected the desired content for the map, select File> Export Map. A 'Save As' window will appear, and select the desired name and location for the produced file. All maps created from ArcReader will be in .bmp format.

To print this newly created image, select the printer icon from the bottom of the image window.

Note: In ArcReader, the user is unable to modify the content of the map title or any of the legends. Therefore, the title will not necessarily describe what is now displayed, and the color ramp for bathymetry cannot be changed to that for the backscatter imagery.

III. Description of Benthic Habitat Layers:

Optical Validation (for both classifications via towboard divers and TOAD video)

Hyperlinked Photos-CLICK on lightning bolt icon

Living Cover

By Scleractinian Coral (percent cover of reef-forming hard corals)

By Macroalgae

By Coralline Algae

Substrate

% Hardbottom (includes rock, rubble, boulder, and manmade)

% Unconsolidated (includes mud, sand)

Optical Data 2001-2005 (TOAD data points, each cruise has a unique color indicating the date of collection).

*Optical Data Locations (*Note: Activate layer to see in combination with optical data classifications. When viewed with a living cover or substrate layer, the black points that remain represent a value of zero for the layer of interest).*

The optical data layers include habitat information derived by classifying a number of categories during the analysis and integration of underwater video, still frames, and diver observations. One of the habitat classifications is **Living Cover**, the percentage of each category (e.g., macroalgae, scleractinian coral, etc) attached to and visibly covering the surface of the seafloor, including plants and sessile organisms; mobile organisms are not included in this category. The second main habitat classification is **Substrate**, defined as the percentage of a substrata type which constitutes the seafloor surface). This classification includes two categories of substrate: *Hardbottom*, including rubble, rock, boulders, and manmade surfaces; and *Unconsolidated* bottom, representing sand or mud. In this benthic habitat map system, the two substrate categories are designated as Total Hardbottom and Total Unconsolidated.

Descriptions of all classification categories are available in the main folder as bh_class_codes.xls, and are also available online at:
ftp://ftp.soest.hawaii.edu/pibhmc/website/webdocs/webtext&figures/bh_class_codes.htm

All of the points in the ***Optical Data Locations*** layer are the locations of all collected optical data.

*Suggested Use: When viewing the values for an optical category, display the location points also. All points with color have the according percentage of the selected category, while all black points have a value of zero for the category at that location.

Basemaps

Bathymetry

- Contours – color (derived from multibeam bathymetry)*
- Contours – grey scale*
- Contours- 5 meter intervals*
- 5 meter bathymetry (higher resolution imagery)*
- 5 meter hillshade*
- 20 meter bathymetry*
- 20 meter hillshade*

Multibeam *Bathymetry* data are collected to provide depth readings for a given area. This information is useful for defining the habitat preferences of a specific species, locating fish habitat, studying geological features of the area, and very importantly, informing researchers of the possibilities for future data collection. *Depth Contours* are derived from the multi-beam bathymetry to indicate the basic depths of the surrounding area, and are especially important in outlining the plans for data collection involving scuba divers. This benthic habitat system includes two layers of contours, one of selected depth values of importance, and one with contours of 5 meter intervals). The layers include a 5 meter grid and 20 meter grid, where each pixel represents 25 m² and 400 m² respectively. Included in this system are the correlated hillshade grids (*5 meter hillshade* and *20 meter hillshade*); the hillshade and bathymetric grid with the same grid sizes should be displayed together. The bathymetry is placed above the hillshade file on the project menu so it will be draped over the geological features.

Geomorphology

- 5 meter slope*
- 5 meter rugosity*
- 5 meter BPI Zones*
- 5 meter BPI Structures*

The *Geomorphology* layers of ***slope***, ***rugosity*** (roughness), and ***bathymetric position index (BPI) zones and BPI structures*** are derived from multibeam bathymetry and may be used for benthic and essential fish habitat characterization, and for the study of

geologic features. (*Definitions of all geomorphology layers are available in the file 'benthic habitat layers PIBHMC.doc', which is provided in the main folder). By combining these benthic habitat layers with bathymetry, backscatter, other derivatives and *in situ* data, they collectively compose benthic habitat maps which are designed to be used to understand and predict moderate depth (~20m – 150m) benthic habitats for different organisms that inhabit coral reef ecosystems. By stacking the layers of information, they can be analyzed to determine which values of each data layer may be an indicator of a particular habitat or benthic structure. For all of the geomorphology layers, one pixel is 5 meters on each side (25 m² of seafloor).

Backscatter

Reson 8101

Simrad em3002d

The *Acoustic Backscatter imagery* indicates the areas of seafloor that reflect high and low intensities of the sonar ping returns. Darker shades represent high intensity backscatter and typically indicate hardbottom substrate, possibly including scleractinian coral and parts of the underlying rock structures. The lighter shades represent low intensity backscatter and indicate soft and absorbent substrate, such as unconsolidated sediment. Backscatter imagery was collected using two different multibeam echosounders: a Simrad em3002d (300 kHz) and a Reson 8101 (240 kHz). A 1 meter grid was used for both systems, where each pixel represents 1 m² of seafloor, yielding high resolution backscatter imagery for the entire area surrounding Tutuila. The mosaics for both the Reson 8101 and the Simrad em3002d imagery are at a much lower resolution than their counterparts of the same name.

Imagery

IKONOS (satellite imagery, not available at all locations)

Ikonos Clipped

Ikonos Derived Depths

Landsat

Charts (Existing NOAA nautical charts to assist in cruise/dive planning).

**APPENDIX 1:
Name and Description of All Benthic Habitat Layers**

OPTICAL VALIDATION: *classifications via towed diver observations and TOAD*
Hyperlinked Photos- [CLICK](#) Lightning Bolt Icon: *still images of seafloor surface*
LIVING COVER: *Percent cover of each category*
 By Scleractinian Coral: *primary constituent of coral reefs*
 By Macroalgae
 By Coralline Algae
SUBSTRATE: *% of seafloor surface that is consolidated and unconsolidated*
 % Hardbottom (includes rock, rubble, and manmade)
 % Unconsolidated (includes mud and sand)
Optical Data 2001-2005: *All cruises are multicolored to distinguish the date of collection.*
Optical Data Locations (*all points are black): (**Note: Activate layer to see in combination with optical data classifications, all visible black points are a value of zero for the layer of interest.*)

BASEMAPS

BATHYMETRY

Contours – color
Contours – grey scale
Contours- 5 meter intervals
5 meter bathymetry: *high resolution imagery- each pixel represents 5m²*
5 meter bathymetry blue
5 meter hillshade
20 meter bathymetry
20 meter bathymetry blue
20 meter hillshade

GEOMORPHOLOGY: *derived from bathymetry, displays habitat characteristics*
5 meter slope
5 meter rugosity: *a measure of roughness and heterogeneity in the habitat*
5 meter Bathymetric Position Index (BPI) Zones
5 meter BPI Structures

BACKSCATTER: *reflection intensity indicates areas of hard and soft bottom*
Reson 8101
Reson 8101 mosaic (lower resolution)
Simrad em3002d
Simrad em3002d mosaic

IMAGERY

IKONOS: *satellite imagery of the island*
Ikonos Clipped
Ikonos Derived Depths
Landsat
Charts: *Existing NOAA nautical charts of the region*
19016_1.kap